International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-8 Issue-5, June 2019

Effect of Bypass Diode under Partial Shading in SPV Module

Kavita Singh, Tarana Afrin Chandel, Mohd. Khursheed Siddiqui, Md. Arifuddin Mallick

Abstract*: *Solar Photovoltaic (SPV) systems are widely used as alternative energy source for the generation of electricity, because of their advantages over other energy sources. The performance analysis of PV modules is depends upon various parameters and shading is one of them. Shading of modules drastically affects the performance of the PV modules. This paper focuses on the study of effect of bypass diode during the partial shading of solar modules and also the effect of shading on the output of SPV module. This study is done by using bypass diode models developed and the simulation is done by using Simscape/MATLAB software. The performance of SPV system can be improved by reducing the shading effect.

***Index Terms*: Solar Photovoltaic, MATLAB/Simulink, Solar Irradiance, Shading.**

I. INTRODUCTION

The conventional energy sources are almost about to deplete over time and that is leading to think about other alternatives of energy sources. With the grown population the demand of energy is increasing as well. This increased demand leads to the idea about using the solar energy as an alternative source. There are many other resources but the solar power is the widely used because it has so many fascinating characteristics. Solar energy is inexhaustible, renewable, cost-effective and environment-friendly form of energy and it will support to the reduction of CO2 emissions. The sun produces huge amount of sunlight daily and that is enough to fulfill the energy needs of the world. This sunlight can be used directly or indirectly depending upon the application. The most usable form of energy is electricity on which our daily life is dependent. This need of electricity can be fulfilled by the solar power. Solar energy is converted into DC power by solar modules [1]. Solar modules are basically photovoltaic cells that are connected in series or parallel depending on need. These silicon made cells use semiconductor technology to convert the sunrays into the form of electricity. This energy conversion is done by using photovoltaic effect. The open circuit voltage produced by a single solar cell is very small i.e. 0.5 to 0.6 V [2]. This small voltage can be made high by connecting the cells in series. These PV cells can also be connected in parallel or sometimes in the combination of series-parallel. The higher will be the voltage if these solar cells are connected in series. The parallel connection of these modules results in higher output current. The long life span about 20 to 25 years makes the solar modules more reliable. Maintenance of modules is quite easy because they do not require any special care [3]. PV modules are used for the maximum utilization of solar energy during the day time because during day time the sunlight is proper if the weather is clear. Although, solar modules gives so many benefits to the human life but they also have some demerits like shading. Shading of modules takes place due to various issues like shadow of trees, mountains, hills, weather change, bird's feces etc. [4]. The overall performance of solar photovoltaic modules is affected by shading of modules. Shading results in the heating of solar modules. The improper illumination of light causes the shading. Shading cannot be removed completely but it can be reduced to an extent so that the power of the solar modules will not be affected more by it. Bypass diodes can be used to reduce the effect of shading on SPV modules. By increasing number of bypass diodes the shading can be reduced and the improved power can be achieved through solar modules. The purpose of this paper is to analyze the effect of shading on PV modules and to overcome the degradation of power.

Manuscript published on 30 June 2019.
* Correspondence Author (s)
Kavita Singh, Department of ECE, Integral University, Lucknow, India.
Tarana Afrin Chandel, Department of ECE, Integral University, Lucknow, India.
Mohd. Khursheed Siddiqui, Department of Electrical Egineering, Integral University, Lucknow, India.
Prof. Md. Arifuddin Mallick, Department of Electrical Engineering, Integral University, Lucknow, India.

II. BASIC PV CELL MODEL

PV cell uses photovoltaic effect to convert the sunlight into electricity. When the light is exposed to the semiconductor materials, some of light of photons are absorbed by the semiconductor material and generate voltage across the cells. Silicon is widely used as semiconducting material. Two types of silicon materials can be used i.e. Mono crystalline silicon and the Polycrystalline silicon for making these solar modules [5]. There are four valence electrons in Silicon and all of four shares a bond with another atom of silicon and hence make covalent bonds. When light fall on the semiconducting material some amount of light is reflected, some is transmitted through the material and left is absorbed by the material.

