An Improved Novel Lipschitz Optimization Algorithm with FBBIC Converter for Photovoltaic System Under Partial Shaded Condition

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Abstract—

This paper presents a maximum power point tracking (MPPT) and a global maximum power point tracking (GMPPT) control strategy for solar systems, both of which use maximum power point tracking (MPPT). The method was developed using a Lipchitz optimization approach and applied on the Full-Bridge Boost Isolated Converter (FBBIC). It takes into account the fact that the outside environment can change quickly. In the Lipchitz Optimization Method (LOM) algorithm, a tangent trigonometric nonlinear function is used as a convergence factor. Soft switch technology for photovoltaic (PV) system FBBIC converters is also made possible by the use of phase-shift and active-clamp circuits. For a final stage, the proposed LOA algorithm was used to investigate and compare the performance of photovoltaic (PV) systems under static and dynamic partial shadowing conditions (PSCs) with other commonly used algorithms such as perturb and observe (P&O), particle swarm optimization (PSO), and others. The proposed control mechanism is shown to be successful and stable, especially when it comes to monitoring speed under PSCs, as demonstrated in this paper. Using simulations, it has been demonstrated that the Lipchitz Optimization Method (LOM) method with the FBBIC topology outperforms other algorithms in the majority of cases.

Keywords—Photavoltaic, LOM, FBBIC, MPPT, Partial Shading

I. INTRODUCTION

Photovoltaic energy systems have grown in popularity over the last few decades, owing to the fact that they are renewable and beneficial to the environment. The amount of energy produced by a photovoltaic array is dependent on the amount of photons that it is sensitive to, how hot it is, and how much voltage it has available. A DC/DC boost converter FBBIC combined with an active clamp converter can be used to adjust the voltage of a PV system in order to get the maximum amount of power from it. Dealing with the maximum and global peak of a Photovoltaic array's P-V curve under varying irradiation conditions is critical for the PV array to monitor the global maximum power point rather than the local maximum power point (GMPPT) (LMPPT). The development of global and local maximum power point tracking (MPPT) algorithms to improve the output efficiency of PV systems that work with PSCs has been the subject of numerous ideas and advances.

To figure out how to track and extract the most power out of a solar panel when the amount of light changes, perturbation, observation, and the incremental conductance approach are frequently used in conjunction with one another. When photovoltaic panels are exposed to sunlight in real time, traditional algorithms such as P&O may not be able to track the output of şolar PV arrays due to the nature of the data. A number of high-precision mppt algorithms have been developed and released as a result of this failure in order to track the global maximum power point tracking technique under a variety of lighting circumstances.

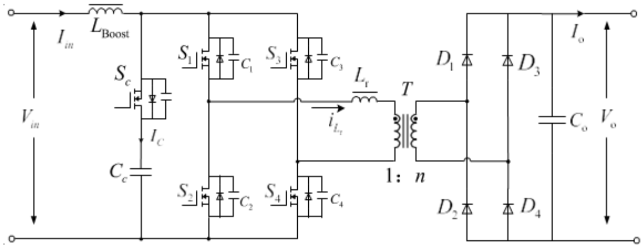

Fig.1 FBBIC with active Clamp Converter

When compared to the usual fuzzy MPPT algorithm, the recommended MPPT strategy in [9], which incorporated the robust fuzzy logic control approach and the fractional-order method, enhanced tracking accuracy in weather fluctuations. The most often researched strategies to extract maximum power under uniform irradiance conditions are perturbation and observation (P&O) and incremental conductance (IC) among the various MPPT methods established thus far. Standard MPPT algorithms, on the other hand, may fail to follow the PV array's output GMPP when it is exposed to PSCs. As a result, several novel MPPT algorithms have been released that can properly track the GMPP of a PV array under PSCs. When compared to the usual fuzzy MPPT algorithm, the recommended MPPT technique, which integrated sophisticated control approaches such as resilient fuzzy control and the fractional-order control method, enhanced tracking accuracy in weather fluctuations. This change will improve algorithm convergence and reduce tracking time. Because the random numbers have been removed, the technique cannot be guaranteed to follow the GMPP in different PSCs. In a solar system with partial shading, a new algorithm was introduced. The key benefit is that once the GMPP is discovered, the steady-state oscillation is reduced.

