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COMPARATIVE STUDY OF SOLAR PHOTOVOLTAIC SYSTEM using MPPT TECHNIQUES

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ABSTRACT: Solar Photovolatic array systems are a form of renewable energy that harnesses the energy from sunlight to produce electrical energy. The attributes of the current and voltage in solar cells are varied, and the MPP of solar cells is temperature-and sun-dependent. Therefore, It's crucial to swiftly change the highest power setting. monitoring control in a variety of temperature and sun Emergencies involving radiation. The comparable cell type is solar circuit was created using MATLAB and Simulink in the suggested solution. Using this structure, a photovoltaic (PV) generator was created that can be utilized with a the use of MPPT unit in addition to a boost converter.

For optimal power output and efficiency for solar Photovolatic system, It's crucial to use it at its MPP (maximum power point). Hence, an efficient The maximum power point tracking (MPPT) method is crucial. While the Perturb and Observe (P&O) method was popular and straightforward MPPT technique, it has a drawback of generating oscillations around the MPP. This shortcoming can adversely affect the accuracy and efficiency of the MPPT technique. The PSO, CS, and GWO methods are relatively new and have shown promising results in terms of accuracy and efficiency. However, each method has its limitations, such as high computational complexity and sensitivity to initial parameters. A thorough evaluation of various MPPT techniques, taking into account different environmental factors including temperature and sunlight irradiance, has shown that the Particle Swarm Optimization (PSO) method outperforms other techniques in terms of both accuracy and efficiency. It is recommended that the selection of an appropriate MPPT technique for a solar PV system should be based on specific system requirements and the desired trade-offs between accuracy, efficiency, and computational complexity. This research paper provides valuable insights into the selection of the most suitable MPPT technique for a given application, which can be useful for seeking specialists in solar energy research and engineering.

The MPPT Algorithms was chosen P&O, PSO, CS, GWO. The results of the simulation demonstrate that a solar panel may produce its most electricity during varying operating conditions.

INTRODUCTION

Solar panels at MPP provide electricity with the highest possible efficiency and the fewest possible losses. These systems comprise interconnected solar panels, or photovoltaic modules, which are mounted on a support structure, typically on a rooftop or the ground. The panels consist of numerous photovoltaic cells that generate a direct current (DC) when exposed to sunlight. Then, using an inverter, the DC power is changed into alternating current (AC) energy, which can be used to power electrical loads or transmitted into the electrical grid. The size and capacity of a solar PV array system can vary based on the energy requirements of the user, the sunlight available, and the location's physical constraints. A significant benefit of solar PV array systems is that they generate electricity with minimal maintenance and without producing any emissions. They are also becoming increasingly cost-effective, making them a popular choice for residential, commercial, and utility-scale applications.

Environmental factors, including temperature, shading, and the angle of sunlight, can impact the efficiency and performance of solar PV array systems. To enhance the system's performance, Maximum Power Point Tracking (MPPT) is commonly used in conjunction with PV arrays. The MPPT technique helps optimize the PV array's performance by ensuring it operates at the maximum power point (MPP). The MPP refers to the point at which the PV array generates the most substantial power output under specific environmental conditions. By using the MPPT technique, the performance and efficiency of the PV array can be improved, leading to better overall system performance.

Variations in environmental conditions, such as temperature, shading, and the angle of sunlight, cause fluctuations in the output voltage and current of the PV array. To maintain optimal performance, the MPPT system continually monitors the voltage and current of the PV array and adjusts the output voltage of the system accordingly. This is accomplished through the use of a DC-DC converter whose duty cycle is continuously adjusted by the MPPT controller. By regulating the energy flow between the PV array and the load, the MPPT controller ensures that the PV array operates at its MPP.Therefore, to optimize the performance of a PV array system, the MPPT technique is crucial. It ensures that the PV array functions efficiently and generates the most substantial possible power output, which can improve the system's overall performance and reduce

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its cost. By installing well-designed MPPT systems, the efficiency of a PV array system can be significantly increased, leading to improved performance in various environmental conditions.

