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Modeling and Simulation of PV Arrays under PSC (Partial Shading Conditions)

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Abstract

In our environment so many harmful gases emit from plant such as thermal power plant these harmful gases are gave the harmful impact on our environmental conditions such as temperature increases acid rains etc. So here we introduced the renewable energy sources use for generating electricity such as solar wind etc. In that paper shows the modelling of PV cell and introduce new maximum power tracking point algorithm that algorithm based on mathematical calculation for detecting the maximum power point MATLAB based CAD package platform has been used for analysis PV array cell performance.

Keywords: PV module, modelling and simulation of PV array and MATLAB based CAD package, solar radiation, partial shading.

1. Introduction

In the new millennium the renewable resources is the most important part which help to increase the power generation safely. The renewable resources uses helps to reduces harmful emission gases like green house gases and reduces the value of fossil fuels In other hand deregulation of electric utility industry and giving chance for high penetration and uses distributed resources. The demand of the costumers is high so it is not possible due to one solar plant. The distributed generation system is played a vital role to fulfil the consumer demand, here distributed generation system two or more power generation plant are interconnected at one power grid that is also called distributed genco. In that paper the modelling of PV system is shown and checks the performance of the PV cell by testing cell on MATLAB platform. The photovoltaic panel is absorbed solar radiation is not converted into electricity but contribute to peak up the temperature of the module, Thus it reducing the electrical efficiency[2][4]. Basically that PV system is generated electricity from sun light. In the function of the PV system is that firstly the sun light in converted in to an DC electricity which stored in a high voltage DC battery then DC power has been converted by using the inverter circuit that is the conversion is called DC to AC. That modelling of PV cell is based on Shockley diode equation and the result on the basic of MATLAB platform.

The most important two major problems in PV generation system is the conversion efficiency of about 9 to 12 % in low radiation condition. The most amount of power generation in PV system continuously changes along with environmental conditions there for research is been carried out for the increase the efficiency of energy produced from PV solar cell System so here introduced the maximum power tracking point of the PV cell which increase the output of the PV system in a solar cell VI characteristic is varies along with temperature and radiation. One unique point in VI characteristic of PV cell that power voltage curve is called the maximum power point this point is said to be operated at maximum efficiency and generate maximum power output. The location of maximum power point can be finding by the help of maximum power point method.[11]

The troubles are compounded by the effect of fractional shading. If PV system consists of a many number of PV panels, it is very hard to make sure that all panels are subjected to the same level of insolation. Dissimilar panels due to factor such as dust, clouds, trees, etc. will in carry out be subjected to different amounts of insolation [10]. This is known as partial shading and can give rise to complex I-V and P-V characteristics such as multiplicity of power peaks as shown in Fig.[4],[3] .

Nomenclature

q Electronic charge $= 1.6021765 \times 10^{-19}$ (C)

k Boltzmann's constant $1.3806503x10^{-23}$ (JK^{-1}).

ΔT Change in temperature (^{o}C).

G Insolation level (W/m^2).

G_o Standard insolation levelof 1000 (W/m^2).

STC Standard test conditions at $25\ ^{o}C$.

K_I Short-circuit current coefficient (A/C^{o})

K_V Open-circuit voltage coefficient (V/C^{o})

R_p Shunt resistance of a PV cell (Ω)

R_S Series resistance of a PV cell (Ω)

a_n Ideality factor of the n[th] diode.

I_{Sn} Saturation current of diode n (A).

I_{mp} Current at maximum power point.

I_{PV} Photovoltaic generated current (A).

I_{sc} Short-circuit current (A).

V_{mp} Voltage at the maximum power point.

V_{oc} Open-circuit voltage (V).

V_{Tn} Thermal coefficient of the n[th]diode kTq^{-1} (V)

P_{mp} Maximum power developed (W).

1.1 PV Generator

PV Generator is a combination of solar cell connection protective part. In modeling the main attracting point is only cell, module, and array. Solar PV cell basically consist of P-N junction is made-up with a thin wafer solution along with layer of silicon semiconductor material. In the V-I characteristic of solar PV cell has shown that the exponential growth which similar to a diode. (Solar energy) photon strikes the solar cell when energy larger than the energy band gap of semi-conductor. In the material Atom electrons are emits and create electron hole. These electrons are carried under the P-N junction internal electric field and create current which parallel to the incident radiation. In case the cell is short circuited this current carried out in the external circuit when the case is open circuited that current is internally shunted by intrinsic p-n junction diode.

