Simple Methode of Modeling and Search of Global Power Peak Under Mismatching Conditions on PV Array

Saad saoud M,Abbassi HA,Kermiche S
Department of electronic
Laboratory of Automatic and Signal
Annaba, Algeria
maro34ss@gmail.com, maro34ss@gmail.com
mskermiche@yahoo.fr

Ouada M
Department of Electromechanical
Badji Mokhtar Annaba university
Annaba, Algeria
ouadamehdi@gmail.com

***Abstract*— Conventional popular maximum power point tracking (MPPT) methods are effective under uniform solar irradiance. However, the main contribution of this paper is algorithm to track the global maximum GP under solar irradiance mismatching conditions or partially shaded conditions (PSCs), because this algorithm is more practical and the multiple local maxima can be exhibited on the power-voltage characteristic curve, where the photovoltaic characteristics get more complex with more than one peaks. The algorithm proposed is simple and can be computed very rapidly, Matlab / Simulink is employed for simulation studies.**

Keywords-component; (MPPT) methods; global maximum GP; shaded conditions; photovoltaic.

I. Introduction

The renewable energies especially photovoltaic technology (PV) represents an alternative by excellence and it is increasingly used in today. This type of energy is not only free and inexhaustible, but also cleans the environment. Moreover, we often speak of a "green energy", as totally avoids the pollution produced by traditional sources.

Photovoltaic (PV) is a method of generating electrical power by converting solar radiation into direct current electricity using semiconductors that exhibit the photovoltaic effect.

The functioning of a photovoltaic array is impacted by temperature, solar irradiance, shading, and array configuration. Frequently, the PV arrays get shadowed, wholly or partially. When the array is operated under partially shaded condition, the P-V characteristic becomes more complex with multiple maximum power points (MPP), mentioned above, can fail to track the absolute MPP. To overcome this problem, more complex algorithms have been developed [1]-[2].

Because of the partial shading conditions (PSC) occur quite common due to clouds, trees, or buildings, it is necessary to develop special MPPT schemes that can track the real MPP under PSC.

In spite of some researchers have worked on real MPP tracking under partial shading conditions [3]-[4], the methods have some drawbacks with complexity of method, tracking failure according to the real MPP position, and difficulties on the application to the installed power conditioning system, etc.

This paper proposes a novel algorithm to track the global power peak under partially shaded conditions. Based on an extensive study of partially shaded PV arrays.

The simulation results are presented to verify the performance of proposed algorithm.

II. PV Array Characteristics Under Uniform Conditions.

The solar cell can be represented by the electrical model shown in" Figure 1". Its current voltage characteristic is expressed by the following equation (1):

$$I = I_{Ph} - I_{d1} - I_{d2} - I_{sh} \qquad (1)$$

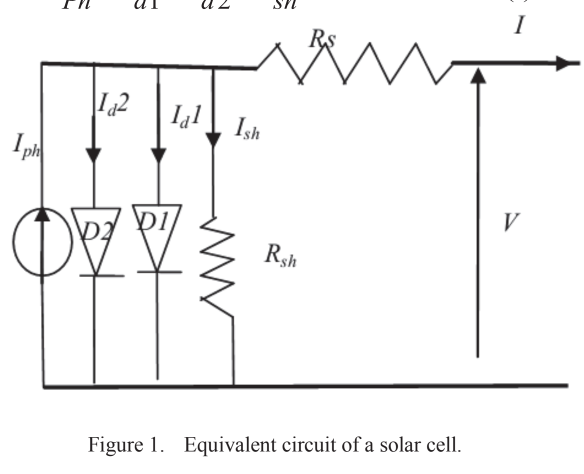

Figure 1. Equivalent circuit of a solar cell.

Where I and V are the solar cell output current and voltage respectively, , *Iph* represents the photovoltaic current , q is the charge of an electron, N is the diode quality (ideality) factor, k is the Boltzmann constant, and Rs and *Rsh* are the series. and shunt resistances of the solar cell. *Id1, Id2*, are the currents of diode 1 and diode 2, Ish is the shunt résistance current.