When the sunlight is present in proper amount and the intensity of light is high enough then the large amount of photons are absorbed and these absorbed photons then excite the electrons. These excited electrons gain high energy to migrate from valance band to conduction band. This movement of electrons from valance to covalent bond leaves the hole there. These free electrons and holes play a vital role in producing electricity and called as light generated electrons and holes respectively.

The basic PV cell model is shown in Figure1. The model includes a current source, diode, shunt resistance, and series resistance.

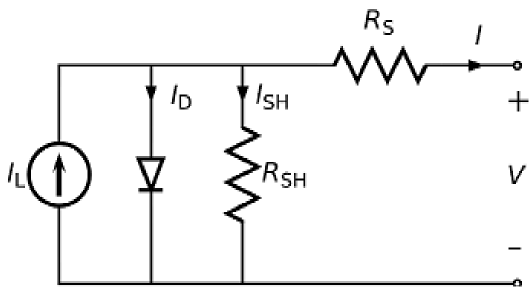
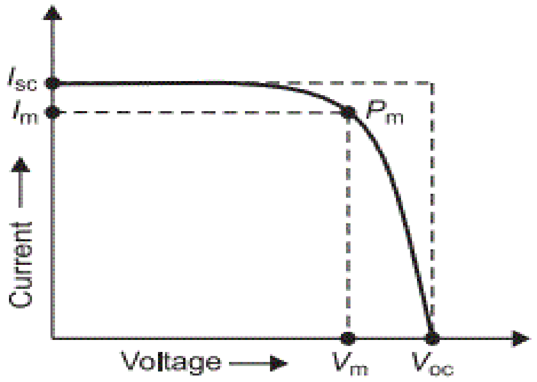


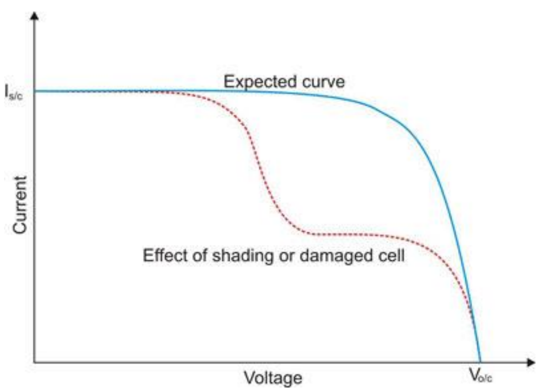
Figure 1 Basic Circuit Diagram of a PV cell

I-V characteristics of a PV Cell

The current-voltage (I-V) characteristics of solar modules are shown in figure.2. Fig. 2(a) represents the I-V curve in ideal case and when there is no shade. Fig. 2(b) shows the I-V characteristics when the Modules are partially shaded. It is clearly visible by fig. 2(b) that shading damages the cell and affects the overall output.



(a)



(b)

Figure 2 I-V Characteristics curve of solar modules

(a) Ideal Case

(b) Under partial shading [6]

III. EFFECT OF SHADING

Shading is the very important issue of concern while analyzing the power at the load. Shading of panels is unwanted but it will occur somehow including the atmospheric reasons such as bad weather, dirt-patches, shadow by tree leaves, etc. and have an adverse effect on the output of modules. Shading of modules can be compared with the clog in a pipe of water. As the flow of water in pipe is restricted by the clog similarly, the shading blocks the flow of current through the shaded module. The current of entire string is decreased even if the small section of module is shaded because all cells are connected in series and next cell is operated by the output voltage of the previous cell hence total power generated at each cell is the sum of all [6]. If a single cell or a string of cell is shaded it behaves as a reverse bias, the circuit get disconnected and act as open circuit. So, even the small amount of shading can substantially affects the maximum output power. Shading can also cause overheating of module which leads the making of hotspot on the module surface. Shaded panels produce less energy as compared to the un-shaded panels. A Partially shaded module is shown in figure 3. The various causes of shading of modules are shown by the figure 4, 5 and figure 6.

