IJITCE

ISSN 2347- 3657

International Journal of
Information Technology & Computer Engineering

Email : ijitce.editor@gmail.com or editor@ijitce.com

International Journal of Information Technology & Computer Engineering

ISSN 2347–3657

Volume 13, Issue 2, 2025

Advanced MPPT Tracking for PV Systems Using Model Predictive Control in Modified SEPIC Topology

[1]Mrs.Sudeepika,[2]Kovelakuntla Farnisha, [3]Potturu Ravi Chandra Naidu,[4]Sunku Naga Likhitha,

[5]Janagani Madhu Priya, [6]Guggilla Sriya Reddy,

[1]Assistant Professor, Department Of EEE, Ananthalakshmi Institute Of Technology And Sciences, Itikalapalli, Near Sk University,Ananthapur.

[2,3,4,5,6]Student, Department Of EEE, Ananthalakshmi Institute Of Technology And Sciences, Itikalapalli, Near Sk University,Ananthapur.

ABSTRACT

With fewer sensors needed, this research aims to reduce hardware costs while still achieving maximum power point tracking (MPPT) in photovoltaic (PV) systems. Using a modified SEPIC converter and an MPPT algorithm based on model predictive control (MPC), the approach aspires to provide efficient MPPT under different environmental situations. The suggested method uses a single voltage and current sensor to accomplish the goal, which drastically reduces the hardware needs in comparison to conventional MPPT methods. To control the current and voltage in the PV system, the modified SEPIC converter is used. The converter's operation is adjusted dynamically to monitor the maximum power point using the MPC-based MPPT algorithm. Optimal power production may be predicted and optimized using the algorithm's model predictive control technique, which makes use of a PV system predictive model. For precise MPPT, the algorithm uses the measured data from the sensors to foretell how the PV system would operate. In order to optimize power extraction, the program makes modifications in real-time. This research shows that the suggested method reduces hardware cost by successfully tracking the PV system's highest power point using only one voltage and one current sensor. Under different operating circumstances, the updated SEPIC converter and the MPC-based MPPT algorithm efficiently extract power. The suggested method is more efficient and cost-effective than conventional MPPT methods, according to the simulation and experimental findings.

INDEX TERMS Model predictive control (MPC)-based MPPT algorithm, modified SEPIC converter, MATLAB simulation and hardware, voltage sensor and current sensor.

INTRODUCTION

As a green and sustainable energy source, photovoltaic (PV) production has been trending up in popularity recently. This work was reviewed and approved for publication by Giambattista Gruosso, an associate editor. sustainable power source. Photovoltaic (PV) production, which converts sunlight into electricity, may drastically alter our energy consumption habits. Solar photovoltaic (PV) production has the advantage of being an endless supply of energy. The sun's endless energy reserves mean that we won't run out of power anytime soon. Solar power, in contrast to fossil fuels, is a renewable resource that may be harnessed indefinitely, unlike the limited nature of fossil fuels. Consequently, producing power with solar systems may provide a long-term and sustainable answer to our energy needs. positions [1, 2], [3, 4]. For anyone who are worried about how their energy usage affects the environment, this is the perfect option. Photovoltaic (PV) generating provides monetary advantages as well as environmental ones. Solar panels are becoming cheaper all the time, which means PV power is getting more and more inexpensive. As a result, an increasing number of individuals may benefit from this technology and save their energy expenses. Furthermore, those who produce more energy than they need and sell it back to the grid may earn money via PV generating. There are still a few obstacles to overcome when it comes to PV generating, even if it has numerous advantages. A major drawback is that it can't produce electricity in places with little sunshine since it relies on sunshine [5, 6, 7]. Use a dc/dc converter with maximum-power point-tracking (MPPT) control to maximize the output of a PV panel. The dc/dc converter's primary function is to elevate the DC power from the PV panels to a voltage level that can be used by the electrical grid [8]. The use of power electronics to boost the voltage and cut the current accomplishes this. A dc/dc converter does more than just change the voltage; it also isolates the PV panel from the grid, which is crucial for safety reasons. By keeping it running at full power, it helps maximize the PV panel's energy production as well [9]. There are a number of advantages to using a dc/dc converter with MPPT control in PV generating systems. Some examples are: One benefit of MPPT management is an increase in energy output, as it allows for the PV panel to run at its maximum power point temperature (MPPT), which is otherwise not achievable. Second, a dc/dc converter improves efficiency by boosting the voltage and lowering the current, allowing the PV panel to produce more energy.

Overall, the system becomes more efficient since less energy is wasted as heat; Third, it gives you more leeway to play about with the layout of your system since dc/dc converters with MPPT controls let you link PV panels in series or parallel to get the voltage and current levels you want [10]. When subjected to a certain set of environmental factors including temperature and irradiance, a photovoltaic (PV) panel will produce its maximum power point (MPP). Nevertheless, these circumstances are dynamic, and the MPP is subject to continuous modification. When the maximum power point tracking (MPPT) function is activated, the dc/dc converter's operating point is fine-tuned in response to the MPP of the PV panel. It does this by making ensuring the PV panel is operating at its most efficient setting, which increases the quantity of energy that can be produced [11], [12]. The most common model predictive control (MPC), ripple current control (RCC), incremental con 100770 ductance (InCond), and perturb and observe (P&O) methods are among the several MPPT approaches described in the literature. A simple and popular maximum power point tracking (MPPT) method is "perturb and observe" (P&O). This method entails changing the photovoltaic (PV) system's operating point and then monitoring the resulting shift in power output. This method finds the maximum power point (MPP) and keeps adjusting the PV system's operating voltage there. However, there are a few downsides to the P&O method, including as sluggish tracking speed and oscillations around the MPP. Another popular method for maximum power point tracking (MPPT), incremental conductance (InCond) relies on the fact that the power-voltage curve of a PV system becomes flat at the maximum power point (MPPT). To find the MPP's direction, InCond constantly compares the PV system's instantaneous conductance with its incremental conductance. This method can adapt to fluctuating irradiance conditions and tracks more quickly than P&O. One novel method of maximum power point tracking (MPPT) is ripple current control (RCC), which perturbs the PV system's operational point using a high-frequency ripple current. The method achieves the MPP by adjusting the ripple current using a feedback loop. RCC is able to manage partial shade circumstances and has a rapid tracking speed. For optimal power extraction from PV systems operating under PSCs, a novel maximum power point tracking (MPPT) controller based on real-time fuzzy logic controllers (RBFCs) was suggested in [13]. Solar PV systems operating under PSCs may benefit from this controller since it beat both traditional and AI-based MPPTcontrollers in a number of important respects. To effectively monitor the maximum power point (MPP), a two-step technique for PV modules was proposed in [14]. This method makes use of an upgraded iRCS-MPC.