When the photocurrent equal:

$$I_{Ph} = (I_{Ph,n} + K_I \Delta T)\frac{G}{G_n} \qquad (2)$$

ΔT =T−Tn (being T and Tn the actual and nominal temperatures [K]), *G* [W/m^2] is the irradiation on the device surface, and *Gn* is the nominal irradiation.

And currents diodes are:

$$I_{d1} = I_{01}[\exp(\frac{V + IR_s}{a_1 V_{T1}}) - 1] \qquad (3)$$

$$I_{d2} = I_{02}[\exp(\frac{V + IR_s}{a_2 V_{T2}}) - 1] \qquad (4)$$

Where I01 and I02 are the reverse saturation currents of diode 1 and diode 2, VT_1 and VT_2 are the thermal voltages of respective diodes. a_1 and a_2 represent the diode ideality constants.

$$I_{01} = I_{02} = \frac{(I_{sc\_n} + K_I \Delta T)}{\exp[(V_{oc,n} + K_V \Delta T)/V_T] - 1} \qquad (5)$$

Isc: short circuit current [A].
Ki: cell's short-circuit current temperature coefficient.
Voc ; open circuit voltage .
A : ideal factor.
Shunt current equal:

$$I_{sh} = \frac{V + R_s I}{R_{sh}} \qquad (6)$$

With Vm is module voltage and Ns is number of cell in series.

The PV array used in this paper is a combination of 3 series of KC200GT modules. Series combination of modules was chosen to obtain higher output voltage of PV module. The KC200GT module itself is composed of 54 silicon cells connected in series. Each module can generate current up to 8.21 A and a voltage of 32.9 volts "Figure 2" in standard condition .and give rise to the maximum power of 200 W peak at standard testing conditions (25 °C, 1000W/m² and AM=1.5)"Figure 3".

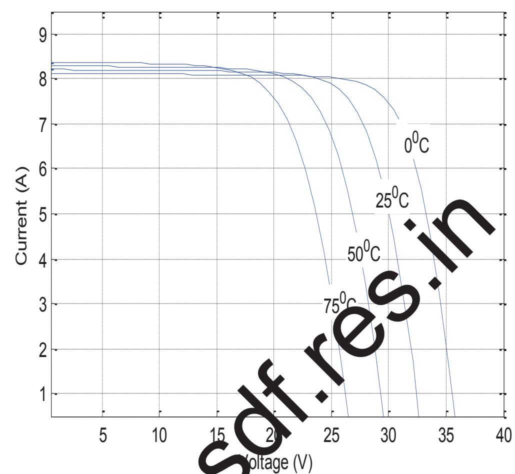

Figure 2. KC200GT module I-V curve at various temperatures.

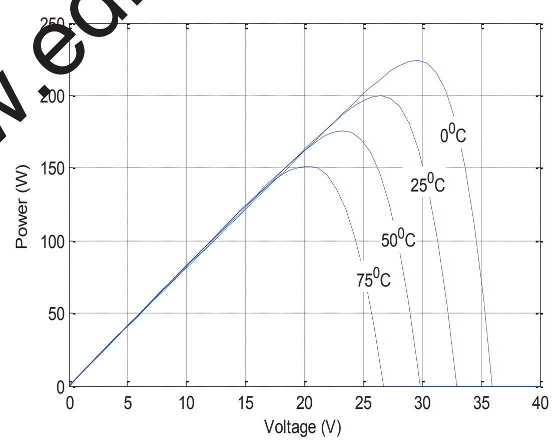

Figure 3. KC200GT module P-V curve at various temperatures.

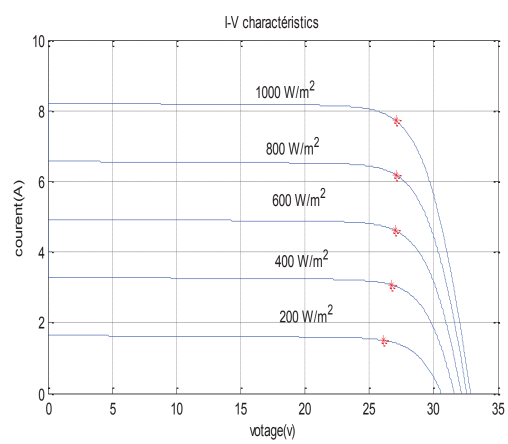

Figure 4. KC200GT module I-V curve at various insolations.