Figure 3 Shading of Panel in Partially Shaded Roof

Figure 4 Birds sitting on the surface of solar module

Figure 5 Shading due to Dirt-patches

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)

Figure 6 Shading due to Bird-Excrements

IV. EFFECT OF BYPASS DIODE ON PARTIAL SHADING

Bypass diodes as the name implies it bypasses the current through it. Bypass diodes is connected in parallel with the solar modules. The increased number of bypass diodes can also results in improved output power. When the solar modules are un-shaded, i.e. when modules receive uniform irradiance, the bypass diode becomes passive or considered as the reverse biased and the current flows through the modules itself. In case of shading occurs in the modules, the current will not pass through the solar cells in the modules as these solar cells are now in reverse bias condition and this will results in power loss due to voltage drop. In this case, bypass diodes plays an important role in the smooth flow of current thus generating voltage. Hence power is increased at the output [8].

In this paper, analysis on partial shading is done by one diode model using MATLAB Simulink software.

PV model using Bypass Diode

The model shown in figure 7 is developed using Matlab/Simscape tool. In this model, only one bypass diode is used to prevent the cells from shading. The different blocks are used to complete the model and to meet the requirements. The controlled current block is used to measure the output current and voltage sensor block is used to measure the output voltage. The product block multiplies the voltage and current of the photovoltaic module. The output power and output voltage of solar module is sent to the Workspace block for plotting the P-V curve.

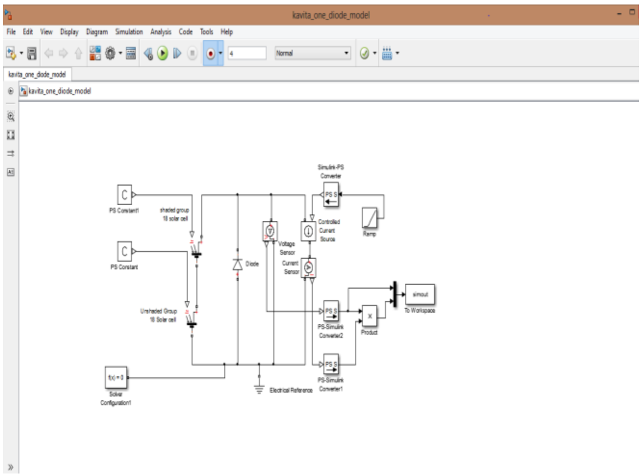
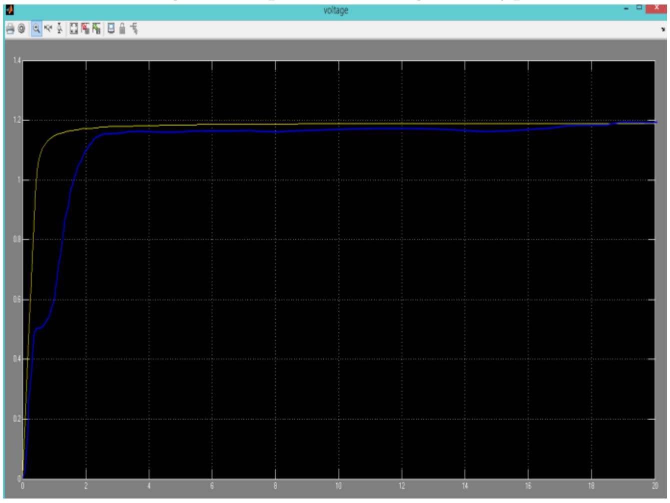


Figure 7 PV model by using single bypass diode

V. RESULTS AND DISCUSSION

The shading analysis is done for the solar module consists of 60 cells and the results are shown by the various curves (voltage, current and power). Shading affects the power and hence the overall output of module. The reduction of power level can be improved by using the bypass diode.

Voltage Curve: Voltage curve shown in the figure 8 represents the output voltage with and without bypass diodes. The yellow line in the curve represents the output voltage in normal irradiance without bypass diode and the blue curve shows the voltage under partial shading with bypass diode.