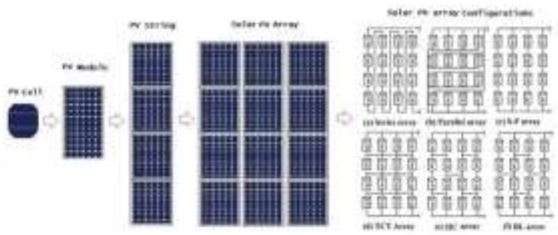
MPPT techniques are primarily used to enhance the efficiency of solar photovoltaic (PV) systems by maximizing the system's power output at its maximum power point (MPP). By optimizing the energy output of the PV system, MPPT techniques offer several specific benefits, including:

1.Maximizing energy production: By constantly monitoring the environmental conditions and adjusting the operating point of the PV system, MPPT techniques can effectively optimize the performance of the system, enabling it to operate at its maximum power point (MPP). This results in higher energy production, increased energy output, and ultimately, a reduction in the overall cost of the solar energy system.

2.Improving efficiency: The MPPT techniques can enhance the efficiency of the solar energy system by continuously adapting the operating point of the PV system. This helps to improve the overall effectiveness of the system, making it more economical and minimizing the energy loss resulting from unfavorable operating conditions.

3.Handling variable environmental conditions: MPPT techniques are particularly advantageous in dealing with the ever-changing environmental conditions that can impact the performance of a PV system, such as temperature fluctuations, shading, and sunlight angle. MPPT techniques can adapt to these conditions, ensuring that PV system operates efficiently regardless of the environmental conditions.

4.Reducing system cost: MPPT techniques offer a cost-effective solution for enhancing the performance of solar energy systems without requiring additional hardware such as solar panels. By optimizing the energy output of the PV system, MPPT techniques can increase energy production and improve overall performance, thus reducing the cost of the solar energy system.



LITERATURE SURVEY

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1."A Survey on Maximum Power Point Tracking Techniques in Photovoltaic Systems" by E. Koutroulis et al. (IEEE Transactions on Sustainable Energy, 2016) covers the different MPPT algorithms, their advantages and disadvantages, recent advancements in the field, and the practical implementation of MPPT techniques in PV systems. The authors also discuss the performance of these techniques under different environmental conditions.

2."A Comprehensive Review of MPPT Techniques for Photovoltaic Systems" by S. Jain and S. Jain (Renewable and Sustainable Energy Reviews, 2018) focuses on recent developments in MPPT techniques for PV systems. The authors review the mathematical models of various MPPT techniques, their performance under varying environmental conditions, and the challenges associated with their implementation in PV systems. They also propose solutions to overcome these challenges.

3."A Review of Maximum Power Point Tracking Techniques for Photovoltaic Power Systems" by S. Mekhilef et al. (Renewable and Sustainable Energy Reviews, 2012) covers classical MPPT techniques like Perturb and Observe and Incremental Conductance, as well as Artificial Intelligence-based techniques. The authors discuss the performance of these techniques under different operating conditions, along with the challenges associated with their implementation in PV systems. They also provide recommendations for improving the performance of MPPT techniques in PV systems.

IMPLEMENTATION OF MPPT TECHNIQUES

Simulink is widely used an instrument for simulating and modelling dynamic systems, that includes PV array systems with MPPT techniques. A standard approach to implement MPPT techniques in

1. Model the PV array system: To start with, the fact that it's essentialto create simulationillustration titled solar power array system using Simulink. This involves setting up the photovoltaic array's specifications, which include number for cells, their efficiency, temperature coefficients, and other environmental factors that can impact the system's performance. Additionally, the model must incorporate the with a DC-DC converter converting DC photovoltaic array's production of electricity into the required voltage and current levels.

2. Choose the MPPT algorithm: After creating the the simulator model of PV array system, subsequent stage is for selectingthe MPP of the Photovolatic array using the proper MPPT method. Simulink offers various MPPT algorithms to choose from, including Perturb and Observe (P&O), PSO, CS, and GWO.

