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Simulation and Modeling of Different Types of MPPT Techniques Based on PV System

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Abstract: *This paper endeavored to analyze the performance of several maximum power point tracking (MPPT) strategies for use with PV installations. Methods like "perturb and observe," "incremental conductance," and "fuzzy logic controller" are evaluated here. Using the simulation program MATLAB/Simulink, we modeled a PV module and DC/DC boost converter and tested them with a variety of MPPT implementations. This research examines three distinct methods for calculating MPPT output: the traditional Perturb and Observe approach, the incremental conductance method, and the fuzzy logic controller. It is evident that when compared to the conventional P&O controller and the incremental conductance approach, the tracking speed achieved by the fuzzy logic controller is more consistent and faster. However, P&O controller's operating point keeps changing around the maximum power point even in steady state operation, which is a major drawback. In this study, we focus on the fuzzy logic controller design and contrast it with the incremental conductance controller and the P&O controller. This algorithm was used to record the daily peak power use. In this setup, a DC-DC converter and fuzzy logic controller work together to keep the PV system's output power at its maximum. MATLAB/SIMULINK is used for all simulations.*

Keywords: Boost Converter, MPPT, Observation and Perturbation, PV Modeling

I. INTRODUCTION

The increasing need for renewable energy is a direct result of the world's dire energy situation. Contrast that with India's goal of 20 GW of solar energy production by 2020; we've only reached half our capacity as of March of that year. This is a huge unrealized potential in a tropical country like ours. The expensive initial investment and low efficiency of solar PV systems are the main factors limiting their widespread use and expansion. Mathematical functional models are needed for PV module research to analyze the performance of newly created systems. However, experts in the field are slow to embrace these fail-safe methods. In order to do the necessary analysis, a simplified Simulink model of the PV module is required. Numerical results for each equation in the Simulink model at constant irradiance (1000W/m2) and temperature are shown. Maximum power point tracking (MPPT) is a critical factor to think about when designing a new solar power system since it is necessary for extracting maximum power output from a PV array under changeable atmospheric conditions. More than a few MPPT algorithms have been developed thanks to the efforts of researchers and businesspeople from all over the world.

Traditional fuels are becoming increasingly scarce, which has boosted the value of renewable energy sources. Wind and solar photovoltaic (PV) generation are two of the most well-known forms of renewable energy production, but there are many others to choose from. Renewable energy sources are preferable to those that rely on finite fossil fuels since they can be used indefinitely with little to no negative impact on the environment. Since the advent of affordable and efficient PV modules, solar power has exploded in popularity, even amid other renewable energy options. PV cells are the building blocks that directly convert solar energy into electricity using the "photovoltaic effect" [1]. As they are more portable and have a lower BoS, they are best used in remote areas. Connecting PV modules in series or in parallel allows for them to produce the necessary amount of energy.

1.1 Block Diagram

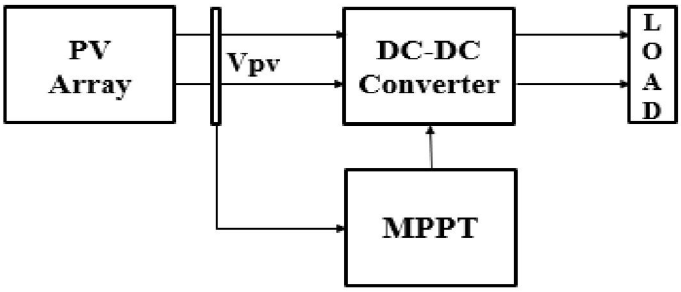

Fig 1.1: Basic block diagram

II. LITERATURE SURVEY

Hassan Abouobaida, Mohamed Cherkaoui" Comparative Study of Maximum Power Point Trackers for Fast Changing Environmental Conditions"

Optimization of the power and efficiency of a solar generator relies heavily on power point tracker algorithms. Maximum Power Point Tracker (MPPT) methods for rapidly varying PV panel conditions are compared in this paper. We compared the methods that are currently used to optimize photovoltaic systems for power efficiency. The Maximum Power Point Tracking MPPT concept is implemented by these algorithms, which are based on the Perturb Observe and Conductance-Increment techniques. The velocity and amplitude of the wave near the ideal spot for each search method are compared here.