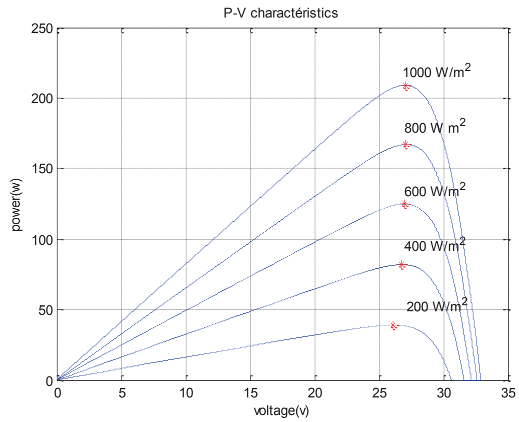

Figure 5. KC200GT module P-V curve at various insolations.

If three panels connected in series with uniform insolation have been considered, the MPP value is p=600 w.

III. PV ARRAY CHARACTERISTICS UNDER PARTIAL SHADING CONDITIONS

The considerable advantage of modeling and simulation method in this research is to cover different scales of a PV system under both normal and partial shading conditions, without analyzing the in-depth semiconductor physics definitions [5].

There are times where some part of the PV arrays might be shaded by heavy cloud, trees or nearby buildings [6, 7].The P–V characteristic of the PV array exhibits multiple local maxima and only one of them corresponds to the global MPP.

If there is one shaded panel in a series connected array, it can then act as a load to the array. The shaded PV cells absorb a large amount of electric power generated by other PV cells that receive high illumination and convert it into heat. This situation is called the hot-spot problem. This is often resolved with the inclusion of a bypass diode to a specific number of cells in the series circuit [8].

The bypass diodes are connected in anti-parallel with each panel, and, in case of the panel being shaded current flows through the bypass diode rather than through the panel [9].

For this study, three panels connected in series with non-uniform insolation have been considered. The same concept can be extended to a number of panels connected in series.

"Figure 6". Shows that the series connection of three panels with 3 bypasses diodes.

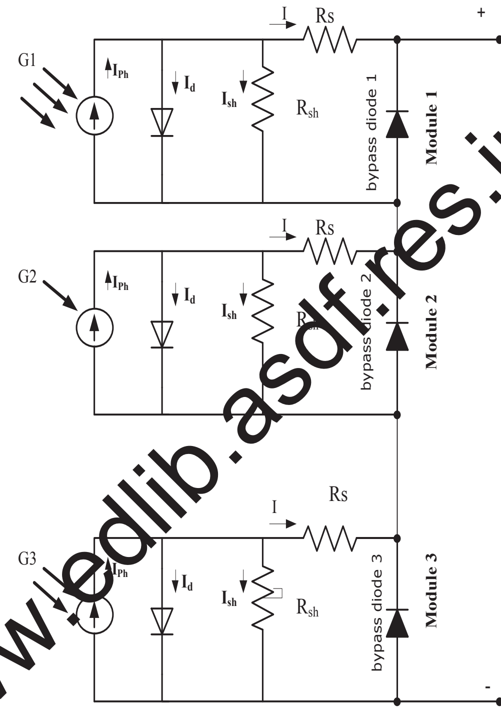

Figure 6. Schematic of 3 Series modules with bypass diodes.

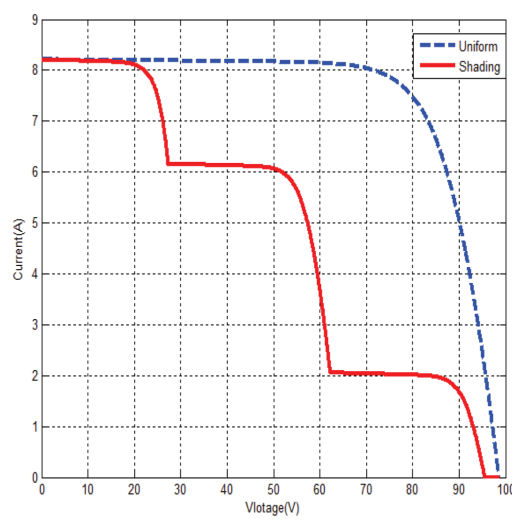

Figure 7. The resulting simulation I–V curve

The inserted bypass diodes may cause multiple peaks are established in the I-V and P-V characteristic curves under partial shaded conditions as shown "Figure 8" and "Figure 9" [6, 10-11]