In terms of overshoot, undershoot, and time to steady state, the proposed system is superior to the conventional P&O and MPC approaches. Under partial shading situations, researchers presented a metaheuristic approach for maximum power point tracking (MPPT) in [15]. Meta heuristic optimization strategies' computing cost and search space exploration are both significantly reduced by this approach. By reaching maximum power point faster and with fewer power losses during tracking, the proposed approach outperforms two other recent MPPT algorithms. Based on the PV panel's output current and voltage measurements, an adaptive block is described in reference [16] that calculates solar irradiance and the parameters of the PV I-V curve circuit. Trackers that depend on observed sun irradiance usually need expensive sensors; however, this technique removes that requirement. In [17], five MPPT controllers for PV systems that make use of AI approaches were created and evaluated side by side. One of them is the PID-based MPPTcontroller, which stands out because to its inexpensive price, simplicity of installation, balanced speed in transient states and accuracy in stable states, and resistance to changes in the parameters. Under partly shadowed and changeable weather situations, a novel ABC-based MPPT algorithm for PV systems was proposed in [18]. Results from simulations comparing the two algorithms reveal that the sug gested ABC-based MPPT algorithm outperforms the PSO-based algorithm in monitoring the global MPP under partly shaded and dynamic weather scenarios. A MPPT algorithm for PV systems with DC control based on the Monodequation is proposed in reference [19]. This novel approach is simpler and less expensive to implement using low-cost controllers and processors due to its reduced processing needs and implementation complexity. A novel maximum power point tracking (MPPT) method for

International Journal of Information Technology & Computer Engineering
ISSN 2347–3657
Volume 13, Issue 2, 2025

photovoltaic (PV) systems subject to dynamic partial shadowing conditions is presented in reference [20].

This technique employs a scheduling procedure to lessen voltage tracking and a skipping mechanism to evade certain regions of the search space. Using machine learning methods, a framework was built in [21] to assess the remaining usable life of a wind turbine and identify the source of any defects. Experiments using data from actual wind turbines proved that the proposed framework was more accurate and efficient. The use of machine learning methods for the purpose of wind turbine malfunction detection and diagnosis was proposed in [22]. The technique entails training a machine learning model using data collected from the wind turbine's many sensors. The study's findings highlight the effectiveness of the proposed technique in identifying wind turbine problems, which in turn may enhance their dependability and decrease maintenance expenses. The more sophisticated model-predictive control (MPC) method predicts the PV system's behavior under various operating situations by using a mathematical model of the system. Using an optimization algorithm, the method finds the sweet spot where the PV system produces the most electricity. MPC is capable of handling complicated environmental circumstances and has a high tracking accuracy [23]. One advanced maximum power point tracking (MPPT) method that has become more popular in recent years for its high tracking accuracy is model predictive control based maximum power point tracking (MPC-MPPT). Using this method to regulate the operating temperature of photovoltaic (PV) panels in order to follow the MPP is an incredibly efficient strategy [24]. The fundamental idea behind maximum power point tracking (MPPT) is to foretell how the PV panel will behave in the future and use that knowledge to regulate the panel's operating point. A mathematical model of the PV panel takes into consideration a number of aspects, including temperature, irradiance, and panel characteristics, in order to make the forecast. The model is then used to forecast the current and voltage that will cause the panel to produce its maximum power output [25].

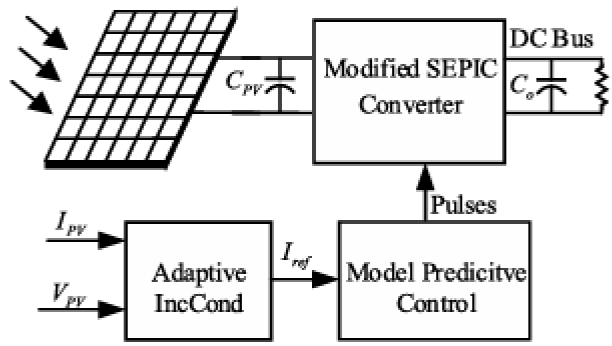

FIGURE 1. The structure of an innovative photovoltaic (PV) generation system incorporates a modified SEPIC converter and utilizes a model predictive control (MPC)-based maximum power point tracking (MPPT) control algorithm.

Following the prediction of the panel's future behavior, the MPC-MPPT controller modifies the panel's operating point to follow the projected MPP. To do this, the panel's voltage and current are continuously adjusted such that the output power remains at its maximum level. To do this, the controller solves an optimization problem that considers both the expected panel behavior and the required output power. Being able to adapt to changing conditions is a strength of MPC-MPPT that sets it apart from other MPPT methods. For instance, the MPC-MPPT controller may swiftly modify the panel's operating point to follow the new MPP in the event of a rapid change in irradiance or temperature. This occurs because MPC considers the panel's future actions and can foresee how the environment will change [26]. A new method for maximum power point tracking (MPPT) based on model predictive control (MPC) and using fewer sensors is presented in this research for photovoltaic (PV) systems. The paper's focus is on the system structure shown in Figure 1. In contrast to conventional MPPT methods for PV dc/dc converters that rely on MPCs, the suggested method just requires a single voltage and current sensor. The total cost of the system's hardware is lowered as a result. The maximum powerpoint may be successfully tracked in different climatic conditions using the suggested method, which is compatible with both fixed and adjustable step sizes. Because of its many benefits, including a low voltage stress, a high efficiency, and a high step-up ratio, a modified SEPIC converter is used in the power stage. Detailed explanations of the MPC-based

MPPT method and the modified SEPIC converter's operating principles are provided.

MODIFIED SEPIC DC–DC CONVERTER ANALYSIS

A high-gain, transformerless SEPIC converter was suggested in [27], and its construction is shown in Figure 2. Two inductor, two diode, three capacitor, and one power switch make up the converter. The converter is programmed to operate in continuous conduction mode in this study. Current state of the switch,

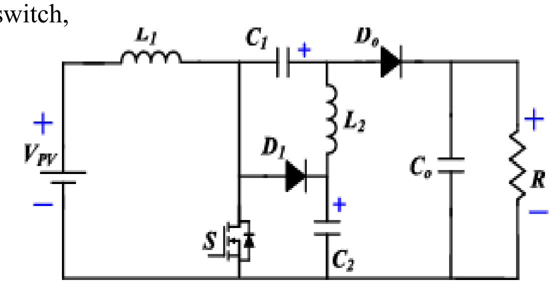

FIGURE2. LayoutoftheupdatedSEPICConverter[27].