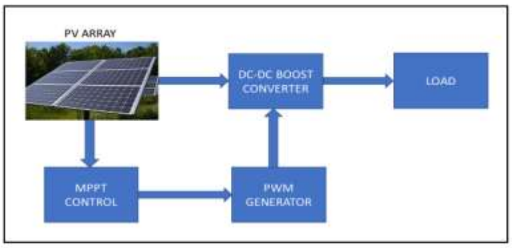

Fig: PV System With MPPT

3. Implement the MPPT algorithm: After selecting the MPPT model, the next step is to implement it in Simulink. This involves adding the MPPT block to the Simulink model and configuring itsthe step size, the maximum and minimum voltage restrictions, and other tuning factors that impacts effectiveness of the MPPT algorithm.

4. Evaluate the performance: After implementing the MPPT algorithm, the next crucial step is to assess its effectiveness under various environmental conditions. Simulink offers convenient tools to simulate the effectiveness of the photovoltaic system on multiple temperatures, levels of irradiance, and other environmental factors. These simulation outcomes can help in evaluating the MPPT algorithm's efficiency and optimizing its tuning parameters.

5. Implement the control system: The concluding phase of MPPTmethod implementation is incorporate it into the control system of the solar power array. This entails merging MPPT algorithm with the DC-DC exchanger and other relevant control systems like grid connection or battery charging (if necessary).

This approach offers a comprehensive framework for executing MPPT techniques for PV array systems using Simulink. The specific implementation nuances will rely on the chosen MPPT algorithm, PV array system specifications, and the intended performance targets.

PSO MPPT TECHINQUE

Particle Swarm Optimisation, also known as PSO, is a prominent optimization technique that may be used for Maximum Power Point Tracking (MPPT) in renewable energy systems, such as solar photovoltaic (PV) systems.

In PSO, a population of potential solutions, called particles, flows around the search space to locate the best solution. Each particle's location and velocity are updated depending on its own best solution

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and the best solution of its neighbours. The process continues until it's reached the highest power point of the PV panel.

PSO Algorithm Flowchart:

The PSO algorithm is a metaheuristic optimization technique inspired by the social behaviour of bird flocks and fish schools. The basic idea is to simulate the movement of a group of particles in a search space towards the optimal solution.

The PSO algorithm can be represented by the following flowchart:

1.Initialize the population of particles with random positions and velocities.

2.Evaluate the fitness of each particle.

3.Update the personal best position and fitness of each particle.

4.Update the global best position and fitness based on the personal best of all particles.

5.Update the velocity and position of each particle based on its current velocity, position, personal best, and global best.

6.Evaluate the fitness of each particle after the update.

7.Check if the stopping criterion has been met. If so, terminate the algorithm. Otherwise, go back to step 3.

SAMPLE RESULTS

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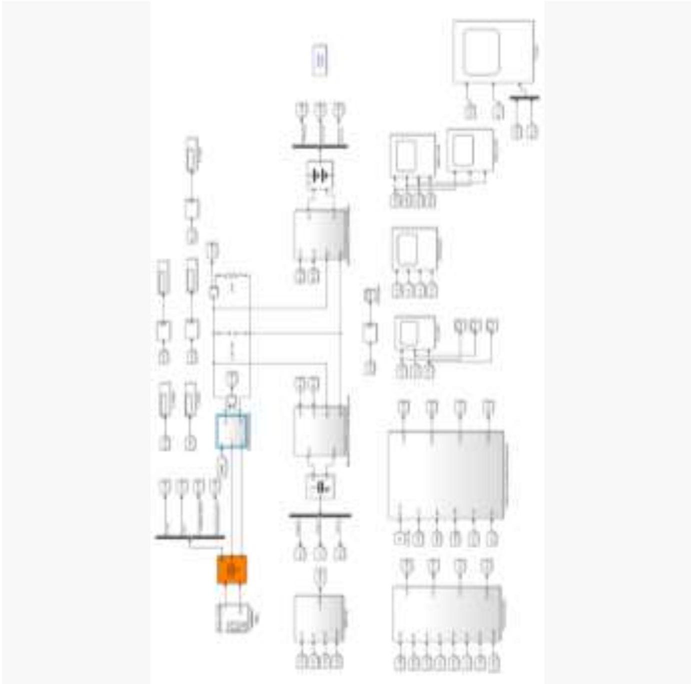

