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NEW MPPT METHOD FOR DUAL AXIAL PHOTOVOLTAIC SYSTEMS USING GENETIC ALGORITHM UNDER PARTIALLY SHADED CONDITIONS

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Saeed Parsafar
Department of Electrical Engineering,
Naein Branch, Islamic Azad University,
Naein, Iran

Mehdi Mahdavian
Department of Electrical Engineering,
Naein Branch, Islamic Azad University,
Naein, Iran

Abstract: By regarding the high cost of photovoltaic systems, utilizing the maximum efficiency of these power sources is a fundamental and undeniable necessity. Photovoltaic systems rarely work at the maximum power point, because the output power of the cell is strongly influenced by the two factors of radiation and ambient temperature. Therefore, peak power tracking (MPPT) plays a key role in increasing the efficiency of these systems. By considering the importance of this issue, in this paper a new MPPT method has been presented for dual axial photovoltaic systems. The occurrence of partially shaded conditions for photovoltaic systems is one of challenges of the proposed MPPT approach. Partially shaded conditions reduce the energy obtained from photovoltaic systems and the occurrence of several peak points in their voltage characteristics. In this paper, using a multi-objective genetic algorithm (genetic algorithm with non-dominated sorting), we seek to optimize the proposed target function. This objective function includes maximizing the power output of photovoltaic units in different conditions, including partially shaded conditions and minimizing losses with the presence of these units in the network.

Keywords: solar energy, photovoltaic system, dual axial tracking, maximum power point tracking, genetic algorithm

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1- INTRODUCTION

1.1 Photovoltaic systems, Maximum power follower systems and partially shaded phenomena

In recent years, the use of new energies has grown dramatically due to the limitation and increase in the price of fossil fuels, as well as environmental issues. The sun's energy is the largest renewable energy source available on the planet, directly or indirectly. One of the big concerns of government is about the climate change which motivates them to find ways worldwide to supply new source of clean energy while minimizing environmental impacts. Any sort of these decisions regarding the investment in energy sectors, changing the infrastructure systems can have direct or indirect influences on the financial development of the country (Rezaie, 2017). It should be noted that these kind of decisions will change the level of financial and economic of a country, have direct influence on the quality of life of citizens of those countries, and it will influence their decisions regarding saving and consumption (Çiftçioğlu, 2015), (Almasifar, 2013). Using photovoltaic systems is one of ways to enjoy solar energy. Photovoltaic systems have many advantages and they are very useful.

The amount of electricity produced by photovoltaic systems in the world doubled every five years (Chen, 2014). Also, over the past two decades, the cost of building and installing a photovoltaic system has dropped by about 20%, and the production capacity of each installed unit has doubled (Mohapatra, 2017). As a result, the growth of these systems is expected to double.

Among these components, the MPPT system is of great importance. To express the performance of an MPPT system, see the flow-voltage curve of a solar panel in Fig. 1. As seen in this figure, for each point there is a voltage and a corresponding current on the curve, which is not necessarily the maximum current or maximum voltage. For example, at point E, the voltage has the maximum value, but the corresponding current is zero. Or for point B, the maximum current is not the corresponding voltage in the maximum value. In order to optimally use the energy generated by the photovoltaic panel, a point must be selected that has the maximum current and voltage. Getting the optimal point by the tracker is done at maximum power. For example, in Figure 1, point C is optimal, i.e. the point at which the maximum voltage and current can be generated (Florida Solar Energy Center). In Fig. 2, the output power is shown in terms of voltage for a photovoltaic panel. By comparing Figures 1 and 2, it is seen that at point C the maximum power is obtained, which the optimal point is. The Maximum Power tracker is actually a high-efficiency DC-DC converter, which adjusts its output voltage to an optimum value to get maximum power.

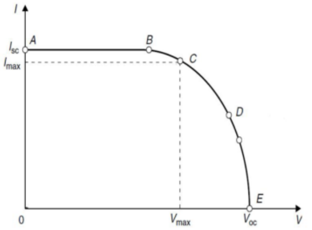


Figure 1: Current-Voltage Curve of a Solar Panel

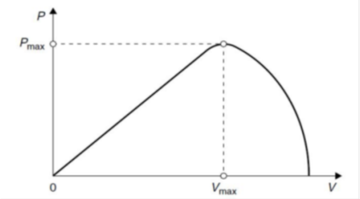


Figure 2: Power-voltage curve of a solar panel

In parts of the day, shadows from adjacent solar cells, trees, passing clouds, hills or surrounding buildings can affect the efficiency of any solar installation. Creating a shadow on a small part of the panel will disrupt the power of all panels. The aforementioned cases will cause the appearance of partially shaded conditions. The occurrence of this phenomenon will lead to losses in system output power, the effects of hot spots and safety and reliability problems.

1.2: Purpose and innovation of the article

Shading is a special issue in photovoltaic power generation systems. Because the full shadowing of a large area is unlikely, so a slight shadow condition is created. By partially shading of the cells of an array, there is a mismatch in the overall photovoltaic power generation system. The cells in shadow conditions significantly reduce the flow of the cell,, But not for output voltage. This mismatch is due to the power generated by the connection of the series of power generation systems. Meanwhile, the old MPPT algorithms are designed to work in just one radiation and do not have the proper performance in shadow conditions. As a result, the improvement and advancement of new and suitable MPPT techniques and techniques for application in partially shaded conditions is essential and inevitable. Considering the importance of the aforementioned materials, in this paper a new MPPT method for dual axial photovoltaic systems has been presented. In this paper, we seek to optimize the proposed target function using a multi-objective genetic algorithm (genetic algorithm with unshielded sorting).

1.3: Article configuration

In the remainder of this article, Part 2 presents the proposed method. For this purpose, the model of photovoltaic arrays is presented, and then the modeling of the partially shaded conditions is discussed. In the following, the proposed method is initiated by tracking the maximum power point in a partially shaded condition and ends with the genetic algorithm. In Section 3, results of the implementation of the proposed method are presented and then these results will be analyzed. In section 4, the conclusion will be presented with details.