A global optimization technique based on the Lipschitz constant and function was introduced in 2017 and has shown promise in conventional benchmarks for global optimization. Lipchitz optimization (LOM) is a technique that optimizes global parameters using the Lipschitz constant and function. Specifically, it has been demonstrated that the LOM technique, which takes advantage of the function's global smoothness, achieves faster convergence rates on globally smooth problems than previously known methods that simply take advantage of the function's local smoothness, and that it is faster than any random research optimization strategies. A global value is assigned to a function for which the Lipschitz constant is known.

These algorithms, despite their high efficiency and performance, have a number of basic problems that must be addressed. The process of adjusting several parameters of various optimization methods, such as the PSO algorithm, is time-consuming. The method may diverge if one or more parameters are entered incorrectly. Both the amount of biological particles present and the starting values of these particles influence track. The approaches necessitate the movement of random numbers from the LMPP to the GMPP; however, this greatly slows down the tracking speed. To summarize, the overall performance of the algorithms listed below is subpar in comparison to other algorithms. The LOM MPPT approach, as well as how to maximize the output power of a PV system while calculating the Lipchitz constant, are discussed in detail. Evolutionary algorithms are often used in the MPPT region of PV arrays and are of particular interest to academics because of their ability to deal with nonlinear difficulties in a straightforward manner. The new LOM MPPT technique is compared to two well-known, high-performance evolutionary algorithms: the modified PSO (M-PSO) algorithm and the modified firefly optimization. Simulations and experiments are used to compare the two techniques (M-firefly). The LOM MPPT approach, as well as how to maximize the output power of a PV system while calculating the Lipchitz constant, are discussed in detail. Evolutionary algorithms are often used in the MPPT region of PV arrays and are of particular interest to academics because of their ability to deal with nonlinear difficulties in a straightforward manner. The new LOM MPPT technique is compared to two well-known, high-performance evolutionary algorithms: the modified PSO (M-PSO) algorithm and the modified firefly optimization. Simulations and experiments are used to compare the two techniques (M-firefly). The remaining sections are laid out in the following manner. Section II discusses the characteristics of a LOM Optimization Algorithm and how it might be used. The operating premise of the LOM MPPT algorithm, which has been proposed, is also explained. The topological structure of the FBBIC Converter is depicted in Section III. The novel method is then tested and compared to two current popular MPPT algorithms, which are developed through simulations and testing. The results of the computational analysis are reported in Section III. The conclusion of the document brings the paper to a close. System Simulation is a term used to describe the process of simulating a system. In 201, Premkumar and sowmya [10] published an efficient global optimization methodology based on the Lipschitz constant that can produce faster rates of convergence on globally smooth problems than previously known methods that rely solely on the function's local smoothness. It works well and has been proved to be faster than a pure random search approach in theory.

If a Lipchitz function f (x), x X, fulfils the Lipchitz condition f (xi)-fmin(x0) k xi-x0 for all xi X, the call k is the Lipchitz constant. The Lipchitz constant k is the function's maximum possible slope, and x0 is the x value that minimizes the function's value. The Lipchitz condition k can be used to calculate the function's upper bound during optimization. There are two upper bound curves at each point x since the Lipchitz criterion includes absolute value symbols. For all possible x values, the LOM global optimization method seeks the maximum value of an unknown function f (x).

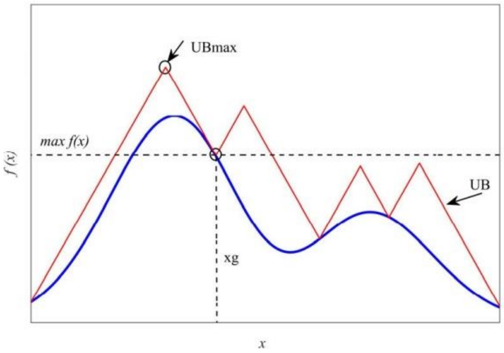

Fig.2 LOM algorithm – an introduction

3) For each iteration, update the best evaluation value max f (x) that has been obtained so far, and then search for a new x until the number of iteration times n equals the maximum number of iterations.