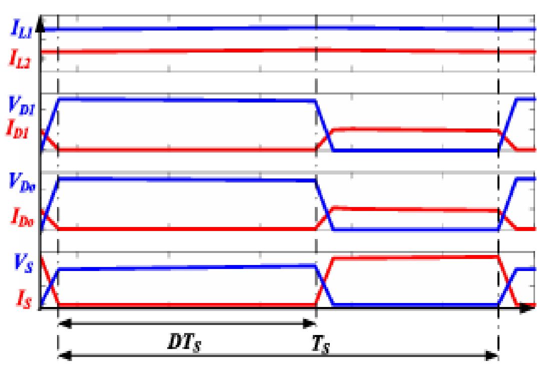

FIGURE3. BehaviorgraphsforupdatedSEPICconverter.

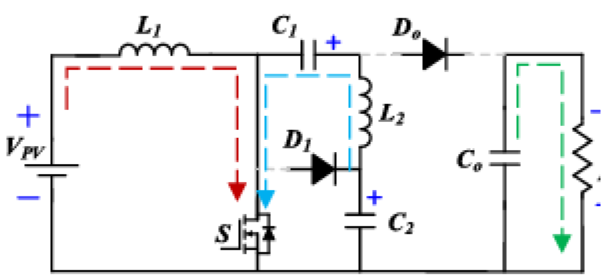

FIGURE4. PerformanceassessmentoftherevisedSEPICconverter, ModeI.

The two modes of operation of the converter are determined by S={0or1}. The next paragraphs detail the many modes of operation that make use of the circuit components with their optimal qualities. Shown in Figure 3 is the operating waveform of the converter. The converter can be operated in two modes: First Mode: The circuit is rearranged as an on/off switch and a power converter when S= 0. Inductors and capacitors convert the input voltage into the output voltage. When the value of S is 1, the circuit is arranged as a buck converter, and the switch is turned on. Inductors and capacitors convert the voltage from the output to the input. To get the required output voltage, the converter may be operated in either mode. The choice of mode is application-specific. The operational waveforms of the converter in Modes 1 and 2 are shown in Figure 3. A high gain, defined as the ratio of the output voltage to the input voltage, may be achieved by the converter, as shown by the waveforms.

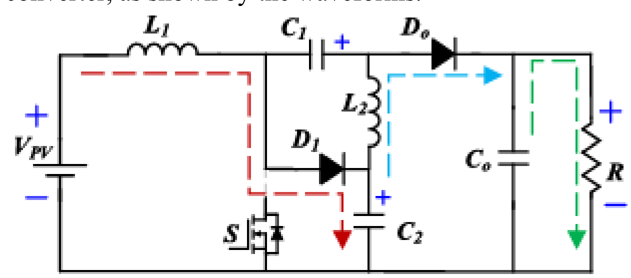

FIGURE5. Performance as sessmentoftherevisedSEPICconverter, ModeII.

A. MODEI The switch turns on when it receives a strong pulse signal. Figure 4 shows that when the switches are turned off, diodes D1 and D2 are not functioning. Here, inductor L1 gets its power from the direct current source, while inductor L2 gets its power from capacitor C2. Here are the equations that illustrate this mode:

$$\begin{cases} v_{L1}(\mathrm{t}) = \mathrm{V}_{PV} \\ i_{PV}(\mathrm{t}) = C_{PV}\dfrac{dV_{PV}}{dt} + i_{L1} \\ v_{L2}(\mathrm{t}) = V_{C2} - V_{C1} \\ C_o\dfrac{dV_o}{dt} = i_{Co} = -V_o/R \end{cases} \quad (1)$$

ISSN 2347–3657

Volume 13, Issue 2, 2025

The switchi turns off when it receives a low pulse signal. HereweareMode #2. While the switch is off, diodes D1 and D2 are on, as shown in Figure 5. They let the injectors deplete their energy. The energy stored in inductor L1 is transferred to capacitor C2 during operation, while the energy stored in inductor L2 is sent to the output capacitor. The characteristic of this mode is defined by the following mathematical equations:

$$\begin{cases} v_{L1}(t) = V_{PV} - V_{C2} \\ i_{PV}(t) = C_{PV}\dfrac{dV_{PV}}{dt} + i_{L1} \\ v_{L2}(t) = -V_{C1} \\ C_o\dfrac{dV_o}{dt} = i_{Co} = i_{L2} - V_o/R \end{cases} \quad (2)$$

TABLE 1. Voltage stress on components of the modified SEPIC converter.

Device	Voltage Stress
Switch S	$\frac{V_o}{1+D}$
Diode D1	$\frac{V_o}{1+D}$
Diode Do	$\left(\frac{1-D}{1+D}\right)V_o$

$$V_{C1} = \left(\frac{D}{1-D}\right)V_{PV} \quad (4)$$

$$V_{C2} = \left(\frac{1}{1-D}\right)V_{PV} \quad (5)$$

$$V_o = \left(\frac{1+D}{1-D}\right)V_{PV} \quad (6)$$

Equation (6) shows the voltage gain of the converter, where D is the duty cycle of the converter. You can see the voltage stress across all of the switching components in Table 1. Because the voltage stress levels of this converter are minimal, low-rated switching devices may be used. To reduce switching and conduction losses and increase system efficiency, low rating devices must be used.