2: PROPOSED METHOD

In this section, the model of the photovoltaic arrays and the output current of these units are presented first. In addition, while expressing the problem of partial shadow, its effect on the performance of solar cells and their production potential is examined. Then, the method of tracking the maximum power point will be provided under the shaded condition. Also, the objective function in this paper, which involves maximizing the power output of photovoltaic units and minimizing losses with the presence of these units in the network, is described. In addition, in order to model the uncertainty of the solar units, the probabilistic approach to estimating the point is also presented. Finally, in order to solve the optimization problem, the optimization algorithm used by the genetic algorithm is described with non-limiting sorting.

2.1: Presentation of photovoltaic array model

In order to evaluate the proposed MPPT method, a two-diode model (Chen, 2014) was used to model photovoltaic array profiles. The equivalent circuit of a two-diode model for a solar cell is shown in Figure. 3.

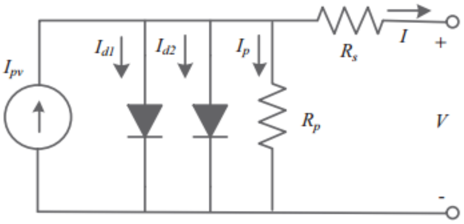


Figure 3: The equivalent circuit of a two-diode model .

Assuming that the photovoltaic array, including the N_{ss} photovoltaic module in series, and N_{pp}, are parallel to the photovoltaic field, the output current of the photovoltaic array will be calculated as shown in Equation 1 [18].

$$I = I_{pv}N_{pp}\left[\exp\left(\frac{V+\lambda IR_s}{a_1V_tN_{ss}}\right)-1\right]-I_{02}N_{pp}\left[\exp\left(\frac{V+\lambda IR_s}{a_2V_tN_{ss}}\right)-1\right]-\frac{V+\lambda IR_s}{\lambda R_p} \tag{1}$$

In which, I is the photovoltaic output current, V is the photovoltaic output voltage, $\lambda = N_{ss} / N_{pp}$, R_s and R_p, respectively, are series and parallel resistors, respectively. V_t , The thermal voltage of the two diode ($Vt = N_s kT / q$), N_s is the number of solar cells connected series in each photovoltaic module, k Boltzmann's constant, q, and a_1 and a_2 are the ideal diode constants. The optical flow is calculated from t Equation 2.

$$I_{pv} = \left(I_{pv\_STC} + K_i\left(T - T_{STC}\right)\right)\frac{G}{G_{STC}} \tag{2}$$

In which I_{pv_STC} produces an optical stream under the standard test conditions (STC) with $T_{STC} = 25^0C$ temperature and radiation intensity $G_{STC} = 1000W/m^2$. The constant K_i is the short circuit current coefficient. The diode reverse saturation current is obtained from the Equation 3.

$$I_{01} = I_{02} = \frac{I_{sc\_STC} + K_i\Delta T}{\exp\left(\frac{V_{\partial oc\_STC} + K_v\Delta T}{V_t}\right)-1} \tag{3}$$

In which, the constant K_v is the open circuit voltage coefficient, I_{pv_STC} short circuit current under standard conditions and V_{oc_STC} open circuit voltage under STC conditions. Indeed, relation (3) can be expressed as I = f (I, V). Nonlinear relation can be solved using standard Newton-Raphson method. The relationship between the current and the voltage of the bypass diode is as Equation 4.

$$V_b = -a_3 V_t \ln\left(1 + \frac{I_b}{I_{0b}}\right) \tag{4}$$

In which, I_b, I0b, V_b and a_3 respectively, the flow through the bypass diode, the saturation current, the bias diode voltage and the inertial current of the diode are biased. The photovoltaic modules used in this work are BP MSX 60; the specifications of the photovoltaic modules are presented in Table 1.

Table1. Photovoltaic Module Specifications

Max power (P_{max})	60 w	Short circuit current (ISC)	3.8 A
Optimize voltage (V_{mp})	1/17 v	The number of cells in the series (Ns)	36 v
Optimize current (I_{mp})	5/3 A	ISC temperature coefficient (° C)	0.003 A
Open circuit voltage (V_{oc})	1/21 v	Voc temperature coefficient (° C-degrees)	-0.08 v

2.2: Modeling of partially shaded condition

If a cell or a small part of a module is placed in the shadows, these cells will absorb power from other cells in place instead of taking part in generating power output. This absorbed power is converted to heat, and the presence of hot spots can damage the cells or cells. Most commercial modules use dual-layer diodes across a cell to overcome this effect. Therefore, the cells located in the shadows are bypassed and, consequently, only the output power of the cells located in the shadow is zero. To simplify the analysis and avoid confusion in partial shaded analysis, we consider a module for having only a single series with a bypass diode. Then, as shown in Figure 4, a more realistic business module can be considered as a series connection of two or more of these simple modules.

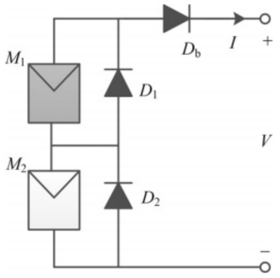


Figure 4 - A photovoltaic system with two photovoltaic modules, a shaded M1 module and a M2 receiver[7].

2.3: Tracking the maximum power point under partially shaded conditions

As shown in the previous section, to protect the photovoltaic panel from the hot spots caused by the active module as a load and power consumption, by-pass diodes are added to the photovoltaic modules. As shown in Fig. 4, in order to protect the photovoltaic panel, the bypass diodes (D_1 and D_2) have been added to the photovoltaic system by connecting them with photovoltaic modules. In addition, the Db diode is usually connected in series in the photovoltaic field to prevent reverse flow of load or flow of unbalanced flow from other parallel photovoltaic fields.

2.4: Configuration structure of proposed photovoltaic array

In this work, in order to show the system's performance, a photovoltaic system with two photovoltaic fields and three photovoltaic modules in each photovoltaic system is considered. Usually, there are two control modes to track the maximum power point: Distributed and focused control methods. The controlling means that the total photovoltaic array is controlled by a maximum power point tracking controller.

2.5: The improved method of tracking the maximum power point

Figure 5 shows flowchart of point tracking algorithm for tracking the maximum power point under of partially shaded conditions. As shown in the figure, the steps involved in implementing the proposed algorithm are as follows. 1) The implementation of the algorithm is always started with a reference voltage value (V_{ref}), which is set at 85% V_{OC} (block 1).