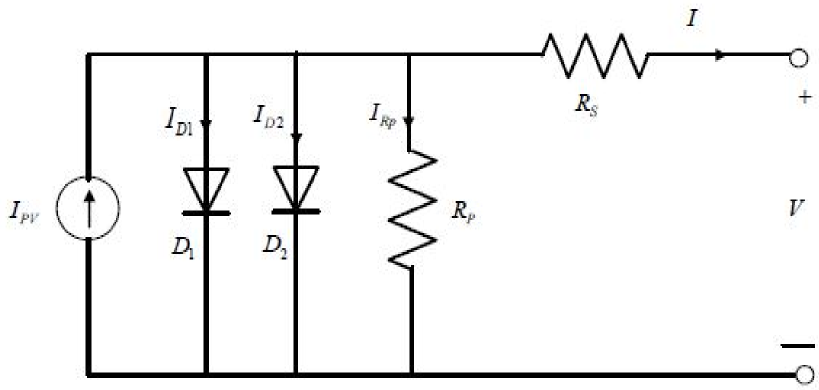

Fig. 1: .A two-diode PV cell model.

2. Proposed Model for PV Solar Cell

A single-diode model is shown in Fig. 3 whose output current equation is

$$I = I_{PV} - I_s\left(\left[e^{\frac{q(V+IRs)}{aV_T}}\right] - 1\right) - \left[\frac{V + IR_s}{R_p}\right] \tag{1}$$

where *IPV* is the generated photovoltaic current, I_s and a are the reverse-saturation current and the ideality factor of the diode respectively, whilst V_T is the thermal equivalent voltage defined in terms of the Boltzmann's constant k , the temperature T (K) and the electronic charge as $V_T = kT / q$ and is approximately equal to 25 mV at room temperature. The resistors *RS* and *RP* are the series and parallel resistances, respectively. Earlier work on partial shading using only one diode and the single series resistance model were ineffective in large PV arrays at low insolation levels i.e. when the effects of recombination becomes important. For this reason, the two diode model, Fig. 4, becomes more appropriate. In this model, the second diode accounts for the low insolation, whilst the parallel resistor accounts for the effects on the open-circuit voltage at higher temperatures. The equation of the output current for the two-diode is[1]

$$I = I_{PV} - I_{S1}\left[\exp\left(\frac{V + IR_s}{a_1 V_{T1}}\right) - 1\right] - I_{s2}\left[\exp\left(\frac{V + IR_s}{a_2 V_{T2}}\right) - 1\right] - \left(\frac{V + IR_s}{R_p}\right) \quad (2)$$

Where I_{S1}, I_{S2} are the saturation currents, a_1, a_2 are the ideality factors; V_{T1} , V_{T2} are the thermal voltages of diodes $D1$, and $D2$, respectively. The photovoltaic current I_{PV} at a given temperature and irradiance is

$$I_{PV} = \left(I_{PV(STC)} + K_I \Delta T\right) * \left(\frac{G}{G_o}\right) \quad (3)$$

Where $I_{PV(STC)}$ is the photovoltaic current at the standard test conditions i.e. $G = G_0$, K_1 is short-circuit current coefficient, ΔT is the change in temperature in Kelvin, G is the surface irradiance of cell and $G_0 = 1000\, W/m^2$ is standard irradiance.

$I_{PV(STC)}$ Proposed in [9] is

$$I_{PV(STC)} = \left(\frac{R_p + R_S}{R_P}\right) I_{SC(STC)} \quad (4)$$

The open-circuit voltage as a function of temperature

$$V_{oc} = \left(V_{OC(STC)} + K_V \Delta T\right) \quad (5)$$

$V_{OC(STC)}$ Is the open-circuit voltage at STC and Kv is the voltage coefficient of open-circuit. The improved current reverse saturation equation at given temperature, proposed by [21] is

$$I_s = (I_{PV} - \frac{V_{OC}}{R_P}) / \left[\exp\left(\frac{V_{OC}}{aV_T}\right) - 1\right] \quad (6)$$

For the two-diode model, I_{S2} is taken to be 1 to10 times I_{S1} and for generality they are set aside equal in the following equation

$$I_{S1} = I_{s2} = [I_{PV} - (V_{OC} / R_P)] / \left[\exp\left(\frac{V_{OC}}{a_2 V_{T1}}\right) + \exp\left(\frac{V_{OC}}{a_1 V_{T2}}\right) - 2\right] \quad (7)$$

The resistors R_S and R_P are obtained using logical technique describe in [7] which matches the Maximum power point $P_{mp} = V_{mp} I_{mp}$ unique to the R_S and R_P combination. The values of a_1 and a_2 can be randomly chosen to fit the curve and in this paper $a_1 = 1.2$, and a_2 can be selected with a appropriate value to fit the curve. In the above equations, $V_{OC(STC)}$, $I_{SC(STC)}$, V_{mp}, I_{mp}, K_v and K_1 are generally found in manufacturers' datasheets.

