Research Article *ISSN: 2319-507X*
Prajwalita A, IJPRET, 2013; Volume 1(8): 109-116 *IJPRET*

INTERNATIONAL JOURNAL OF PURE AND APPLIED RESEARCH IN ENGINEERING AND TECHNOLOGY

A PATH FOR HORIZING YOUR INNOVATIVE WORK

EFFECT OF SYSTEM PARAMETER VARIATIONS ON OUTPUT CHARACTERISTICS OF A SOLAR PHOTOVOLTAIC DEVICE

A.PRAJWALITA, H. G. VIRANI

Faculty in Dept. of Electronics and Telecommunication Engineering, Goa College of Engineering, Ponda.

Accepted Date:

27/02/2013

Publish Date:

01/04/2013

Keywords

Photovoltaic system,

Series resistance,

Shunt Resistance,

Solar insolation,

Ambient temperature,

Partial shading

Corresponding Author

Ms. A.Prajwalita

Abstract

The effect of the environmental factors, especially irradiance intensity (G) and temperature cannot be neglected in the present day multidimensional PV systems. Due to the varying nature of these factors, a modeling technique is required for the most suitable Maximum Power Point Tracking (MPPT) method under changing conditions. In addition to the inevitable environmental variations, the system parameters such as parasitic resistances also have an effect on the power extracted from a PV. Thispaper presents the modeling and simulation of the photovoltaic (PV) systems with the system parameter variations under uniform and partial shading and temperature variations.

I. INTRODUCTION

The PV system presents a non-linear P-V and I-V characteristic which is strongly dependent on the environmental conditions. The fluctuating nature of the irradiation and the temperature are the main factors which determine the output characteristic of the solar PV system. Thus in addition to a study of PV output characteristics under uniform conditions, a study in partial shading conditions is also essential. Further variations in the system parameters such as parasitic parallel and series resistances also affect the fill factor and in-turn affects the PV characteristics. A dependable model so developed will facilitate the further study of maximum power point tracking methods and dynamic performance of converters easier.

II. MODELING OF PV SYSTEM

A multidimensional PV system consists of a number of PV arrays, each of which is controlled by individual DC/DC converter. Each array is made of PV modules which in-turn are a combination of series and parallel connected solar cells. A solar cell is represented by two diode model of a solar cell, the current produced by which is given by [1]

$I = I_{ph} – I_{o1} (e^{qV/kT} – 1) – I_{o2} (e^{qV/2kT} – 1)$(1)

Where I_{ph} is the solar generated current, I_{o1} is the dark saturation current due to recombination in the quasi-neutral regions and I_{o2} is the dark saturation current due to recombination in the space-charge region. From a circuit perspective, it is apparentthat a solar cell can be modeled by an ideal current source I_{ph} in parallel with two diodes – one with an ideality factor of 1 and the other with an ideality factor of 2.

For simplicity a single diode model with diode ideality factor between 1 and 2 is considered for further modeling and simulations. The single diode model of a solar PV module is as given in Fig.1. Also parasitic resistances R_s and R_p as shown in Figure.1 depict the non-ideal conditions. [2]

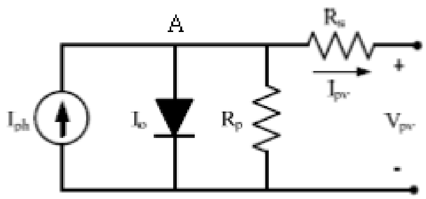

Figure 1. Equivalent circuit of a PV system

The modeling equations [2] can be derived usingKirchhoff's law on the node A

$$I_{pv} = I_{ph} - I_o \qquad (2)$$

where I_o is the diode current, I_{pv} is the PV output current.