2) Meanwhile, it calculates the number of photovoltaic modules, N. Under uniform radiation conditions, there is only one peak in the voltage-voltage curve. Maximum power point tracking methods, such as the P & O tracking process, can work well. Therefore, when partially shading occurs, continuous operation of the P & O method keeps the operation at maximum power level (blocks 2 and 3).

3) When the maximum power point is found, the information of that point, including power and voltage, is stored (block 4).

4) To ensure regular checking, the timer interrupt status shadow status is used (block 5).

5- When the voltage of the photovoltaic module is larger at the same point than the other ($V_i > V_j$), it means that a partial shadow has occurred, When the absolute difference between Vi and Vj is greater than a predetermined constant (used to eliminate sample disturbances and minor differences due to changes in light in the radiation), the sub procedure of the maximum power potential tracking is called (Block 7).

6) Sub procedure maximum power point tracking finds maximum comprehensive power point. . Then, exploitation will be maintained at this new point. The maximum power potential point tracking subroutine determines the position of the peak power point on the power-voltage curve (block 8).

7. When the voltage of each photovoltaic module is less than zero (Vi <0), this means that the peak power point is on the left-hand side of the peak point in the voltage-voltage curve and the reference voltage of the peak point is set at 80% V_{OC} (Block 9)

8) Then, a method for tracing the maximum power point used to trace this point is used (blocks 10 and 11).

9) When the photovoltaic module's voltages are less than zero, the peak power point is on the right-hand side of the peak point on the voltage-power curve. Voltage of all photovoltaic modules based on the quantity and calculation of M, the number of modules in the group with the smallest voltages is divided into two groups (Block 12).

10) This M module will be bypassed and no output power will be produced. Therefore, the reference voltage of the left peak is 80% VOC * (1-M / N) (block 13).

11) After that, the same maximum-power point technique is used to track this peak (blocks 14 and 15).

12) By comparing the powers of this peak point (new peak power point) and the previous peak point (old peak power point), the maximum power point is obtained comprehensively (blocks 16 and 17).

13) Finally, the reference voltage is set to the maximum total power peak point voltage and the operation remains at this point until the timer interrupts.

14) Finally, the reference voltage is set to the maximum total power maximum point (blocks 18 and 19)

15), and until the timer resumes, the operation remains at this point (block 20).

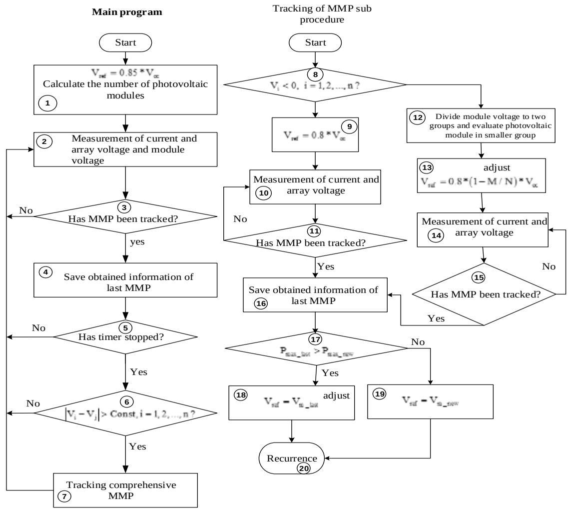


Figure 5 - Maximum power point tracking flow control

2.5: Introducing the target function

The intensity of sunlight is uncertain and cannot be accurately predicted in the coming hours. Therefore, in this study, the effect of the uncertainty of the intensity of sunlight that leads to the uncertainty of the output power of photovoltaic units will be examined. For this purpose, a probabilistic approach to estimating the point will be used, which is described below. Also, maximizing the output power of photovoltaic units and reducing network losses with the presence of these units are two of the objectives considered in this issue. The minimum and maximum allowable temperatures for power generation by solar cells, as well as the permitted voltage range (in order to maintain stability) are among the most important constraints that will be considered in this regard.

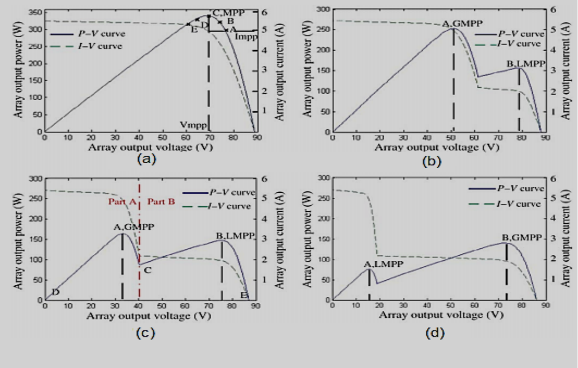


Figure 6: Voltage and Current Voltage Characteristics of the Photovoltaic Array under Partially Shaded Conditions. A) Non-shading modules; b) a drop shaded module with 400 watts per square meter. C) Two drop shaded modules with 400 watts per square meter. D) Three drop shaded modules with 400 watts per square meter[8].

In order to minimize network losses after tracing the maximum power point, the difference between the amount of loss before and after tracking must be maximized. In other words, the maximum point tracking can reduce network losses to a greater degree. Therefore, the first part of the objective function is to minimize network losses, as shown below in Equation 5.

$$\mathrm{of}_1 = \mathrm{Max}\left(\mathrm{P}_{\mathrm{loss}}^{\mathrm{MPPT,b}} - \mathrm{P}_{\mathrm{loss}}^{\mathrm{MPPT,a}}\right) \tag{5}$$

In that, $P_{loss}^{MPPT,a}$ و $P_{loss}^{MPPT,b}$ respectively, are the network losses after and before the maximum power point detection. In order to determine the losses of the network, before and after tracking the maximum power point, a load distribution must be performed on the network, which for this purpose, the post-pre-sweeper load-distributing method is used.