An Innovative Mpc Based Pv Mppt Method For Optimal Power Tracking

A sophisticated control technique, model predictive control (MPC) can regulate many different types of systems. The key to MPC's success is its ability to foretell the system's actions based on its model. A control input that minimizes a cost function—an error measure between the system's output and a desired reference—is commonly calculated using the model. The procedure is then repeated when the system is given the control input. When compared to other control approaches, MP Chasse provides various benefits, such as: MPC is capable of handling systems that include more than one state variable. • System restrictions may be considered by MPC. • Multiple-parameter control (MPC) may be used to systems that exhibit resistance to conventional control methods. For a more in-depth look at the MPC process, refer to Figure 6: A model of the system that needs controlling is created as the first stage in model-procedure control (MPC). Both deterministic and stochastic models are possible, and the former may be linear and the latter nonlinear. • Prediction: The model's future behavior of the system may be predicted after its development. Predictions are usually made over a certain time frame, which

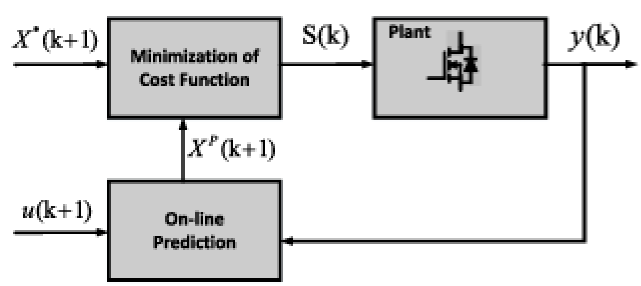

FIGURE 6. Model predictive control block diagram.

TABLE 2. Components main specifications.

Component	Value
DSPACE 12012	Main control device
Ts Sampling time	10 us
Switches type	IRFP27N60KPBF
Diode type	MUR860 — 8 A / 600 V

Represents the number of steps that the controller will gaze into the future. To find the control input that would minimize the cost function, an optimization issue must be addressed. This is known as optimization. Numerical methods like the simplex algorithm and the interior point technique are usually used to address optimization problems. • Control input: The system is then given the control input discovered in the optimization problem. • Iterate: The controller iteratively applies the control input to the system after utilizing the updated model to forecast its future behavior, finds it by solving the optimization problem, and then repeats the procedure. The forward Euler technique is used to equation (1) in switch on mode and equation (2) in switch off mode to produce the discrete time model of the redesigned SEPIC converter.

$$I_{PV}^{1}(\mathrm{k}+1) = \left(\frac{T_S}{L_1}\right) \mathrm{V}_{PV} - I_{PV}(\mathrm{k}) \tag{7}$$

$$I_{PV}^{0}(\mathrm{k}+1) = \left(\frac{T_S}{L_1}\right) (V_{PV} - V_{C2}) - I_{PV}(\mathrm{k}) \tag{8}$$

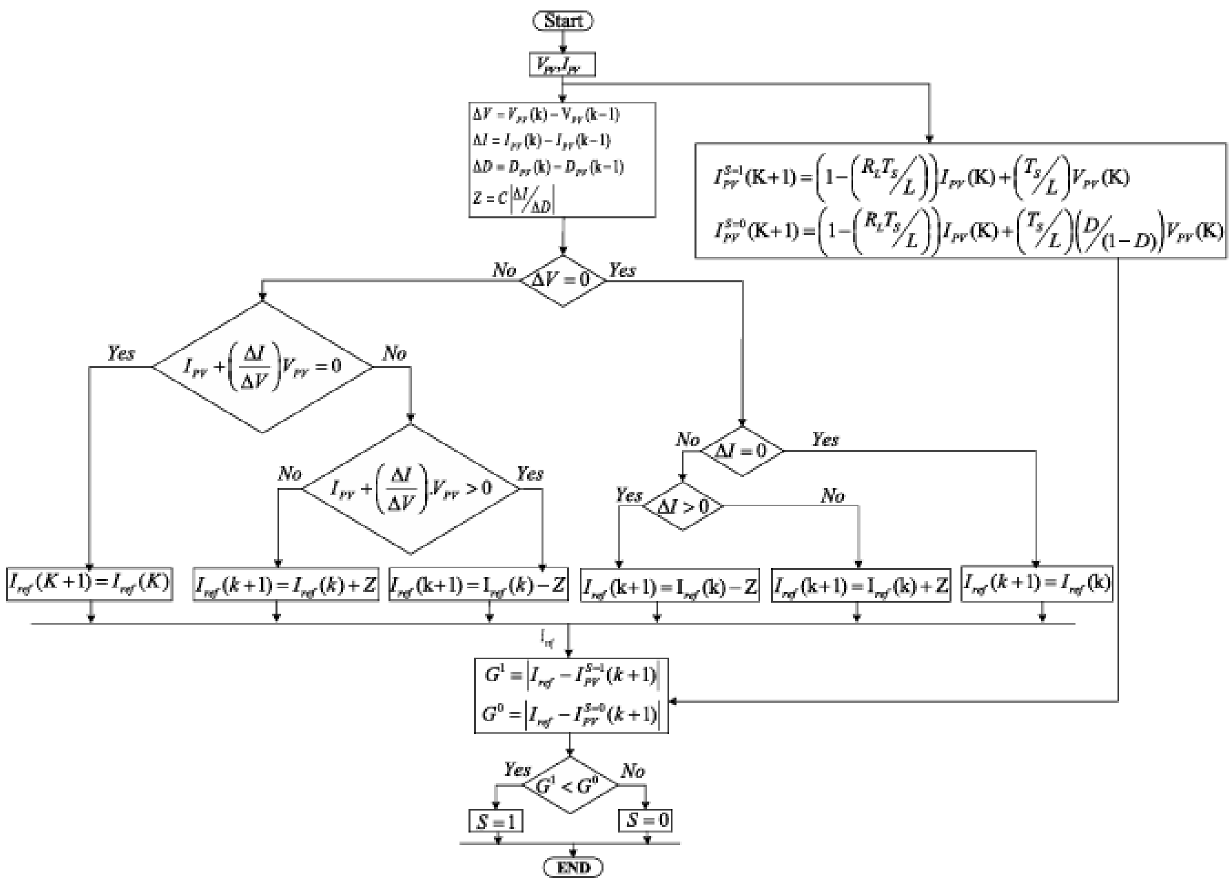

FIGURE 7. The diagram depicting the proposed method for tracking the maximum power point (MPP) using model predictive control (MPC) with fewer sensors.

$$g^{\sigma=\{0,1\}} = \left|I_{ref} - I_{PV}^{\sigma}\right| \tag{9}$$

Iref stands for the current reference and g for the objective function. The incremental conductance approach is used to acquire the current reference, Iref. In Figure 7, we can see the flow diagram of the MPC-MPPT method that has been suggested. The MPC-MPPT technique just requires the PV current and voltage data, as shown in the picture. The reference current is generated using an incremental conductance technique to match the highest power operation. After that, the MPC approach is used to regulate the converter so that it follows the reference current. The voltage observer takes the place of the capacitor's voltage sensor, as mentioned before. In the f lowchart, the perturbation step size (Z) may be either fixed or adjustable. Assigning a constant value to Z allows for the implementation of a fixed step size MPC-MPPT. On the other hand, the following equation may be used for adaptable Z design:

$$Z = C.\left|\frac{\Delta I}{\Delta D}\right| \quad (10)$$

Together, the current value of the PV current (I) and the difference between the current and prior values of the reference current (D) are used, together with a scaling factor (C).