The solar generated current I_{ph} is affected by solar irradiance and temperature and given by

$$I_{ph}(G) = (I_{sc} + K_i T_{dif}) \frac{G}{G_r} \qquad (3)$$

where K_i is the temperature coefficient, T_{dif} is the deviation of the operating temperature from the reference temperature ($T_k - T_r$) and G and G_r are the operating and reference irradiances respectively. Thus we see the strong dependence of solar generated current on ambient temperature and solar irradiance.The diode current with a saturation current, I_{o1} is given by the Schockley Equation as

$$I_o = I_{o1}\left[\exp\left(\frac{q(V_{pv} + I_{pv}R_s)}{AK_b T_k}\right) - 1\right] \qquad (4)$$

where I_{o1} varies in accordance with temperature and is given as

$$I_{o1} = I_{rs}\left(\frac{T_k}{T_r}\right)^3 \exp\left[\frac{qE_{go}}{AK_b}\left(\frac{T_{dif}}{T_r T_k}\right)\right] \qquad (5)$$

where Ego refers to the band gap energy of Si semiconductor (between 1.1 and 1.2 eV).

Considering the effect of the series and parallel resistances, R_s and R_p , the PV cell's output current is written as

$$I_{pv} = I_{ph} - I_{o1}\left[\exp\left(\frac{q(V_{pv} + I_{pv}R_s)}{AKT_k}\right) - 1\right] - \frac{(V_{pv} + I_{pv}R_s)}{R_p} \qquad (6)$$

The overall capability of the PV system should be enhanced by connecting the cells either in series or in parallel, in which case, all the cells in the PV module, Ns being their given number, would contribute to the output power. The output of the module is given as

$$I_{pv} = I_{ph} - I_{o1}\left[\exp\left(\frac{q(V_{pv} + I_{pv}R_s)}{N_s AKT_k}\right) - 1\right] - \frac{(V_{pv} + I_{pv}R_s N_s)}{R_p N_s} \qquad (7)$$

Since I_{pv} exists on both side of the equation, Newton's Method is used to successively update the I_{pv} with changing conditions.The equations (2)-(7) are used to model a PV array consisting of 2 modules each made of 36 solar cells, to obtain the I-V (P-V) characteristics of the PV array using MATLAB™ as a tool.

The I-V curve of a PV system describes its energy conversion capability at a given irradiance and temperature conditions. It represents the combinations of current and voltage at which the system can be operated, if irradiance and temperature are considered to be constant.The span of the I-V curve ranges from the short circuit current (Isc) at zero volts, to zero current at the open circuit voltage (Voc). At the 'knee' of a normal I-V curve is the maximum power point (Imp, Vmp), the point at which the array generates maximum electrical power.

At voltages well below V_{mp}, the flow of solar-generated electrical charge to the external load is relatively independent of output voltage. Near the knee of the curve, this behavior starts to change. As the voltage increases further, an increasing percentage of the charges recombine within the solar cells rather than flowing out through the load. At Voc, all of the charges recombine internally. The point Pmax is the maximum power point. Fig.2 shows a typical I-V (or P-V) curve.[3]

The fill factor(FF) of a PV module or string is an important performance indicator. It is defined as the ratio of two areas defined by the I-V curve, as shown in Fig. 3. [3]

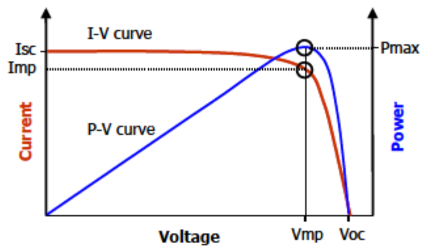

Figure 2.The I-V and P-V curve of the typical PV device.

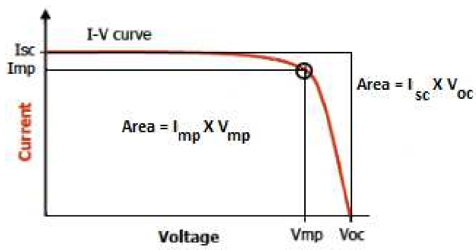

Figure 3. Fill Factor (FF) , defined as (Imp X Vmp)/(Isc X Voc)

The fig. (4) shows the output characteristics of a PV module as per Table.1.