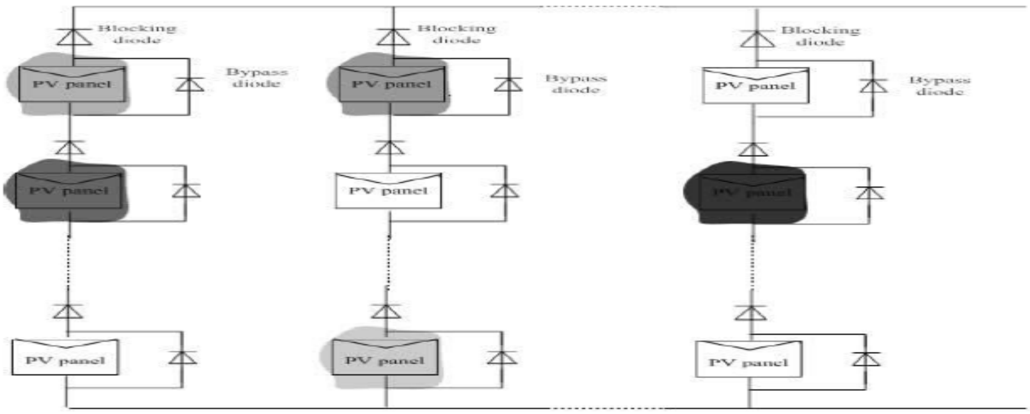

Fig. 2: The insolation can be specified for each individual module as depicted.

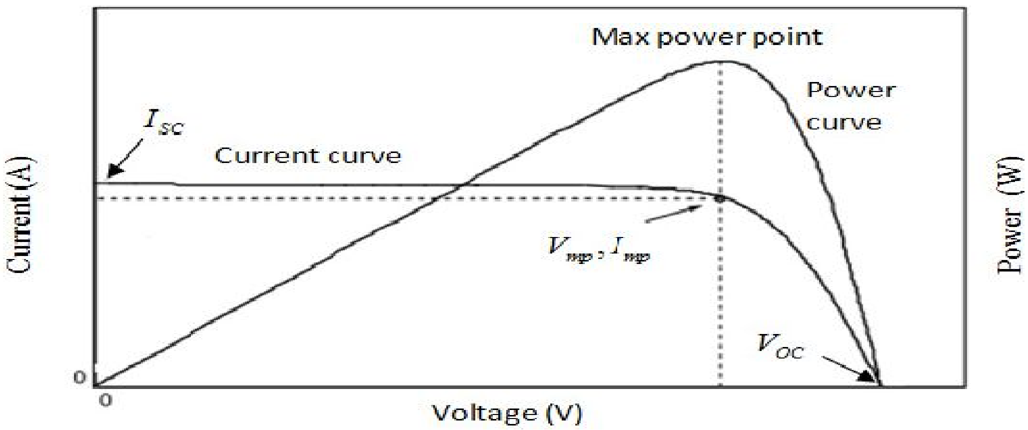

Fig. 3: A typical current-voltage I-V curve for a PV cell.

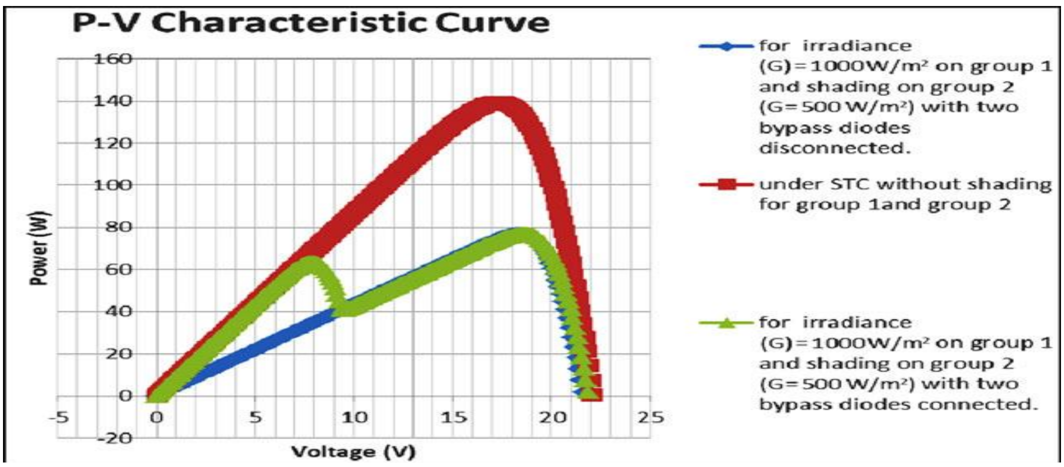

Fig. 4: A typical P-V characteristic curve for different cases.

3. Result and Discussion

MATLAB based computer aided design package with graphic is used in this paper to simulate PV array module for different level of shading. The performance of PV array module is shown in V-I characteristic and P-V characteristic shown in figure. The package allows the user to specify the type of the PV model example MSX 60 [12]. In series the no. module and the no. of parallel path also specified as per module. That is more realistic than the previous approach where the complete parallel path under the same level of shading. Now, the temperature of each module is also can be specified. In that paper the package is used to simulate the operation that is MSX 60 module that will be arrange in 45 parallel paths along with 10 unit in series and the result V-I and P-V characteristic of P-V array module shown in Fig. 4.

4. Conclusion

Matlab package with the graphical interface along with computer aided design which help to analysis of pv array module has developed, it is used to examine the performance by the effect of partial shading for the commercial use of pv module and result identify from the modeling and simulation from data sheet of manufactures.

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