RESULTS AND DISCUSSION

Efficiently tracking the greatest power point is a crucial component in making the most of solar energy. However, solar panels often encounter partial shading situations caused by dust and sand in regions with sandy climates, like the Middle East. Having an effective MPPT tracker is crucial for improving the photovoltaic system's economic performance in different operating situations. The main objective of this research is to create a tracker that may enhance the overall efficiency of PV plants in various scenarios. The DSPACE DS1202 is used to execute the suggested method once it has been simulated on the MATLAB platform. The experiment makes use of an 85W PV module, which, at nominal radiation and temperature of Gn=1000 and Tn=25◦C, generates a current of 4.9 A and a voltage of 17.8 V, respectively.

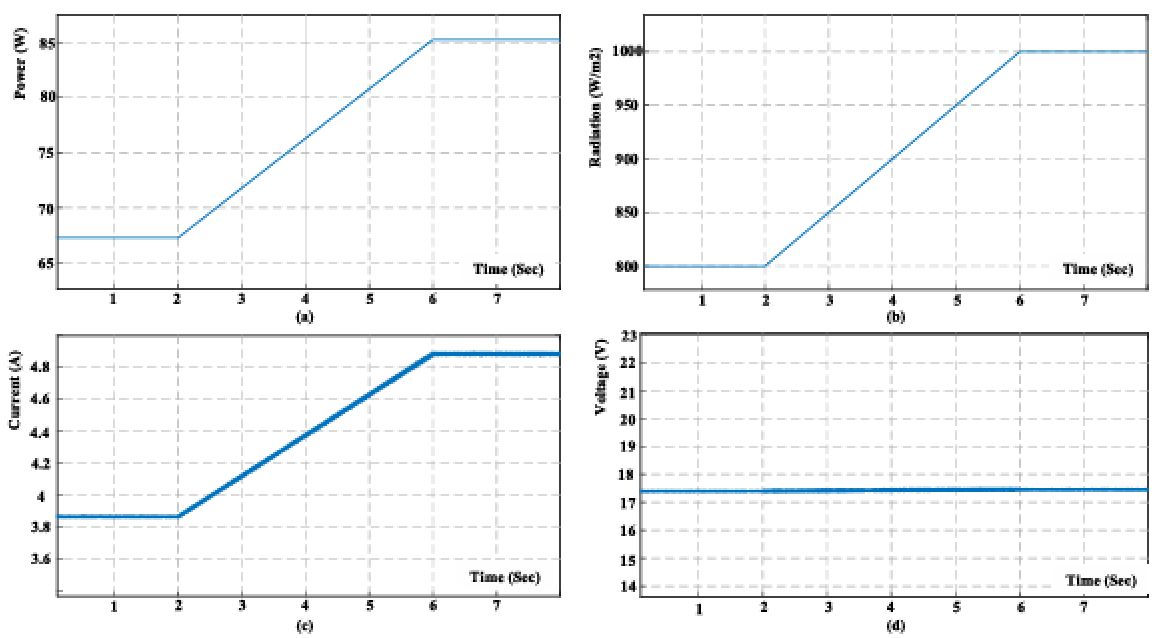

FIGURE 8. PV Output characteristics with gradual variation in solar radiation(a) Photovoltaic Power Generation, (b) Solar Irradiance, (c) Photovoltaic Current, and (d) Photovoltaic voltage.

Figures 8 and 9 show the outcomes of the MATLAB platform's simulation, whereas Figures 10–12 display the outcomes of the DSPACE DS1202's implementation. Earlier in this work, we established that solar radiation, out of all the factors, has the greatest impact on the output characteristics of PV panels. With the suggested approach, even in partially shaded environments, the maximum power point may be effectively tracked. The PV plant's total efficiency is enhanced as a consequence. Results

International Journal of Information Technology & Computer Engineering

ISSN 2347–3657

Volume 13, Issue 2, 2025

from both simulations and real-world applications demonstrate that the suggested approach has great potential to boost PV plants' economic performance even in sandy climates.

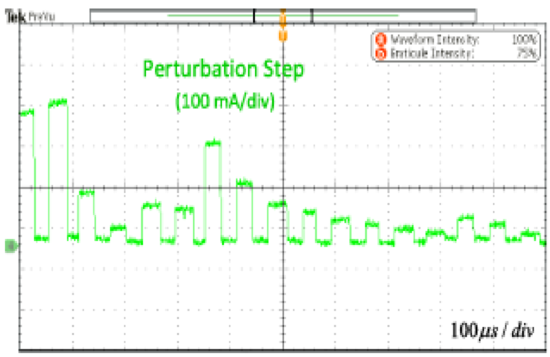

FIGURE 11. The electrical properties of the photovoltaic (PV) output are displayed as the radiation levels fluctuate between 1000 and 800 [W/m2].

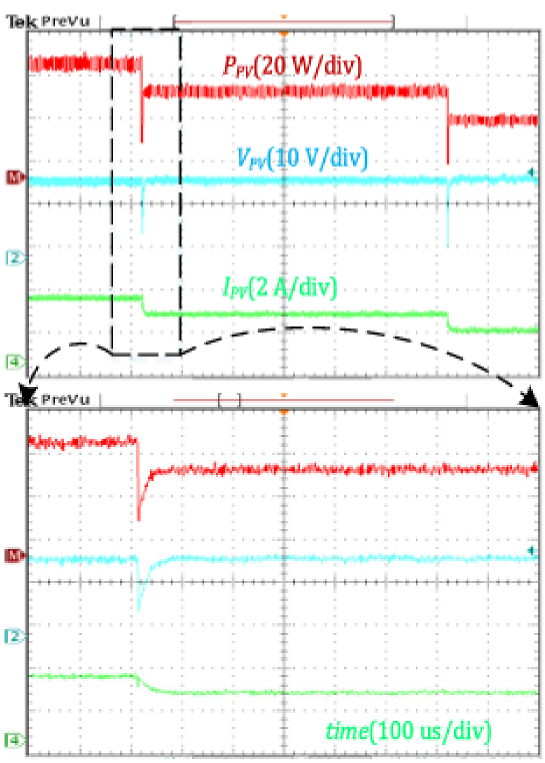

Figure: The electrical properties of the photovoltaic (PV) output are demonstrated as the radiation levels vary from 1000 to 900 and then further to 800 [W/m2].