Table 1. PV module specifications

Pmax= 55.03 W	**FF = 0.767**
Vmp = 17.97 V	G = 1000 W/m^2
Isc = 3.301 A	Ta = 298 K
Voc = 21.71 V	No. of cells = 36
Imp = 3.062 A	

Physically it means that for 2 PV modules with same Isc and Voc, the module with the higher fill factor will produce more power. An ideal PV module will have a fill factor of 1, which is physically unrealizable.Any effect that reduces the fill factor willreduce

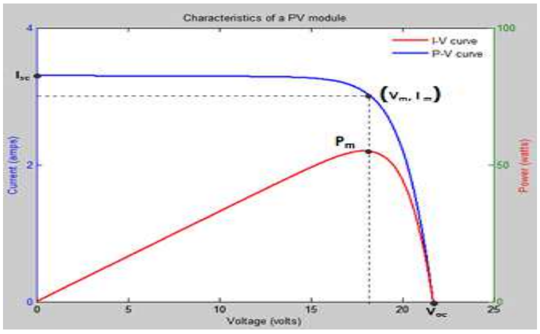

Figure 4. I-V and P-V characteristics of a PV module consisting of 36 series connected solar cells

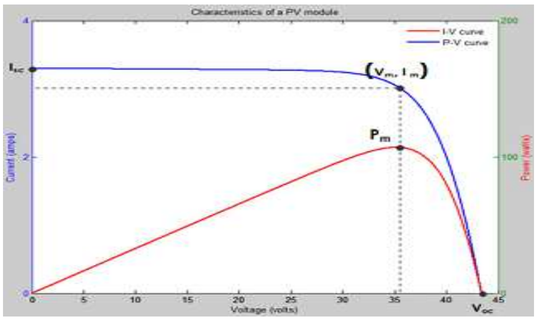

Figure 5. I-V and P-V characteristics of a PV module consisting of 2 modules

III. DEVIATION FROM THE IDEAL CHARACTERISTICS

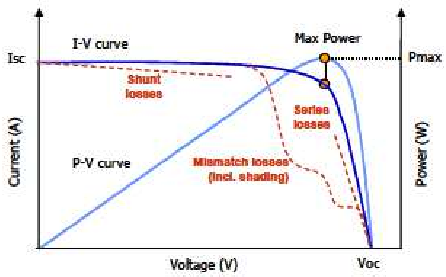

Figure 6.Losses that reduce the PV output

the output power by reducing I_{mp} or V_{mp} or both. The effects of series losses shunt losses and mismatch losses are as shown in Fig.3. Partial shading belongs to the mismatch category.[3]The deviations in I-V curve from the expected can be categorized as

i. The measured I-V curve with higher or lower current than predicted

Research Article **ISSN: 2319-507X**
Prajwalita A, IJPRET, 2013; Volume 1(8): 109-116 **IJPRET**

ii. The I-V curve with higher or lower Voc value than predicted.

iii. The slope of the I-V curve near Isc does not match the prediction. iv. The slope of the I-V curve near Voc does not match the prediction. v. The I-V curve with notches or steps.

The deviation (i) is a direct consequence of changing irradiation or degradation of the PV modules over time.(ii) is caused by the cell temperature variations and complete shading of few cells. Fig (7)-(8) depict the effect of the solar insolation and temperature on the output characteristics.(iii) and (iv) are mainly due to the shunt resistances and series resistances. These resistances are due to the existence of shunt paths, excessive wiring and interconnect resistances and mainly due to module I_{sc} mismatch. Fig. (9)-(10) depict the effect of the parasitic resistances on the output characteristics.(v)from the ideal characteristics is the major contributor to the reduction in power output from the module. The potential causes for

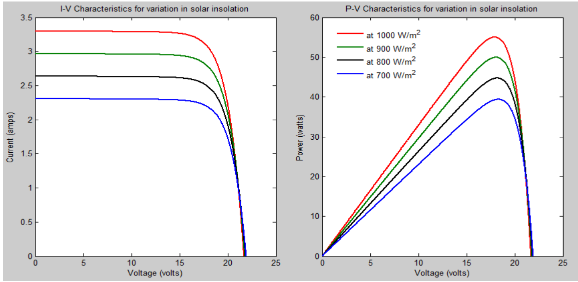

Figure 7. I-V and P-V characteristics of a PV module for variation in solar irradiance