The greatest value max f (x) and the corresponding variable g, which represents the ideal value of the function being evaluated, should be printed out when each iteration is completed.

A. Local Optimum Mapping-Based MPPT Algorithm (also known as MPPT-LOM)

The maximum power point tracking (MPPT) of a PV system is, at its heart, a problem of global optimization. The LOM algorithm is a novel and effective method of tracking the GMPP of a PV system by use of global optimization. It is proposed in this paper that the LOM be used to implement an MTTP algorithm. As part of this investigation, a PV system with an FBBIC converter is used to test the LOM-based MPPT approach. These converters are capable of tracking the MPP of a PV array at all times, regardless of how much sunlight strikes the array, how hot it is, or how much load is attached. A resistive load is utilised to absorb the power that is transferred from the PV system to the boost converter for the sake of this inquiry, rather than an actual inverter, which would be more appropriate. This helps to make the experimental setup as minimal as possible. The maximum power point (MPP) of the PV system can be determined by monitoring the duty cycle of the switch that controls the boost converter.

Algorithm:

```
LOM (N, K, X)
  1. Inputs: Lipschitz total iteration times N, constant K and input space X.
  2. During Initialization : find the function value, upper bound at $x_{min}$ curves and max f(x)
  3. Iterations:
       While $n<N$
         Selectarandom$x$inthespace$X$.
         Ifupperbound($x$)>   max $f(x)$ ThenCalculate $f(x)$andupdatemax$f(x)$.
           Calculatetheupperboundcurvesatthepoint$x$.
         Endif
       EndWhile
  4. Output:max$f(x)$.
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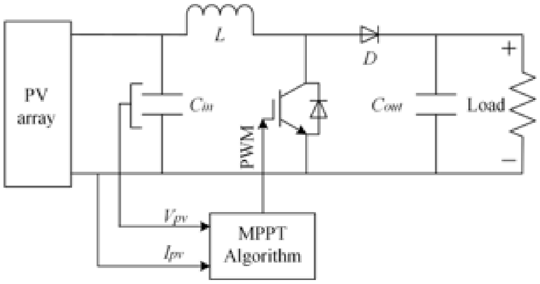

Fig.3 MPPT based PV System

III.THE TOPOLOGY STRUCTURE OF THE FBBIC CONVERTER

For this study's MPPT and DC booster management of PV arrays, the FBBIC converter design is used due to the demand for a high-power, high-ratio converter by the PVDC boost collecting system. Illustration of the topological structure can be found in Figure 1. In Figure 1, L represents the boost inductor, S1–S4 represents the full-bridge circuit, Cs1–Cs4 represents the junction capacitance of the switches, Lr represents the transformer's equivalent leakage inductance, and C0 represents the output capacitor. The timing scheme and critical waveforms of the converter are illustrated in Figure 2. Using the leakage inductance of the transformer as a