The second part of the objective function, which maximizes the output power of photovoltaic units, is expressed as in Equation 6.

$$\mathrm{P}_{\mathrm{pv}} = \mathrm{Max}\left(\left(\mathrm{I}_{\mathrm{pv\_STC}} + \mathrm{K}_{\mathrm{i}}\left(\mathrm{T} - \mathrm{T}_{\mathrm{STC}}\right)\right)\frac{\mathrm{G}}{\mathrm{G}_{\mathrm{STC}}}\right) \times \mathrm{V}_{\mathrm{pv}} \quad 6)$$

In the following, the method of genetic optimization algorithm is used with unsteady sorting, which is used to optimize the proposed goals.

2.6: Genetic optimization algorithm with non-dominated sorting

Genetic algorithm is a method for solving complex optimization problems, and the resulting solutions are of desirable quality. In this paper, a genetic algorithm is used with an unauthorized sorting, which is a very powerful algorithm for solving single-objective and multi-objective optimization problems. The main difference between this algorithm and the standardized algorithm is the sorting mechanism of the responses. Concepts such as conquering, ranking and congestion distance are one of the most important and fundamental concepts of this algorithm (Kalyanmoy, 2001).

3. SIMULATION AND RESULTS

In this section, the proposed method has been evaluated for tracking the maximum power point and the reduction of losses, implemented in two studies, in the first part, by introducing four different shaded patterns, the function of the proposed method is examined when changing from one pattern to another. In the second part, power fluctuations, voltage, and also power losses under various radiation and shaded scenarios are investigated and analyzed.

3.1:First Study

In this study, four different shaded patterns shown in Table 2 have been examined and tested.

Table 2: Different shaded patterns examined

Shaded pattern $[M_{11},M_{12},M_{13},M_{21},M_{22},M_{23}]$ **(وات بر متر)**	**Pattern number**
[1000 ،1000 ،1000 ،1000 ،1000 ،1000]	**SP₁**
[200 ،400 ،1000 ،400 ،800 ،1000]	**SP2**
[200 ،400 ،800 ،400 ،200 ،500]	**SP3**
[200 ،400 ،800 ،1000 ،1000 ،600]	**SP4**

For SP1, radiation on all photovoltaic panels is uniform. As a result, there is only one peak in the characteristic curve of the power-current of the photovoltaic array. There are several peaks for the three other shaded patterns. By applying the maximum-power tracing algorithm based on the genetic algorithm with an unlocked ordering for these four cases, the flows in each photovoltaic array (I_1 and I_2), the p_{ideal} power, and the average power measured with the implementation of 30 times the proposed method, (P), is shown in Table 3.

Table 3: Performance of Maximum Power Point Tracking Algorithm under Different Shaded Plans

Pattern number	P_{ideal} (W)	I_2 (A)	I_1 (A)
SP1	402	4/47	4/47
SP2	353	4/38	3/33
SP3	99	1/61	1/52
SP4	175	1/61	4/5

As can be seen, the proposed method can track the maximum power potential, which is approximately the same as the ideal power in 4 partial shades. Note that this output power is based on the assumption that there is no power leakage in the photovoltaic system results from the use of DC-DC converter, power losses from wire connection or other factors. When performing this method of tracking the maximum power point in the real system, the power taken out is less than ideal. The ability to find the maximum total power point for new weather conditions is especially important for places with frequent climate change, such as tropical regions. In order to demonstrate the ability to trace the proposed algorithm under transient conditions, the following issues have been considered.

- First item: Change the shadow pattern from SP1 to SP2.

- Second item: Change the shadow pattern from SP1 to SP3.

- Third item: Change the shadow algorithm from SP1 to SP4.

The sampling period of the maximum power point tracking algorithm is 0.01 sec. Transient changes in the power and flow of each photovoltaic array for the first, second and third cases are shown in Figures 7 to 9, respectively.

As it can be seen, when the shaded pattern in fifth second (center of the x-axis) changes from non-uniform conditions to partially shaded conditions, the trajectory algorithm of the maximum recommended power point can find out the maximum total power point for the new shaded pattern, for example, when the changes from SP1 to SP2, SP1 to SP3 and SP1 to SP4 are respectively, power changes from 402 to 353, 402 to 99, and 402 to 175. By simulating all the cases, we find that the number of repetitions required for convergence is less than 15. Since the sampling period of the peak power tracking algorithm has an effect on tracking speed, it must be appropriate to the place where photovoltaic systems are located, When setting the sampling period, the maximum-power tracing algorithm, for example, at 0.01 seconds, measures an average of 30 times the algorithm's execution time of 76.05 seconds. This means that the use of a genetic method with an indefinable sorting can lead to a maximum point of comprehensive power at a very short time. This quick response capability for photovoltaic systems where radiation conditions are changing rapidly is very important.

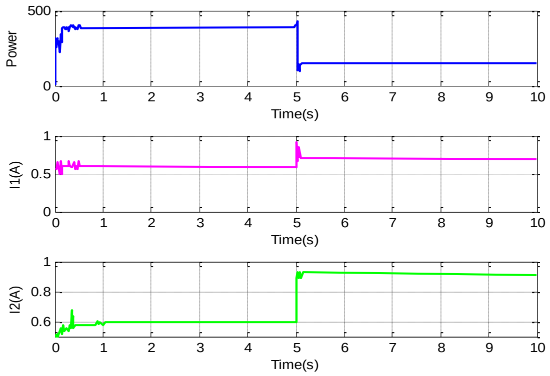


Figure 7: Transient response of the method of tracking the maximum proposed power point for the first case. Shaded pattern changes from SP1 to SP2

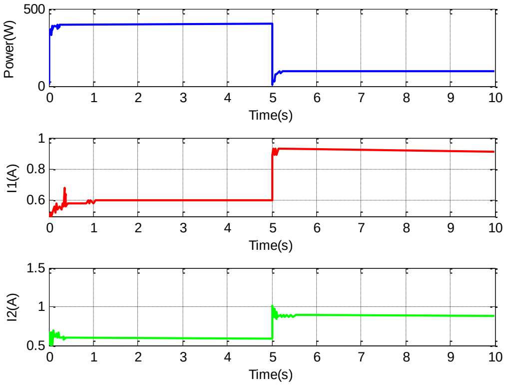


Figure 8: Transient Response of the method of tracking the maximum proposed power point for the second case. Shaded pattern changes from SP1 to SP3