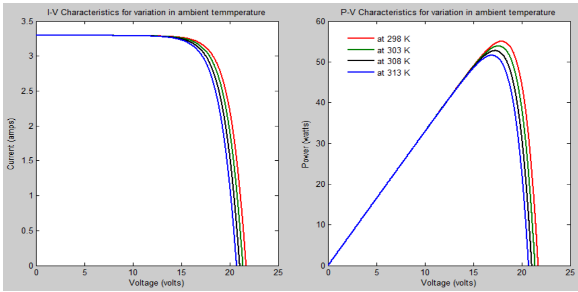

Figure 8. I-V and P-V characteristics of a PV for variation in ambient temperature

This deviation are partially shaded array damaged PV cells and short-circuited bypass diode. Bypass diodes are present to prevent a section of the cells from going into reverse bias and causing hotspot failures. Fig. 11 shows the I-V and P-V characteristics for the partial shading condition. Of the 36 series connected cells, 18 are illuminated with a solar insolation of 1000 W/m^2 and the rest at 800 W/m^2. This effect causes notches in the I-V and P-V curve with a significant reduction in the power output.

IV. SIMULATION RESULTS

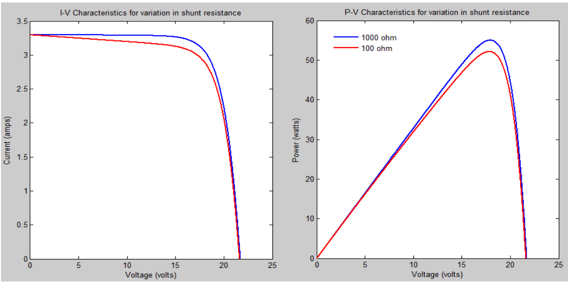

Figure 9. I-V and P-V characteristics of a PV module for variation in shunt resistance

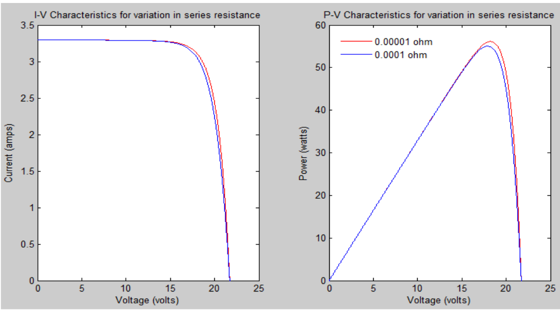

Figure 10. I-V and P-V characteristics of a PV module for variation in series resistance

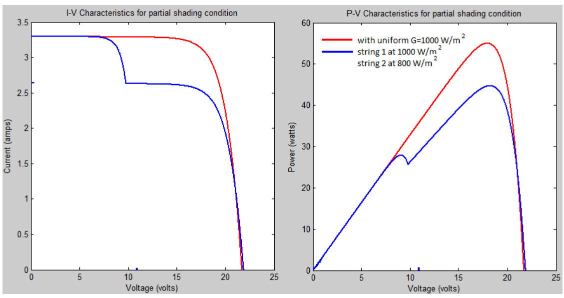

Figure11. I-V and P-V characteristics for partial shading condition

Fig (4)-(5),(7)-(11) show the simulation results for the PV system modeled as per the specifications given in table.1 using the modeling equations described in section II for variations in the parameters such as series and shunt resistance, solar irradiation and ambient temperature.

V. CONCLUSION

From the simulations, we see the effect of the parameter variations on the ideal PV output characteristics match with those described theoretically in Fig. 6. Further improvement in this work aims at study of suitable maximum power point tracking methods and dynamic performance of converters to enhance the energy harvesting capability.

References

1. Antonio Luque; Steven Hegedus;, "Handbook of Photovoltaic Science and Engineering," 2nded., ISBN 978-0-470-72169-8

2. Adriana Trejos; Daniel Gonzalez; Carlos Andres Ramos-Paja; , "Analytical Modeling of Partially Shaded Photovoltaic Systems,"

energies, 2013 , January 2013 ; doi:10.3390/en601028

3. Guide To Interpreting I-V Curve Measurements of PV Arrays

4. El Ouariachi, M.; Mrabti, T.; Tidhaf, B.; Kassmi, Ka.; Kassmi. K. Regulation of the electric power provided by the panels of the photovoltaic systems. Int. J. Phys. Sci. 2009, 4, 294–309.