Having an efficient maximum power point tracking (MPPT) system is crucial for making the most of solar energy. Solar panels sometimes encounter situations where they are partially shaded by dust and sand in locations where sandy weather is common, like the Middle East. This may cause the maximum power point tracking (MPPT) system to lose track of the MPP, which in turn reduces the amount of electricity that the solar panel can generate. The overarching goal of this work is to design a maximum power point tracking (MPPT) system that can increase PV plant efficiency across a range of operating situations. Before implementing it with the DSPACE DS1202, the suggested approach is tested in MATLAB. In the experiment, an 85W PV module is used, which, when subjected to standard radiation and temperatures of Gn=1000 and Tn=25◦C, generates a maximum power of 4.9 A current and 17.8 V voltage, respectively. The findings acquired from the DSPACE DS1202 implementation are shown in Figures 10–12, whereas the results obtained from the MATLAB platform are shown in Figures 8 and 9. As mentioned before in this study, the main factors influencing the output characteristics of PV panels are ambient temperature and solar radiation, with the former having a stronger effect than the latter. Radiation levels range from 500 to 1000 W/m2 and show a dramatic shift in Figure 8. The matching PV output power, output cur rent, output voltage, and solar radiation are shown in Figures 8(a)-(d). With an efficiency of more than 99.5%, the suggested MPPT controller can monitor the maximum power under every condition. Solar radiation fluctuates slowly in most real-world situations because of things like clouds moving by or sand piling up. Figure 9 shows a simulation of this slow shift in solar light. Under different operating situations, including partial shade, the suggested MPPT system can effectively track the MPP. As a result, the PV plant's total efficiency is enhanced. Results from both simulations and real-world applications show that the MPPT system is a viable option for improving PV facilities' economic performance in sandy weather. Tests and implementations utilizing the DSPACE DS1202 further confirm the system's performance.

International Journal of Information Technology & Computer Engineering
ISSN 2347–3657
Volume 13, Issue 2, 2025

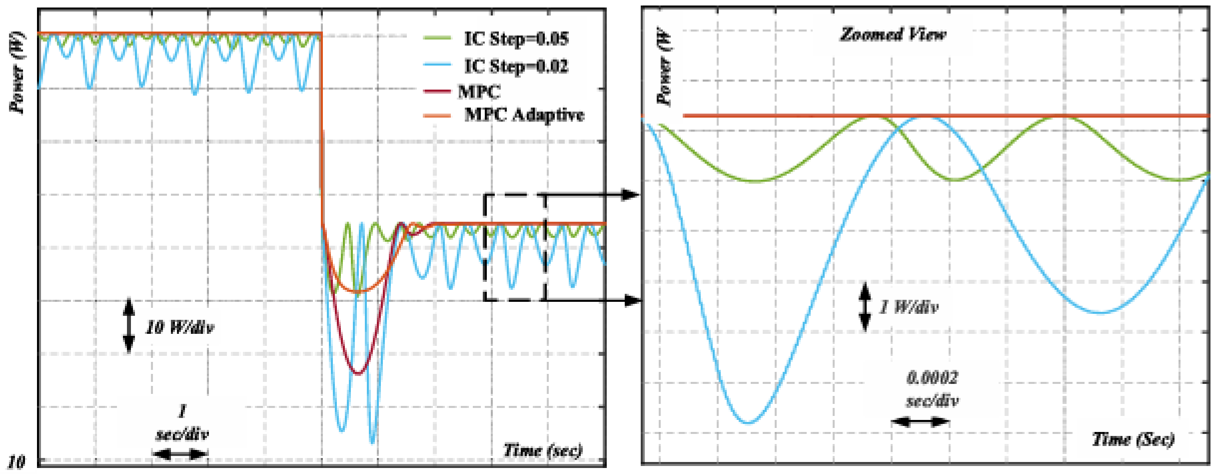

FIGURE 14. Performance comparison of proposed and other MPPT techniques under abrupt radiation change

.

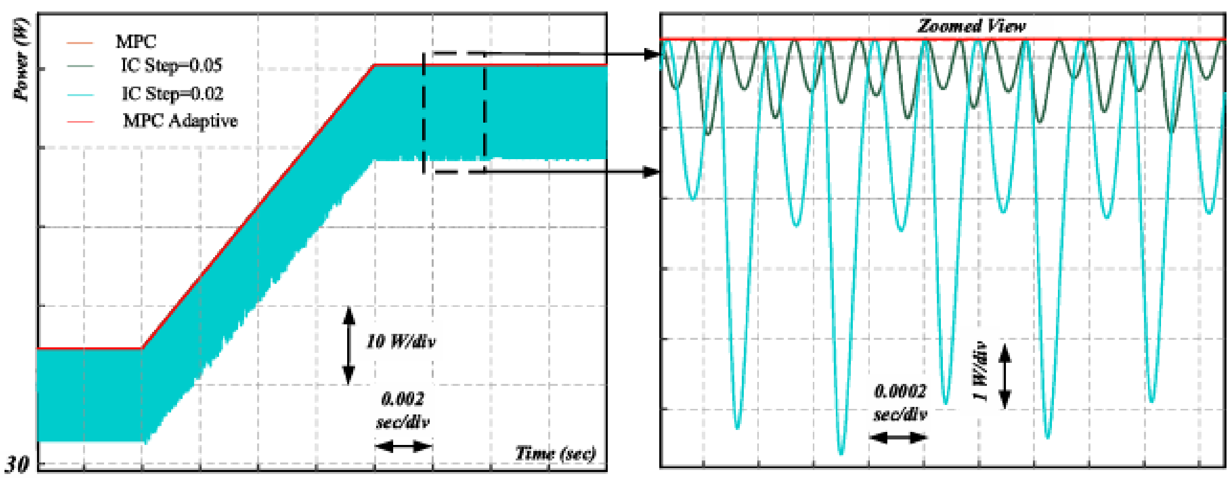

FIGURE 15. Performance comparison of proposed and other MPPT techniques under gradual radiation change.