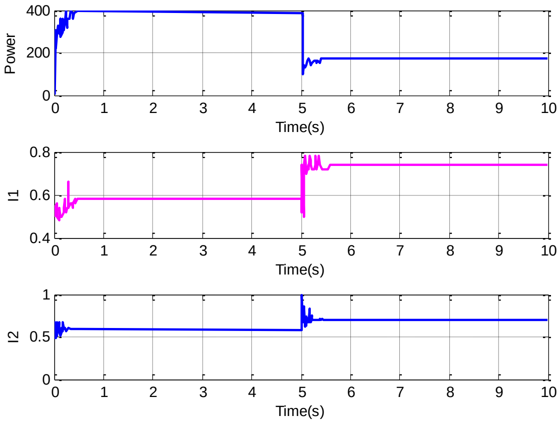


Figure 9: Transient Response of the method for tracking the maximum recommended power point for the third case. The shaded pattern changes from SP1 to SP4

3.2: second study

Since partial shaded conditions are a random phenomenon, many situations and conditions may occur, however, in order to evaluate the performance of the proposed algorithm, three different cases are presented with a slight shaded degree change that covers a wide range of radiation levels. Figure 10 illustrates the topology of the photovoltaic array in this study, which includes two photovoltaic modules.

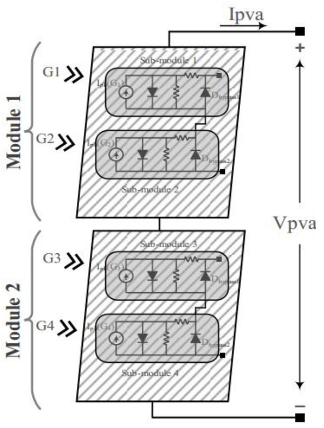


Figure 10: The photovoltaic array circuit diagram[7].

Due to the existence of two bypass diodes in each module, the three different scenarios considered in this study are as follows.
1) The first module, the radiation level is 1000 watts per square meter (G1 = G2 = 1000) and the second module receives a radiation level of 350 watts per square meter (G3 = G4 = 350)

2) The first module receives a radiation level of 1000 watts per square meter (G1 = G2 = 1000) and the second module receives radiation levels of 700 and 500 watts per square meter (G3 = 700, G4-500)

3) The first module receives radiation levels (G1 = 1200, G2 = 700) and the second module receives radiation levels (G3 = 500, G4-300).
The results are compared using non-dominated genetic optimization method, Assuming that partial shading occurs, the power output of the photovoltaic system for the first scenario is shown in Figure 11. As it can be seen, if the maximum power point is not tracked, the power output of the photovoltaic unit will experience many fluctuations.

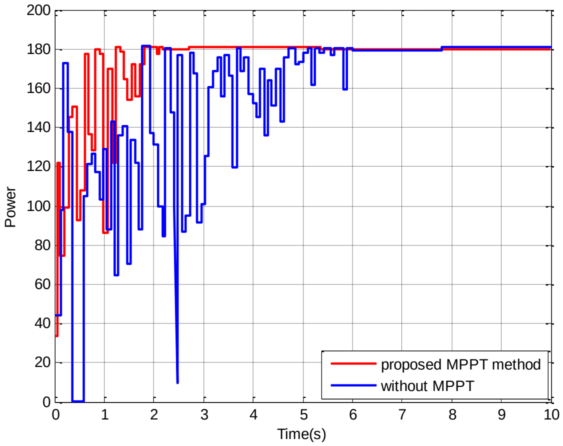


Figure 11: The output power of a photovoltaic unit in two modes without traceability and optimal tracking by the proposed method in the first scenario

And as long as the shadow fails, it will not be able to operate at the maximum power. The use of genetic algorithm-based tracking method with non-clutter sorting makes it possible to track the maximum power potential with less fluctuation and also in much shorter time.

In the second scenario, the output power of the photovoltaic system consists of three peaks with minor differences among the power values associated with them. The mean peak power value is about 184.47 watts, while other peaks on the left and right of the maximum total power point are 183.14 watts and 183.27 watts, respectively. Therefore, this scenario creates a slight shaded condition in which the difference between the maximum local and comprehensive power points is less than 1.5%. The purpose of implementing the proposed method under these conditions is to assess its ability to track the maximum power point in a comprehensive manner, while the values of local responses are largely close to the optimal total. In this case, as shown in Fig. 12, the tracking method based on the genetic algorithm has been able to track the maximum power potential with a non-dominated ordering at a very short time and with low volatility. Most of the trajectory techniques for trajectory maximum power are capable of tracking when the maximum total power point is before the maximum local power point. However, if the maximum total power point occurs after the maximum local power point, all these techniques are captured at the maximum local power point.

Hence, in this scenario, the performance of the proposed technique is evaluated under partial shaded conditions and assuming that the maximum power point is observed after the maximum local power point. Figure 13 shows how the proposed method accurately traces the maximum point of comprehensive power, regardless of the positions of the maximum local power points.

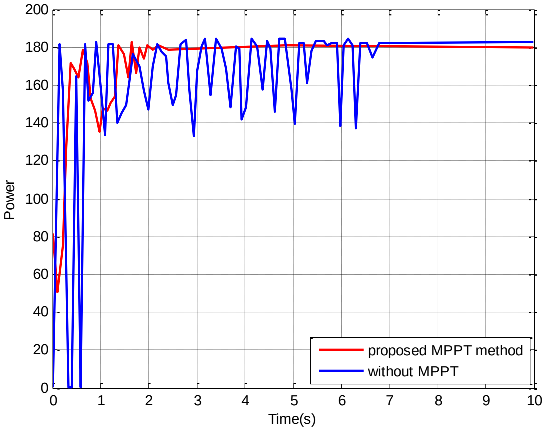


Figure 12: Maximum power point tracking in the second scenario

Compared to soft computing methods, their reliability under partial shade conditions is not normally a standard comparison criterion, and other factors such as convergence rate, simplicity, output stability and computational burden are also important. One of the distinct advantages of the proposed method is its higher speed in tracking the maximum power point, the reason is that this process does not allow particles to search for the unnecessary part of the search space. In fact, during the initial repetition, the area of the maximum power point is determined, and in the final repetition, the exact value of the maximum power point is traced.