Vipul Moon, Shweta Bansod, Prajakta Kharat, Aarti S. Pawar" Variable Step-Size Based P&O Algorithm For Pv Systems Under Varying Irradiance Levels"

Because PV systems are nonlinear, a combination of techniques is required to extract the highest amount of electricity possible. Maximum Power Point Tracking (MPPT) is a technique used to get the most energy possible from photovoltaic generators in the solar system. This study presents research on the popular P&O maximum power point tracking (MPPT) techniques used in PV systems. In addition, a strategy for dampening MPPT's steady-state oscillation utilizing the P&O technique is proposed. The suggested method takes the familiar P&O framework and adds a way for gradually increasing the size of the perturbation. The restriction of a dynamic boundary is provided to ensure that the algorithm will not stray from the tracking locus. The proposed method has the potential to significantly improve the accuracy of the MPPT steady state. The suggested MPPT approach resulted in an increase in average MPPT of nearly 2.99% compared to traditional P&O under changing irradiance. Results from MATLAB/Simulink simulations of the suggested method indicate that it is both faster and more accurate than the standard P&O approach.

Ali. M. Eltamaly A. I. Alolah M. Y. Abdulghany" Digital Implementation of General Purpose Fuzzy Logic Controller for Photovoltaic Maximum Power Point Tracker"

Embedded general-purpose processors are the focus of this work, which introduces a general-purpose fuzzy logic controller. Maximum power point trackers in solar energy systems benefit from the usage of this controller. The suggested approach, however, has a great deal of versatility and may be used in many other contexts. The architecture is scalable with respect to the number of inputs and the number of membership functions (MFs), both of which may be used to describe the output. As C is widely used and very effective in embedded and control applications, it was chosen as the language to implement the suggested model. Two inputs of seven MFs each and a single output of seven MFs are used to illustrate and validate the operation of a maximum power point tracker for a solar energy system. The simulation result produced is consistent with the general purpose fuzzy logic controller.

M. Berrera, A. Dolara, Student Member, IEEE, R. Faranda, Member, IEEE, and S. Leva, Member, IEEE." Experimental test of seven widely-adopted MPPT algorithms"

In recent years, advances in technology have enabled greater use of renewable energy and boosted the use of distributed generating on a massive scale. In particular, solar generation is expanding and is expected to grow much larger in the years to come. Since the output characteristic of photovoltaic generators is nonlinear and varies with solar irradiation and cell temperature, optimizing its production under varied settings (for example, climatic scenarios) is essential. In

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this research, we conduct an in-depth comparison of seven popular MPPT algorithms and conduct an in-depth experimental evaluation of their effectiveness while taking into account fluctuations in sun irradiation.

III. MPPT TECHNIQUES

The maximum power point tracker (MPPT) is a high-efficiency direct current (DC) to direct current (DC) converter that provides the optimum electrical load to a solar panel or array and generates a voltage suited for the load.

- Perturb and observe (P&O) technique
- Incremental conductance (INC)technique
- Fuzzy logic controller (FLC) technique

3.1 Perturb and Observe (P&O) Technique

The "perturb and observe" (P&O) technique is frequently employed. The approach relies on the power-voltage derivative of the PV module, which is a property of the module. The P&O approach is based on the comparison of the power after a deliberate rise or reduction in voltage with the power before the disturbance.