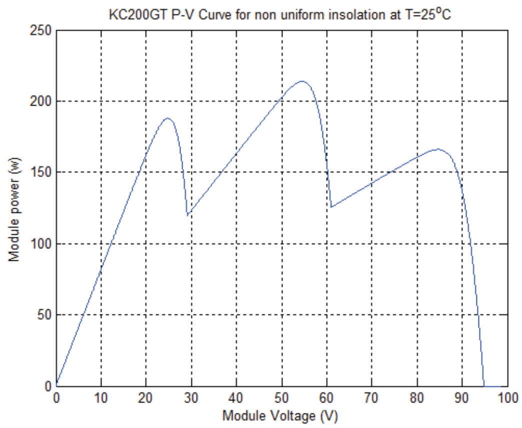

Figure 8. The resulting simulation P–V curve at shading conditions..

IV. PROPOSED GLOBAL MAXIMUM TRACKING ALGORITHM

Few researchers [12]–[13] have worked on GP tracking schemes for PV arrays operating under non uniform insolation conditions. Miyatake et al. [13] have reported an MPPT scheme that uses Fibonacci sequence to track the GP under partially shaded conditions. In [14] a review on the state-of-the-art maximum power point tracking (MPPT) techniques existing is presenting by Kashif et al. But in [15] authors said that the "Power Curve Slope" MPPT method is effective under shading conditions. In this technique, the sign of ∂P/∂V at different points is used to track the global maximum, the change of ∂P/∂V sign from negative to positive indicates the existence of another maximum on the right side of the existing one [16]. If a local maximum is found, as indicated by the change of the sign of ∂P/∂V, it is compared with the stored maximum. If the detected local maximum is greater than the stored maximum, the stored maximum will be updated.

Authors in [17] give Comparison between conventional methods and GA approach for maximum power point tracking of shaded solar PV generators.

The presence of multiple peak reduces the effectiveness of the existing MPP tracking (MPPT) schemes. There is a need to develop special algorithm that can track the GP under these conditions. This paper proposes a simple algorithm that can give this operation.

Where the principal idea for this algorithm that track the power local maximum peaks by the tracking of current and voltage (P=V*I) and compared it to detected the global peak power. In another hand this algorithm has the advantage of a very quick and it is able to eliminate the store of values (V and I), that is to say this algorithm not needs data base measures. The stapes of proposed algorithm as shown in the flowchart "Figure 9"

.The proposed MPPT does not present any complexity compared to the classical ones.