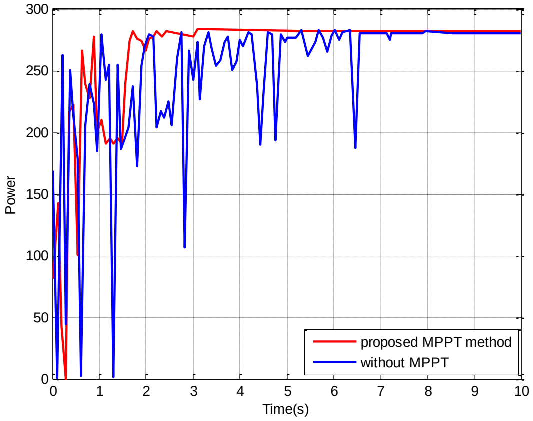


Figure 13 - Comparison of maximum power point tracking in two modes without traceability and optimal tracking by the proposed method in the third scenario

Another important result is the application of the proposed technique for tracking the maximum power loss potential during tracking periods and the steady state. Many traditional or combined methods cause relatively high power losses. The main reason for this is that most of these methods are based on incremental guidance or hill climbing theories. As a result, even when the area of the maximum power point is successfully identified, it leads to constant fluctuations in the output of the photovoltaic system. Since the efficiency of the photovoltaic system is a critical factor, these fluctuations around the maximum power point can cause significant power losses, which can further reduce the overall efficiency of the photovoltaic system. Another effect of these volatility oscillations is the volatility created by constant changes over the course. Regarding the input / output correlation of DC / DC converters, any small change in the work cycle changes the level of the output voltage of the converter regardless of the type of converter used in the system. The reason for lower fluctuations in tracing the maximum total power point by genetic optimization with unstable sorting is to find particles of all parts of the search space during runtime to find the maximum point of comprehensive power. In the case of a rapid change in the shaded condition in the photovoltaic system, which it is very common in residential grids, significant losses of power and also low voltage stability will occur. Figure 14 shows the voltage fluctuations during tracking periods and the steady state in the output of the photovoltaic system for the three scenarios. As you can see, the genetic trace detection method with an unlocked sort decreases the intensity of voltage fluctuations during the peak power tracking period, and can be shortened in a shorter time frame Fluctuations.

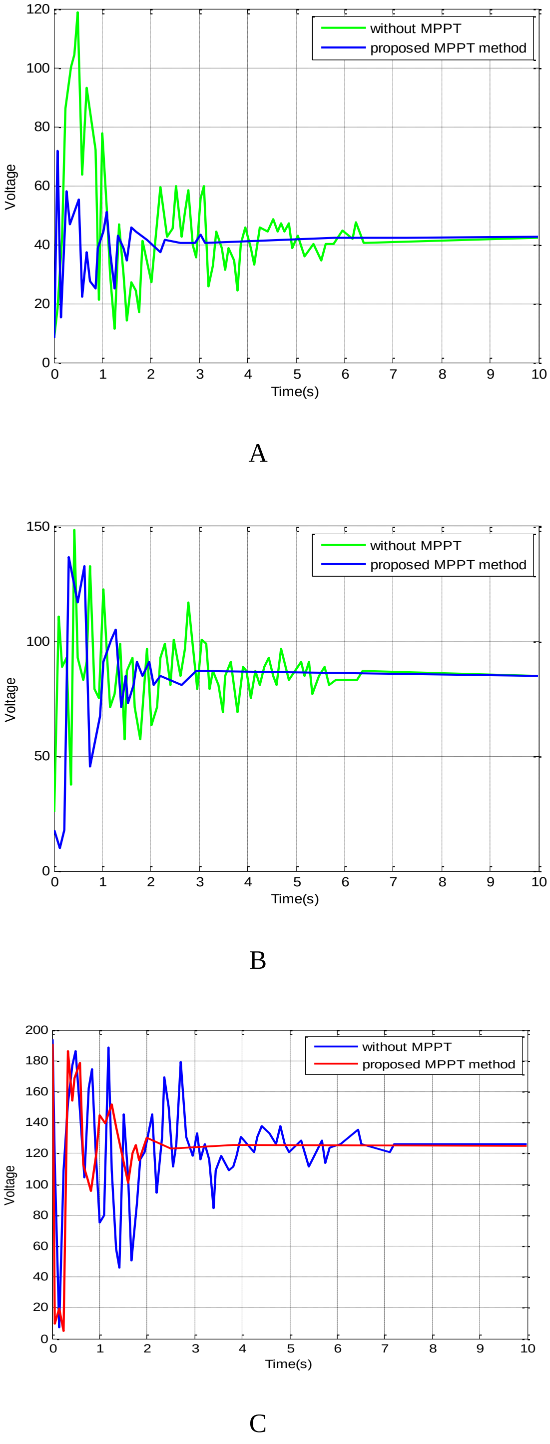


Figure 14: Voltage fluctuations during tracking the maximum power point A) Scenario 1 b) Scenario II c) Third scenario

As previously mentioned, one of the objectives of this paper is to examine the effect of the proposed method for tracking the maximum power point based on genetic algorithm with non-limiting sorting on power loss reduction. Assuming the use of photovoltaic systems in the IEEE 33-bus network shown in Fig. 15, whose parameters, including line (Hung, 2010) ,Power loss curves in different lines in both cases before and after tracing the maximum power point are shown in Fig. 16. As can be seen, the proposed method reduces power losses in network lines. Therefore, the proposed approach in relation to both objectives is to maximize output power and reduce power losses with successful performance.