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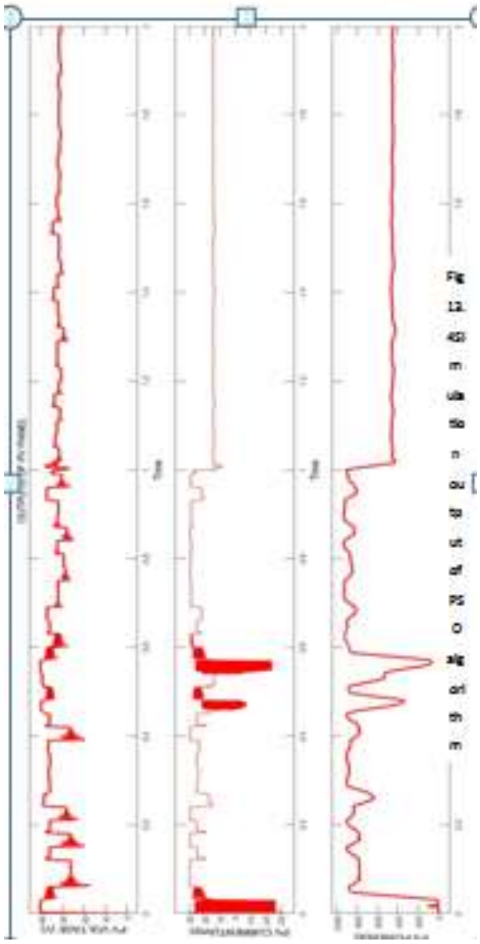

Fig 13. 4Simulation output of PSO algorithm

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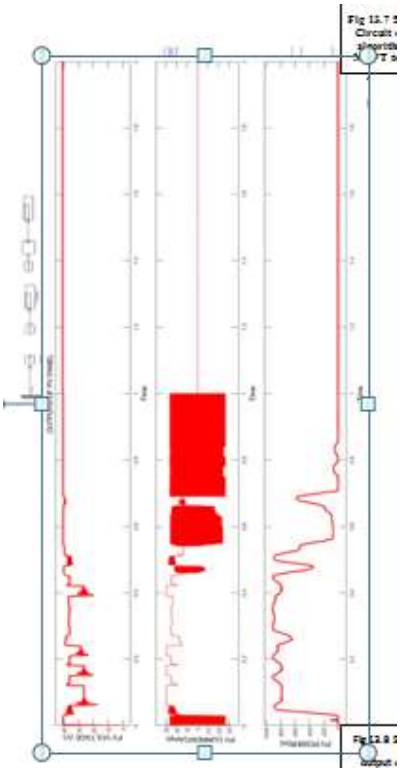

CONCLUSION

In this project we proposed The efficiency of these strategies in maximising the power production from a solar PV system may be determined by comparing MPPT techniques such as P&O, PSO, CS, and GWO. The literature assessment and analysis of various strategies have led to the conclusion that each methodology has advantages and disadvantages, and that the best technique to use will rely on a number of variables, including the properties of the solar panels, the environment, and the cost of the system.

The P&O method is a simple and mostly used MPPT technique due to its low cost and ease of implementation. However, it has some limitations such as oscillations in power output under rapidly changing irradiance conditions. It offers a balance between speed and accuracy, making it a suitable option for real-time applications.

The Cuckoo Search (CS) technique is another optimization algorithm that has been successfully applied to MPPT. It has been shown to be effective in quickly finding the Grey Wolf Optimisation (GWO) approach is a more recent optimisation algorithm that has shown promising results in MPPT applications, particularly under partial shading situations.

In conclusion, a comparative study of MPPT techniques among P&O, PSO, CS, and GWO techniques can provide useful information for system designers and manufacturers. Each technique has its strengths and limitations, and the choice of technique should be based on several factors such as solar panel characteristics, environmental conditions, and system cost. Further research is required to optimize these techniques for real-world applications and to explore the potential of new optimization algorithms in MPPT.

Based on the results of the comparative study of MPPT techniques for a 1 kW solar PV system, it can be concluded that each technique has its strengths and limitations. The choice of MPPT technique should be based on several factors such as solar panel characteristics, environmental conditions, and system cost. The PSO technique was found to be the most effective in maximizing the power output of the 1 kW solar PV system, but further research is required to optimize these techniques for real-world applications and to explore the potential of new optimization algorithms in MPPT.

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