In addition to the hardware specifications listed in Table 1. The MPC_MPPT method, presented in this work, may operate with either fixed or adjustable step sizes. The program was put through its paces in both typical and extreme weather scenarios. The majority of the current MPPT algorithms in the literature rely on the MPPT controller's step size. As an example, in order to obtain accurate maximum power tracking, algorithms like P&O, hill climb, and IncCond employ a minor perturbation step. However, this approach might slow down tracking speed or even cause tracking to fail. Although tracking efficiency drops with a big perturbation step, tracking speed goes up. Both the fixed and adaptive perturbation step sizes were used to assess the proposed technique. A change from 1000 to 500 and back to 1000 is seen in Figure

10 for the radiation (W/m2). Power, current, and voltage are shown for the PV output. With an efficiency of over 99.5%, the controller responds superbly to changes in radiation. Figure 11 depicts an alternate scenario where the radiation dose (W/m2) drops from 1000 to 800. Figure 13 depicts the adaptive perturbation stage.

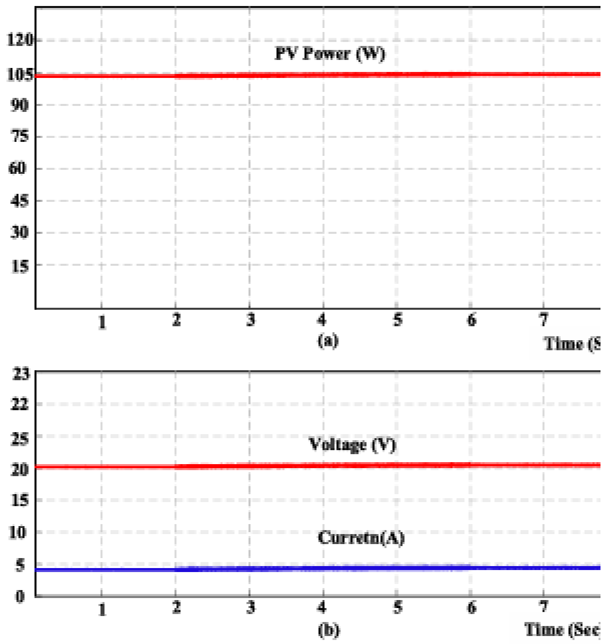

FIGURE17. PVmoduleoutputcharacteristics,voltage,current andpower.

The new MPC_MPPT method is compared with the widely known IncCond algorithm at different stepsizes, as well as with fixed and adjustable step sizes (Figures 15 and 16). With gradual variations in sun radiation, the comparison is carried out. Figure 16 shows the comparison between various strategies for progressive radiation changes, while Figure 15 shows the comparison of MPPT methods under abrupt radiation changes. At the highest power point, the slope of the PV curve is zero, and the IncCond algorithm is a regularly used approach in PV applications based on this idea. The Inc. Conditional method was tuned with two perturbation step sizes of 0.02 and 0.05. All MPPT algorithms can monitor the MPPT when the sun radiation (W/m2) rapidly declines from 1000 to 800, as demonstrated in Figure 14. In either case, the suggested system retains its performance. Under all conditions, it can reach maximum power with an efficiency of above 99.5%. The IncCond approach, on the other hand, is quite sensitive to the stepsize. The effectiveness of IncCond falls when it experiences bigger oscillations with a step size of 0.02 than 0.05. The profitability and viability of large-scale systems may be impacted by this. The gradual change in solar radiation is illustrated in Figure 15. Aside from the Incodal algorithm's heavy reliance on step size, the proposed system surpasses the others, which have comparable performance for both adaptive and fixed step sizes. More oscillations and worse efficiency are the effects of choosing a step size of 0.02 instead of 0.05. Complexity, efficiency, trackingability, trackingspeed, and dependability are some of the key criteria that determine the choosing of an MPPT approach. The solar radiation levels in the example study shown in Figure 13 showed a dramatic fluctuation, oscillating from 1000 to 900 and then further to 800W/m2. It was predicted that the PV module used in the experiment would yield 55 W of electricity under these circumstances. But for all three radiation levels, the suggested method successfully tracked the maximum power point. The algorithm's short reaction time of around 50 microseconds to changes in the environment was also noteworthy. Underscoring its resilience and dependability, the algorithm's effective implementation under such circumstances provides evidence of its potential for usage in real-world applications. Due to the occurrence of several peaks, partial shadowing poses a substantial difficulty for photovoltaic (PV) systems and may cause control failures.

To solve this problem and lessen the impact of partial shade, many methods have been suggested in the literature. Over the last ten years, scientists have examined and contrasted a number of MPPT approaches, including P-V characteristics, models, and ways to measure the peak output of PV modules and arrays under partial shadowing (PSC). While studies on PV models aim to provide a unified model of the PV array and a realistic model of the PV unit for usage in complicated situations, studies on PVout put characteristics examine failure, power loss, and voltage changes in the MPPT technique under PSC. When it comes to upgrading the GMPPT algorithm for PV system applications, the findings of these research are crucial. Using heuristics and clever optimization algorithms, traversing all maximum points, and defining the area of maximum power are the three categories of maximum power tracking techniques. Every option has its own set of pros and cons. Citations [28], [29]. In order to replicate partial shadowing as closely as possible, the PV module's cells are split into three groups, with each group exposed to a different amount of radiation. Each group is provided with bypass diodes to guarantee continuous current flow even when partially shaded. The three groups have been given radiation doses of 1000W/m2, 300W/m2, and 600W/m2 correspondingly. The resultant output power of the system under study is shown in Figure 16. The method that we have proposed is meant to monitor the system's global maximum power point. Figure 17 shows the operating point of the system according to the suggested control mechanism. Section V. Review Using model predictive control (MPC) and only two sensors, this research proposes a dependable approach for identifying the maximum power point (MPP) of a photovoltaic (PV) system. An observer obtained from the converter analysis replaces the voltage sensor. Either a fixed or adjustable step size may be used with the technique. It has been shown that the algorithm can reach the MPP in very difficult circumstances. In detail, the article explains the suggested control method. The efficiency of the algorithm was confirmed via testing it under different scenarios. When using either fixed or adjustable perturbation step sizes, the technique produced similar results.

An improved SEPIC converter for photovoltaic uses is also covered in the article. High efficiency, low voltage stress, and a high voltage gain are just a few of the benefits of this converter. In order to ensure the system's proper functioning, the DSPACE DS1202 was used throughout its implementation. Fast tracking and great efficiency were only two examples of the algorithm's stellar performance shown by the findings. A more in-depth description of the suggested method is provided here: • The MPC algorithm forecasts the MPP by using a PV system model. To keep tabs on the MPP, the algorithm determines the best control input to use. • The PV system is controlled to follow the MPP. • The algorithm is iterated endlessly to follow the MPP's changes. Comparing the suggested method to existing MPP monitoring methods reveals various benefits: You can trust it to keep tabs on the MPP even in the most challenging environmental circumstances. • It optimizes the use of the PV system and gets the most electricity out of it. • It requires just two sensors and is easy to set up.