Voltage in Normal Irradiance (without bypass diode)

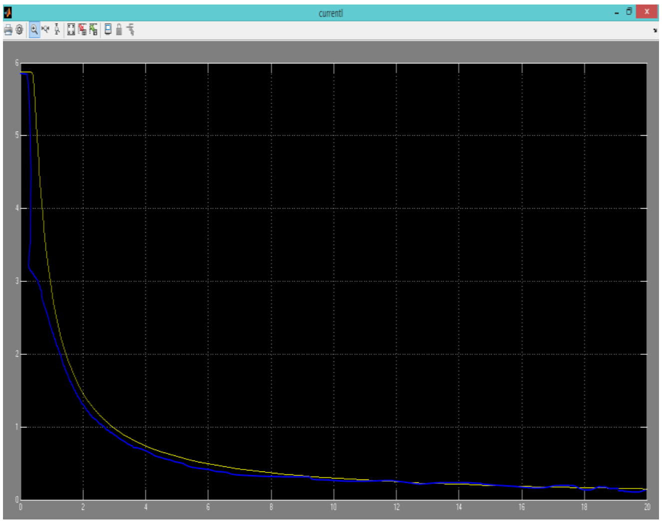
Voltage under partial shading (with bypass diode)

Figure 8 Voltage Curve

Current Curve: The current curve shown in figure 9 represents the current by solar modules with or without bypass diodes. The yellow curve shows the current in normal irradiance without using bypass diode and the blue curve represents the

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)

current drawn under partial shading when bypass diode is used.

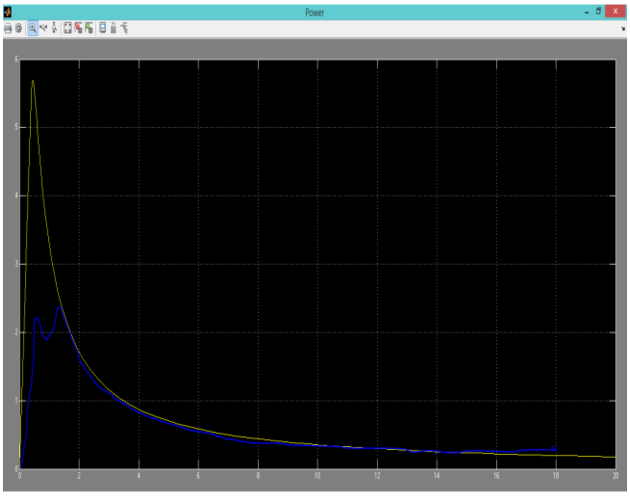


Current in normal irradiance (without bypass diode)

Current under partial shading (with bypass diode)

Figure 9 Current Curve

Power Curve: The power curve is shown in figure 10 represents the power generated by the solar modules with and without bypass diodes. The yellow curve shows the power when the irradiance is normal. The blue curve shows the power under the partial shading with using bypass diode.



Power under partial shading (without bypass diode)

Power under partial shading (with bypass diode)

Figure 10 Power Curve

VI. CONCLUSION

This paper comprises the analysis of partial shading and the effect of bypass diode on the shading of SPV modules. This analysis is done by developing a PV model with the help of MATLAB/Simscape. The effect of partial shading on the output of the solar modules is reduced by using the bypass diodes. The graphs clearly represent the improvement in the power when the bypass diode is used. The power is increased with the use of bypass diode because this diode provides a path to current flow so that the current will not get blocked and modules can easily generate power. This power can be further enhanced by increasing the number of bypass diodes.