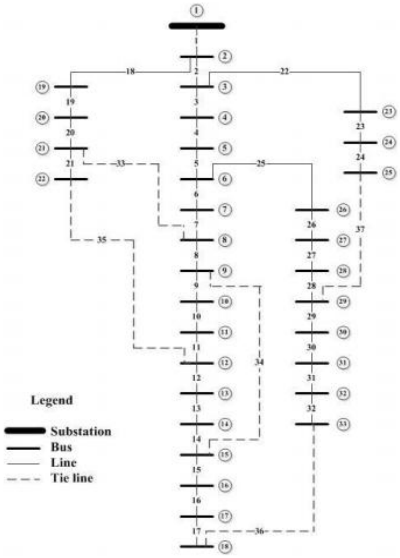


Figure 15: IEEE 33-core radial distribution network

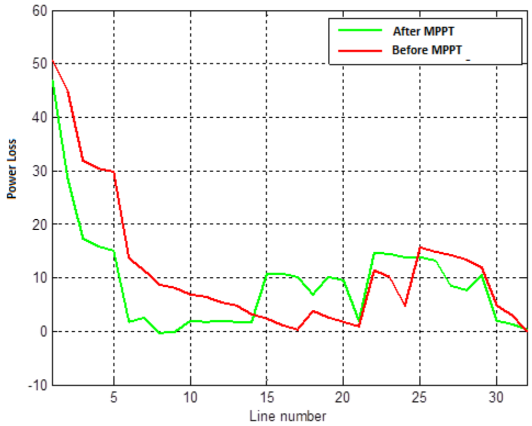


Figure 16: Comparison of power losses in different network lines before and after tracing the maximum power point in the distribution network

The voltage of different network shafts in both cases before and after tracing the maximum power point is also shown in Figure 17. As can be seen, the utilization of photovoltaic units at the maximum power point improves the network voltage profile.

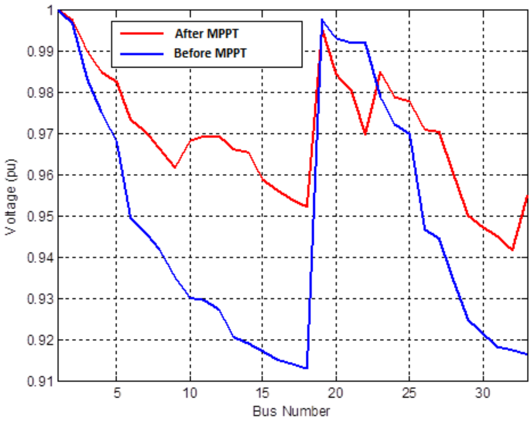
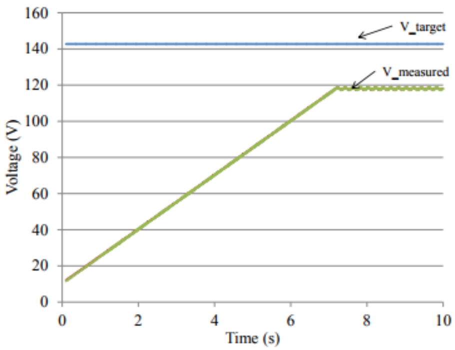


Figure 17: Comparison of voltage in different shafts in both modes before and after tracing the maximum power point

3-3 Comparison of the performance of the proposed method with other methods

Figure 18 shows voltage tracing using the three methods of P & O, PSO and SA for a sample case (Lyden, 2016) As can be seen, the P & O method, after a relatively long period of time, performs tracking, and its tracking accuracy is also very low, and has about 15% error. The PSO method, though capable of performing a trace operation in a shorter amount of time, But this method also has a 15-pin error in voltage tracking, The SA method also performs tracking at the same time as the PSO method. As you can see, though tracking has been carried out with great accuracy, the process of dampening the oscillation and reaching a steady state has been a long time. So that tracking fluctuations are passed after 9 seconds.



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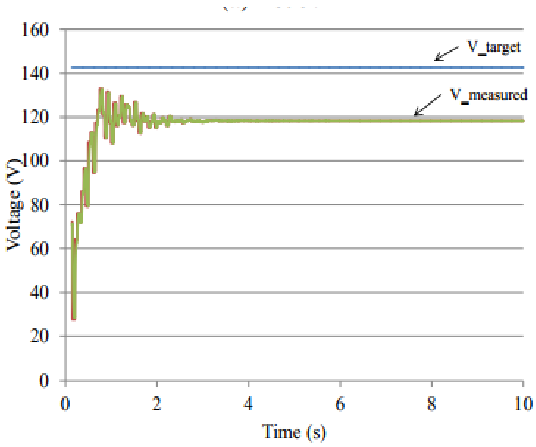
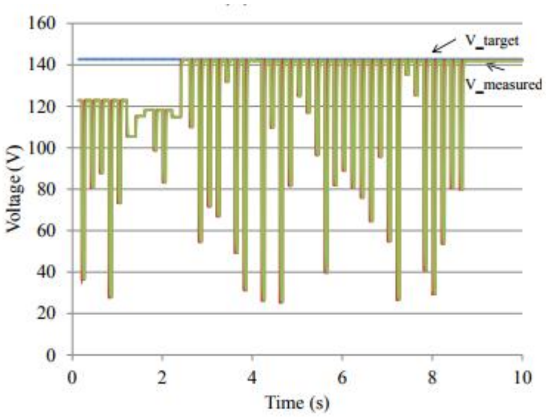


B



C

Figure 18: Voltage-time diagram of sample case for implementation of maximum power point tracking. A) P & O method b) PSO method c) SA method

Figure 19, shows tracing using the suggested method. As you can see, tracking is done with low volatility, high accuracy and over a short period of time. Therefore, the proposed method has a more favorable performance than other proposed methods.