source of power, Sc and Cc form an active-clamp circuit that can be used to control the peak voltage at both ends of switches generated by the leakage inductance of the transformer, achieve zero-voltage switching (ZVS), and minimise switching loss. There is a 180-degree phase difference between the driving pulses S1, S4, and S2, S3 and between the driving pulses S1, S4. In normal functioning, the duty cycle range is between 0 and 100%. (0.5,1). Upon turning off all four switches S1-S4, the energy stored in the inductor L Boost is trapped inside the loop, resulting in a huge peak voltage at both ends of the switch circuit.

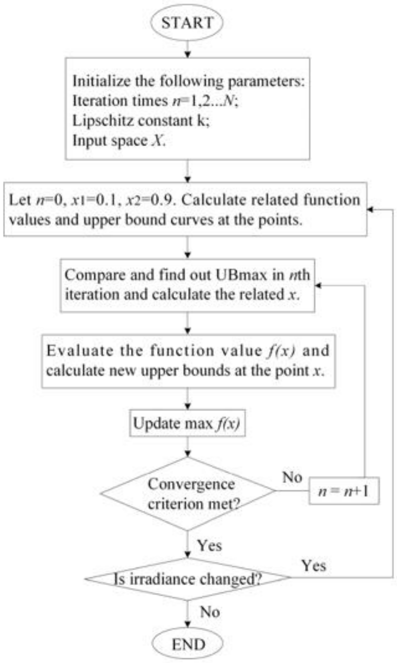

Fig.4 LOM Flowchart

In the initial phase (t1), all four switches, S1-S4, are turned on, putting the circuit into boost mode. Furthermore, the inductor current grows linearly with a slope equal to Vin/LBoost as the inductor current increases. The output voltage is provided by the capacitor C0.

Disconnect the S2, S3 switches on Stage 2 (t1-t2) from the rest of the stage (t1-t2). The active clamp switch Sc is still deactivated at the time of writing. The clamp capacitor Cc receives a portion of the inductor current from the body diode of the Sc. It is possible to minimise the peak voltage in the presence of leaky inductance.

In the presence of the active clamp switch Sc's body diode and due to its conduction, the voltage at both ends of the switch S is about zero at the second time step. The S is triggered by pressing the ZVS key on the keyboard. After that, the clamp capacitor and the stored energy of the inductor current are connected to the load. The leakage current of the transformer has now surpassed the leakage current of the input inductor.

The active clamp switch Sc is disengaged at the end of stage four (t4-t5). Because the transformer leakage current exceeds the input inductor current, the excess current flows to the junction capacitances of S2 and S3, as well as to the junction capacitance charge, as shown in the diagram. When the leakage current of the transformer equals the current of the input inductor, the body diodes S2, S3 are activated to provide protection.

The body diode is triggered in the fifth stage (t5-t6) in order to generate ZVS for the switches S2, S3, and S4. Because all of the switches S1-S4 are turned on at the same time, the circuit will operate in Boost mode for the time being.

It is after t6 that the circuit begins the second phase of its cycle, which corresponds to Stages 1 through 5.

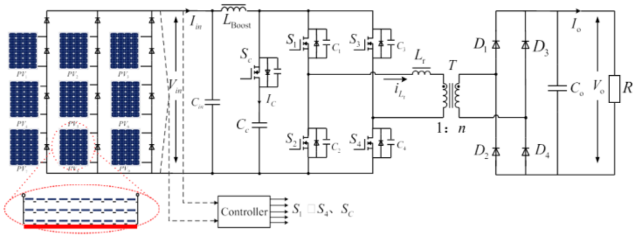