REFERENCES

1. A.K. Mukherjee and Nivedita Thakur, Photovoltaic Systems Analysis and Design, PHI Learning Private Limited, Delhi.
2. Tarana Afrin Chandel, Md. Arifuddin Mallick, Mohd. Yusuf Yasin, "Performance of Partially Shaded Solar Photovoltaic System", International Journal of Recent Technology and Engineering, ISSN: 2277-3878, Volume-7, Issue-6, March 2019, pp. 1444-1449.
3. Ekpenyong, E.E and Anyasi, F.I, "Effect of Shading on Photovoltaic Cell", IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) e-ISSN: 2278-1676, p-ISSN: 2320-3331, Volume 8, Issue 2 (Nov. - Dec. 2013), pp. 01-06 www.iosrjournals.org
4. Amardeep Chaudhary, Shriya Gupta, Dhriti Pande, Fazal Mahfooz, Gunjan Varshney, "Effect of Partial Shading on Characteristics of PV panel by using Simscape", International Journal of Engineering Research and Applications ISSN: 2248-9622, Vol. 5, Issue 10, (Part - 2) October 2015, pp.85-89. www.ijera.com
5. Samer Said, Ahmed Massoud, Mohieddine Benammar and Shehab Ahmed, "A Matlab/Simulink-Based Photovoltaic Array Model Employing SimPowerSystems Toolbox", Journal of Energy and Power Engineering 6 (2012) pp. 1965-1975.
6. Available at: www.seaward-groupusa.com
7. "Working Principle of Solar Cell or Photovoltaic Cell", https://www.electrical4u.com/working-principle-of-photovoltaic-cell-or-solar-cell/.
8. Kavita Singh, Tarana Afrin Chandel, Saif Ahmad, "Effect of Bypass Diode under partial shading in SPV module: A Review", International Journal of Recent Technology and Engineering, ISSN: 2277-3878, Volume-8, Issue-1, May 2019, pp. 700-704.

AUTHORS PROFILE

Kavita Singh received her B.tech degree in Electronics and Communication Engineering, from PSIT Kanpur, affiliated to UPTU (Later AKTU) in 2014. She worked as a guest lecturer in Govt. Polytechnic, Mau for two years. She is currently pursuing M.tech in Renewable Energy from Integral University, Lucknow. Her area of interest includes Renewable Energy Technology.

Tarana Afrin Chandel received B.Tech degree from Magadh University in 2002 and M.Tech degree from U.P Technical University in 2009. She is pursuing PhD in Renewable Energy System in the Department of Electronics and Communication Engineering, Integral University, Lucknow. She is working as an Associate Professor in the Department of Electronics and Communication Engineering, Integral University, Lucknow. She is acting as a **Principal Investigator (PI)** in a govt. project (**Performance Analysis of 1MW Grid Connected Solar Photovoltaic System using Image Analysis**) sponsored by IEI, Kolkata, West Bengal. She is honored as **Pride of India** by International Publishing House on 12 September 2018. She is awarded **Excellent Teaching in Higher Education** in International Women Research and Connect Award 2018 on 8 March 2018, **Best Faculty in Rural Institution**, in the National Conference on Exploring Science and Technology for the Future Developments held on 25 November 2017, **Best Paper Award** by in 4 National conference on Challenges & opportunities for Technical Innovation on 19th & 20th February 2016 held at Ambalika Institute of Management and Technology, Lucknow, U.P and **Rashtriya Gaurav Award** for her Excellence in Meritorious Services, Outstanding Performance and Remarkable Role by Dr Bhishma Naraian Singh at the Seminar on Global Participation of India's Economic Development at New Delhi on 24 May 2010. She is Life member of various societies like ISTE, IEI and Robotics Society, I.U.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)

Mohd. Khursheed Siddiqui received his B.E. and M.Tech in (Electrical Engg.) degree in 2006 & 2008 respectively from Aligarh Muslim university, Aligarh, India. He is presently working as Associate Prof. in Electrical Engg. Dept. in Integral University, Lucknow, India. He is a life member of IEI. His area of interest are Renewable Energy System, Power Electronics, Electrical machine drives, Power System & Control.

Prof. Md Arifuddin Mallick receives his B.Sc Engg and M.Sc Engg from AMU, Aligarh, from 1994 and 1998 respectively. He received his Ph.D degree in 2011 from Integral University, Lucknow. He is presently working as Professor in Department of Electrical Engg, Integral University. His research interest includes renewable energy, energy policy, instrumentation, power system modeling, electrical machine and drives. He is serving as fellow of Institution of Engineer, India, member of IEANG (Hongkong), Associate member of IETE, Member of IEEE respectively. He has also authored many books on electrical engineering. He has also delivered lecture in national and international conferences and seminar. He has many publications in national and international journal and conference proceedings. He also serves as reviewer in national and international journals. He is presently guiding government project on solar photovoltaic system. Moreover, he has two patents to his credit.

Published By:
Blue Eyes Intelligence Engineering
& Sciences Publication (BEIESP)