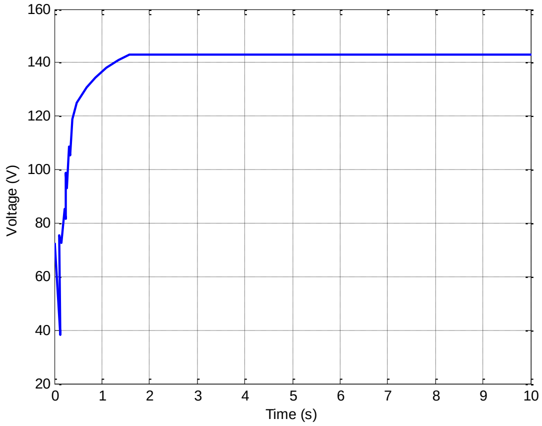
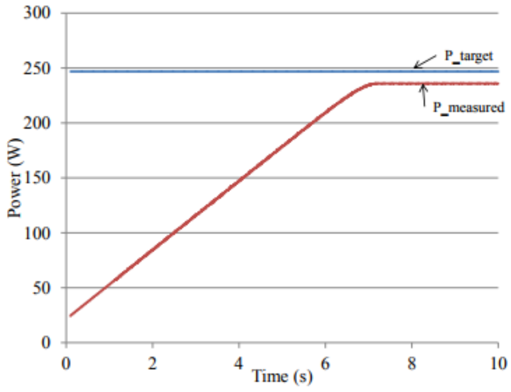
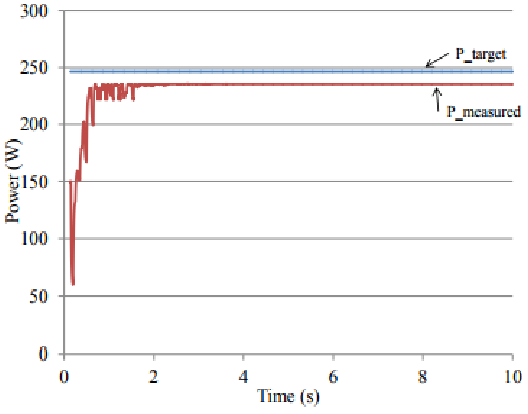


Figure 19: Voltage-time diagram of the sample case for implementing the maximum power point tracking using the proposed approach.

Figure 20 shows power tracing using three methods, P & O, PSO and SA . As it can be seen, similar to the voltage tracking, the P & O method has a slow performance and low accuracy in a way that its error is less than or equal to the target value of 5%. The PSO method has a higher rate than the P & O method and performs traceability in 2/2 second, but it has 6% error. SA method, despite the high precision, has many fluctuations in tracking, which also increases the tracking time.



A



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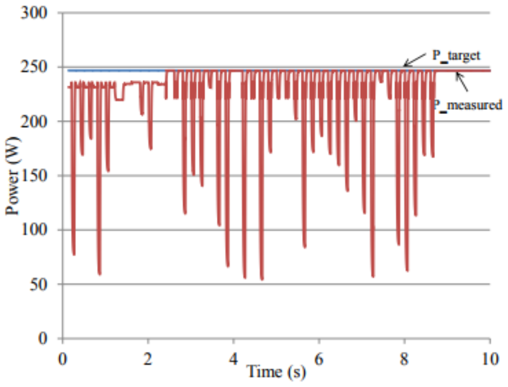

C

Figure 20: Power-time diagram of the sample case for implementation of maximum power point tracking. A) P & O method b) PSO method c) SA method

Figure 21 shows power tracing using the suggested method. As you can see, tracking is done with low volatility, high accuracy and over a short period of time. Therefore, the proposed method is more effective than P & O, PSO and SA methods.

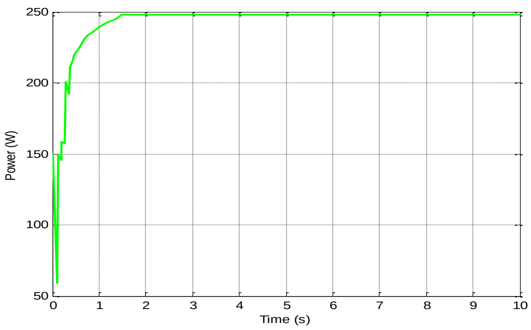

Figure 21: Power-time diagram of sample case for implementation of maximum power point tracking using the proposed approach.

4: CONCLUSION

In this paper, while presenting a model of photovoltaic arrays and their output current, the problem of partial shading and its effect on the performance of solar cells and their power generation were investigated. Also, the method of tracing the maximum power point under partially shaded conditions and target function, which includes maximizing the power output of photovoltaic units and minimizing losses with the presence of these units in the network. In addition, in order to model the uncertainty of solar units, a probabilistic approach is used to estimate the point, and for solving the optimization problem, the genetic algorithm has been introduced with non- dominated sorting. The results of the implementation of the proposed method are as follows:

- The proposed method can track the maximum total power point under different scenarios and optimally change the partially shaded pattern. This is especially important in areas with frequent climate change such as tropical regions.

- The use of a genetic algorithm with non-dominated sorting can result in a maximum point of comprehensive power at a very short time.

- Assuming a partially shaded event, if the maximum power point is not tracked, the power output of the photovoltaic unit will experience many fluctuations and will not be able to operate at the maximum power point until the shadow fails. Using the genetic algorithm-based tracing method with non-clutter sorting makes it possible to detect the maximum total power point with less fluctuation and in a much shorter time.

- Performance evaluation of the proposed approach In the situation where the maximum local power points are located on the left and the right of the maximum power point, shows that the proposed method is still capable to maximize the output power of photovoltaic units at very short time and with low volatility. In fact, the proposed approach, unlike many previous traditional approaches, accurately traces the maximum point of comprehensive power, regardless of the positions of the maximum local power points.

- One of the distinct advantages of the proposed method is its higher speed in tracking the maximum power point. The reason is that this process does not allow particles to search for the unnecessary part of the search space. In fact, during the initial repetition, the area of the maximum power point is determined, and in the final repetition, the exact value of the maximum power point is traced.

- Another important factor is the application of the proposed technique for tracking the maximum power reduction potential during tracking periods and the steady state. The presence of fluctuations around the maximum power point can cause considerable power losses, which can further reduce the overall efficiency of the photovoltaic system. Another effect of these volatility oscillations is the volatility created by constant changes over the course. Regarding the input / output correlation of DC / DC converters, any small change in the work cycle changes the output voltage level of the converter regardless of the type of converter used in the system. The reason for lower fluctuations in tracing the maximum total power point by genetic optimization with unstable sorting is that the particles explore all parts of the search space during runtime to find the maximum point of comprehensive power. In the case of a rapid change in the shaded conditions in the photovoltaic system, which is very common in residential grids, a significant amount of power losses will occur as well as low voltage stability.

- Genetically-based trace detection with non-occlusive sorting reduces the intensity of voltage fluctuations during the peak power tracking period, and is capable of slipping over a shorter time frame.

- Comparison of the losses of the proposed method before and after tracing the maximum power point indicates the effectiveness of the proposed approach in reducing power losses in network lines. Also, comparing the voltage of different network shafts in both cases before and after tracking the maximum power point also indicates the improvement of network voltage profile.

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