REFERENCES

[1]. M.E.Khodayar, M.R.Feizi, and A. Vafamehr, ''Solar photovoltaic gener ation: Benefits and operation challenges in distribution networks,'' Electr. J., vol. 32, no. 4, pp. 50–57, May 2019, doi: 10.1016/j.tej.2019.03.004.

[2]. IEA, Paris, France. (2022). Solar PV, IEA. [Online]. Available: https://www.iea.org/reports/solar-pv

[3]. Jennifer Morris | MIT Energy Initiative, MIT News | Massachusetts Institute of Technology. (2020). Researchers Find Benefits of Solar Photovoltaics Outweigh Costs. [Online]. Available: https://news.mit.edu/ 2020/researchers-find-solar-photovoltaics-benefits-outweigh-costs-0623

[4]. A. Gonzalo, A. Marugán, F. Márquez, ''Survey of maintenance man agement for photovoltaic power systems,'' Renew. Sustain. Energy Rev., vol. 134, pp. 110347–110352, Dec. 2020.

[5]. M. B. Hayat, D. Ali, K. C. Monyake, L. Alagha, and N. Ahmed, ''Solar energy—A look into power generation, challenges, and a solar-powered future,'' Int. J. Energy Res., vol. 43, no. 3, pp. 1049–1067, Mar. 2019.

[6]. O. Abdel-Rahim, A. Chub, D. Vinnikov, and A. Blinov, ''DC integration of residential photovoltaic systems: A survey,'' IEEE Access, vol. 10, pp. 66974–66991, 2022, doi: 10.1109/ACCESS.2022.3185788.

[7]. N. Kapilan, K. C. Nithin, and K. N. Chiranth, ''Challenges and opportuni ties in solar photovoltaic system,'' Mater. Today, vol. 62, pp. 3538–3543, Jan. 2022.

[8]. M. Kumar, K. P. Panda, J. C. Rosas-Caro, A. Valderrabano-Gonzalez, and G. Panda, ''Comprehensive review of conventional and emerging maxi mum power point tracking algorithms for uniformly and partially shaded solar photovoltaic systems,'' IEEE Access, vol. 11, pp. 31778–31812, 2023, doi: 10.1109/ACCESS.2023.3262502.

[9]. H. Y. Ahmed, O. Abdel-Rahim, and Z. M. Ali, ''New high-gain trans formerless DC/DC boost converter system,'' Electronics, vol. 11, no. 5, p. 734, Feb. 2022.
[10] M. Tayyab, A. Sarwar, I. Parvez, M. Tariq, M. R. Hussan, S. Mekhilef, B. Alamri, and A. Alahmadi, ''Maximum power point tracking in a solar PV system:

Current trends towards nature-inspired optimization tech niques,'' Int. Trans. Electr. Energy Syst., vol. 31, no. 12, p. e13197, Dec. 2021.

[10]. S. Mohanty, B. Subudhi, and P. K. Ray, ''A grey wolf-assisted perturb & observe MPPTalgorithm for a PV system,'' IEEE Trans. Energy Convers., vol. 32, no. 1, pp. 340–347, Mar. 2017, doi: 10.1109/TEC.2016.2633722.

[11]. O. Abdel-Rahim and H. Funato, ''A novel model predictive control for high gain switched inductor power conditioning system for photovoltaic applications,'' in Proc. IEEEInnov.SmartGridTechnol.-Asia(ISGTASIA), Kuala Lumpur, Malaysia, May 2014, pp. 170–174, doi: 10.1109/ISGT Asia.2014.6873784.

[12]. S. R. Kiran, C. H. H. Basha, V. P. Singh, C. Dhanamjayulu, B. R. Prusty, and B. Khan, ''Reduced simulative performance analysis of variable step size ANN based MPPT techniques for partially shaded solar PV systems,'' IEEE Access, vol. 10, pp. 48875–48889, 2022, doi: 10.1109/ACCESS.2022.3172322.

[13]. A. Hussain, H. A. Sher, A. F. Murtaza, and K. Al-Haddad, ''Improved restricted control set model predictive control (iRCS-MPC) based maximum power point tracking of photovoltaic module,'' IEEE Access, vol. 7, pp. 149422–149432, 2019, doi: 10.1109/ACCESS. 2019.2946747.

[14]. I. Pervez, C. Antoniadis, and Y. Massoud, ''A reduced search space exploration Metaheuristic algorithm for MPPT,'' IEEE Access, vol. 10, pp. 26090–26100, 2022, doi: 10.1109/ACCESS.2022.3156124.

[15]. A. M. A. Malkawi, A. Odat, and A. Bashaireh, ''A novel PV maximum power point tracking based on solar irradiance and circuit parameters estimation,'' Sustainability, vol. 14, no. 13, p. 7699, Jun. 2022, doi: 10.3390/su14137699.

[16]. M. Kermadi and E. M. Berkouk, ''Artificial intelligence-based maxi mum power point tracking controllers for photovoltaic systems: Com parative study,'' Renew. Sustain. Energy Rev., vol. 69, pp. 369–386, Mar. 2017.

[17]. A. S. Benyoucef, A. Chouder, K. Kara, S. Silvestre, and O. A. Sahed, ''Artificial bee colony based algorithm for maximum power point tracking (MPPT) for PV systems operating under partial shaded conditions,'' Appl. Soft Comput., vol. 32, pp. 38–48, Jul. 2015.

[18]. J. C. Camilo, T. Guedes, D. A. Fernandes, J. D. Melo, F. F. Costa, and A. J. Sguarezi Filho, ''A maximum power point tracking for photovoltaic systemsbasedonmonodequation,''Renew.Energy,vol.130,pp. 428–438, Jan. 2019.

[19]. M. Kermadi, Z. Salam, J. Ahmed, and E. M. Berkouk, ''A high performance global maximum power point tracker of PV system for rapidly changing partial shading conditions,'' IEEE Trans. Ind. Elec tron., vol. 68, no. 3, pp. 2236–2245, Mar. 2021, doi: 10.1109/TIE. 2020.2972456.