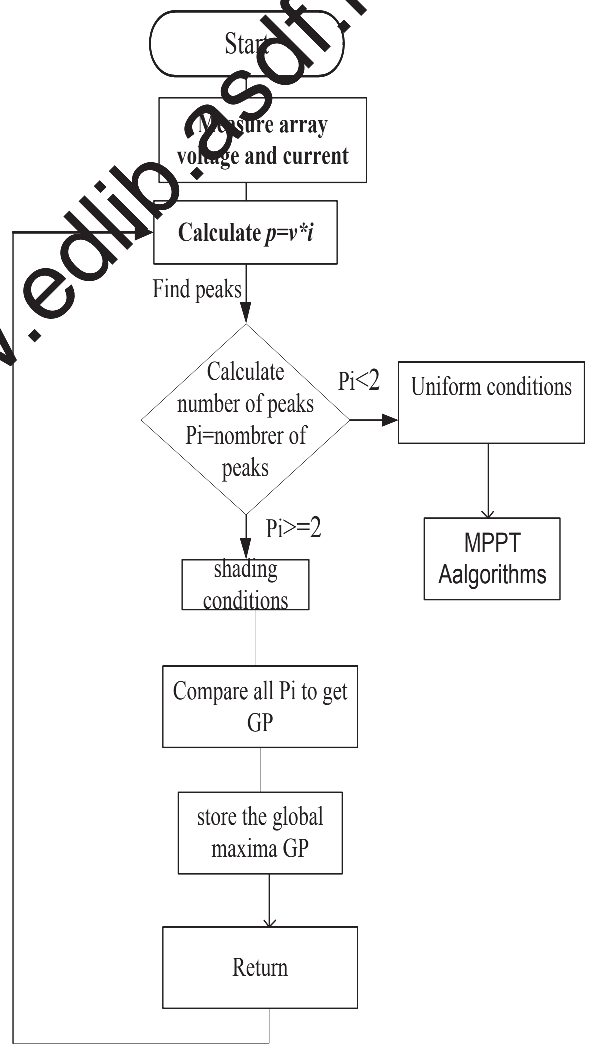

Figure 9. Flowchart for the proposed algorithm.

V. RESULTS AND DISCUSSION

This section presents the simulation results with the proposed algorithm, the first step of this study is aimed to simulate the characteristics of three panels KC200GT connected in series response during the partially shaded where we chose the parameters of test :

The first group under uniform insolation G1= 1000 w/m^2, the second group is shaded by G2=250 w/m^2 and the third group is shaded by G3=500 w/m^2

. When the first group current becomes greater than second and third groups current, the shaded modules absorbs energy. To solve this problem, a bypass diode, connected in parallel to every group.

The second step is tracking of the maximum global power where it is based on two phases:

The first to find the locals peaks, the system scans the power values periodically to find all peaks, shown in "Figure 10".

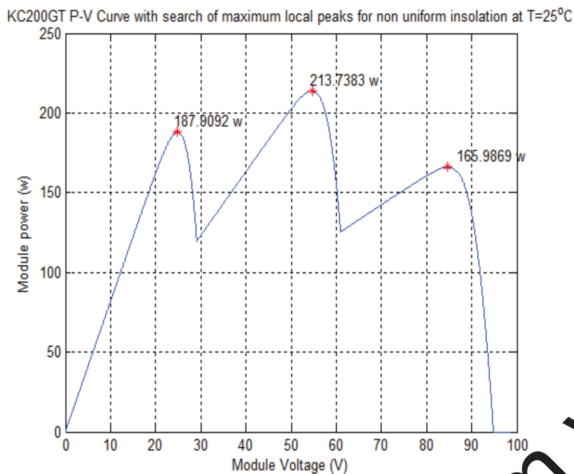

Figure 10. Search of maximum local peaks.

The second phase with the comparison process the algorithm gives the maximum global peaks which is the maximum power point, shown in "Figure 11".

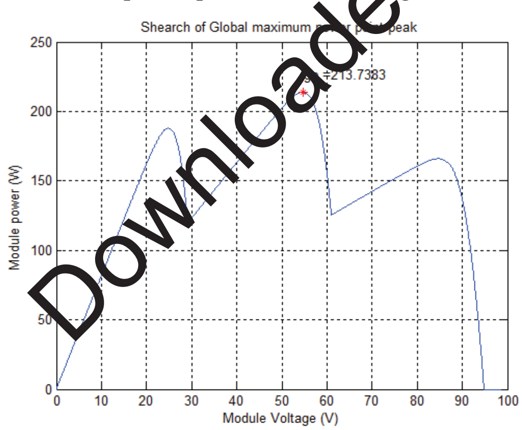

Figure 11. Search of maximum global peak power.

VI. CONCLUSION

In this paper, a novel and simple approach for tracking a global maximum power under phenomena of partial shadings is proposed and a simulation of uniform insolation and shading effects in PV arrays has been done.

The results acquired during the simulations it indicate that the response of proposed algorithm is perform with influence of this conditions and it is capable to track the MPP with simplicity ,fast response, and high precision.

The following conclusions emerge from this study:

1) The hot-spot is a problem caused where the shaded PV cells absorb the electric power generated by other PV cells with uniform insolation and convert it into heat.

2) The shaded panels should be bypassed by a diode bypass when they are in series connection.

3) The presence of multiple peaks is a need to develop special algorithm that can track the GP under shading conditions.

Number of peaks power = number of shaded panels +1.

5) Power result by PV cells under shading conditions is very small with PV cells are under uniform insolation.

The authors intend to validate the results with all types of DC- DC converters and to implement them on DSP for experimental validation.

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