Fig.5 Proposed Converter with PV as Input

IV RESULTS

The model of the LOM-based FBBIC converter for an updated solar system is partially shadowed conditions and was done using the MATLAB 2019B software.

The output power of the converter with and without the LOM algorithm is clearly depicted in Figure 6, which is easy to understand. With or without the LOM method, there are huge variations in output power as well as abrupt rising and falling edges in output power when partial shading is in effect.

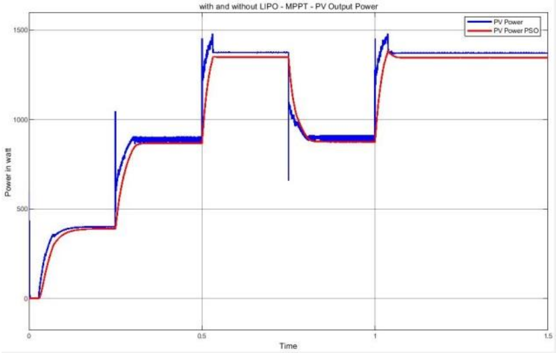

Fig.6 with and without LOM

In fig.7 depicts the irradiance variation in a photovoltaic system for simulating results in partial shadowed conditions by adjusting the irradiance.

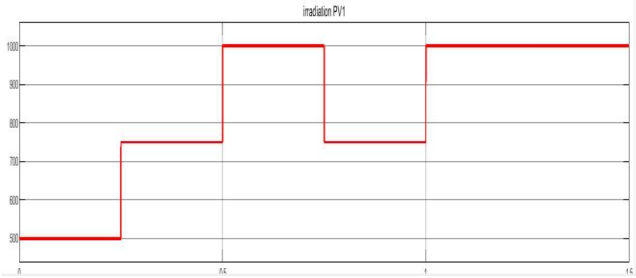

Fig.7 Irradiance

In fig.8 displays the output voltage and current of the FBBIC converter. The output voltage fluctuates in response to changes in irradiance. The current will fluctuate somewhat in response to changes in irradiance.

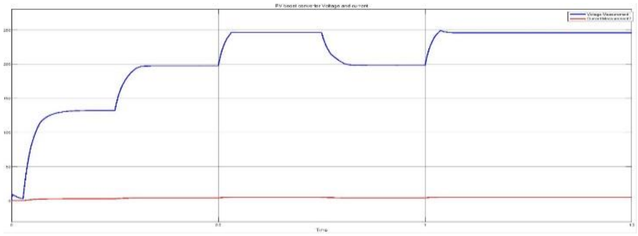

Fig.8 FBBIC Converter Voltage and Current

Fig.9 shows the photovoltaic panel voltage vs photovoltaic power

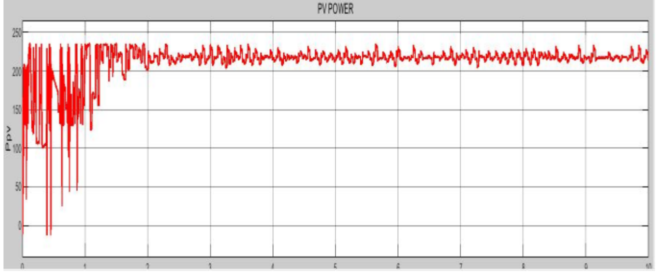

Fig.9 PV Voltage Vs PV Power

It displays the output current and voltage of the FBBIC converter. The output voltage fluctuates in response to changes in irradiance. The current will fluctuate somewhat in response to changes in irradiance.

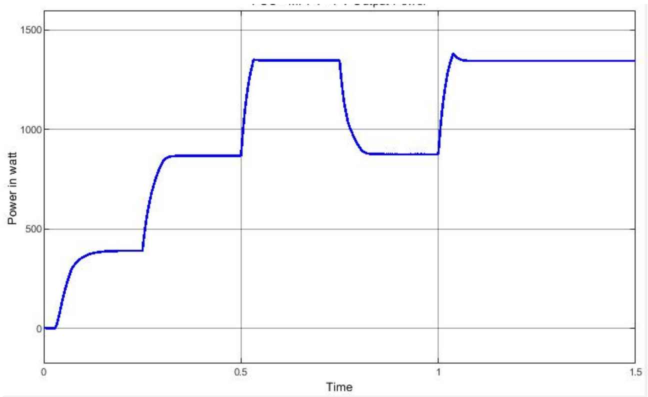

Fig.10 MPPT PV Output Power

In comparison to traditional and other algorithms, the simulation results reveal that the LOM-based MPPT algorithm has a greater efficiency and tracking speed. Under partial shading, the suggested LOM-based MPPT algorithm performs exceptionally well.

V CONCLUSION

This study presents a new LOM MPPT algorithm that performs exceptionally well under partial shadowed situations. The operational principle of the proposed LOM MPPT algorithm is provided, as well as the output characteristics of the PV array under partial shadowed situations. MATLAB was used to simulate the LOM MPPT method, which was implemented in the FBBIC converter. The Lipschitz constant is a crucial parameter in the LOM MPPT algorithm, and the paper explains how to calculate it. The proposed method has good dynamic performance and can monitor the GMPP under a variety of partial shaded conditions. The M-PSO and M-firefly algorithms were chosen for comparison and performance testing through simulations and experiments.

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