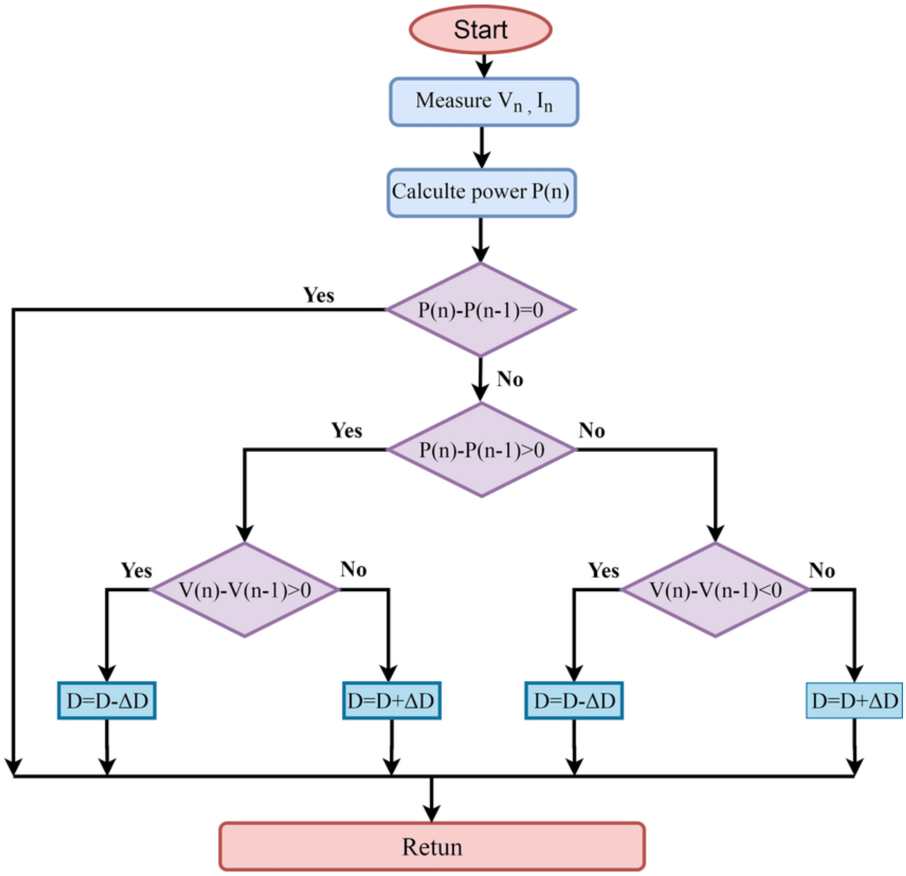

Fig 3.1: Flow chart of P&O

3.2 Incremental Conductance (INC) Technique

The Incremental Conductance (INC) Maximum Power Point Tracking (MPPT) method has also seen widespread use in many PV installations. This technique is regarded as an efficient means of locating the greatest power point. This strategy's foundation is built on the principle of exploiting power differences.

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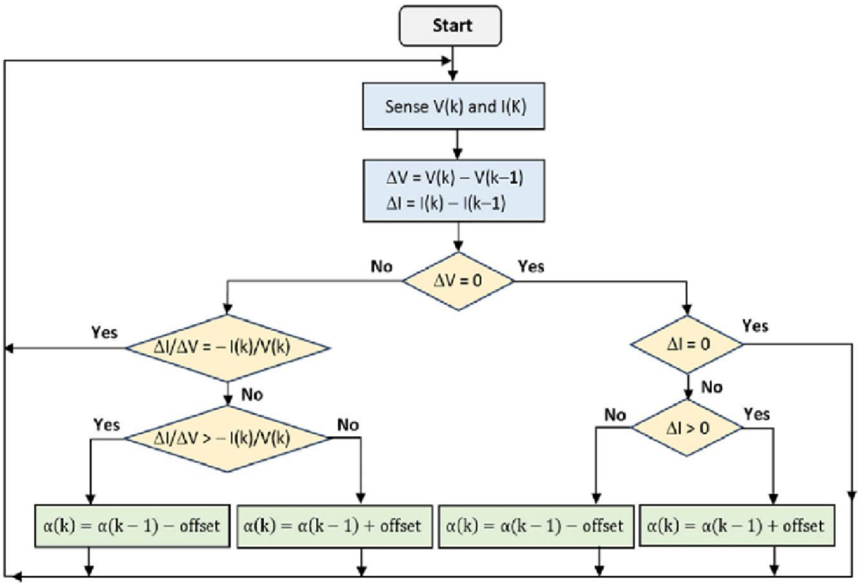

Fig 3.2: Incremental Conductance Method Algorithm

3.3 Fuzzy Logic Controller (FLC) Technique

Moreover, the MPP in PV systems can now be tracked with the use of fuzzy logic controllers. They benefit from not requiring knowledge of the unique model, making their design simpler and more resilient.

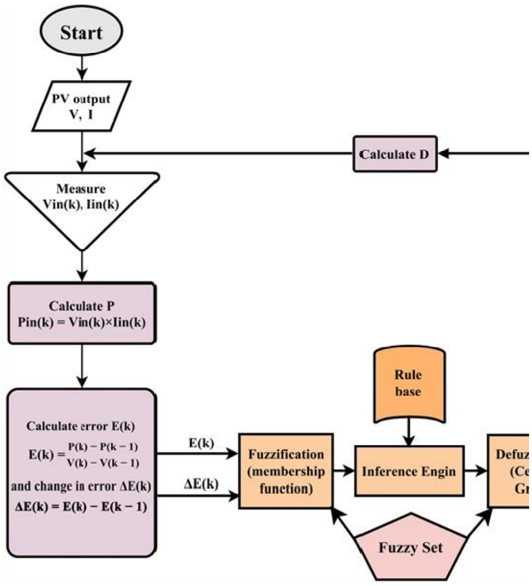

Fig 3.3: Flowchart of the proposed FLC

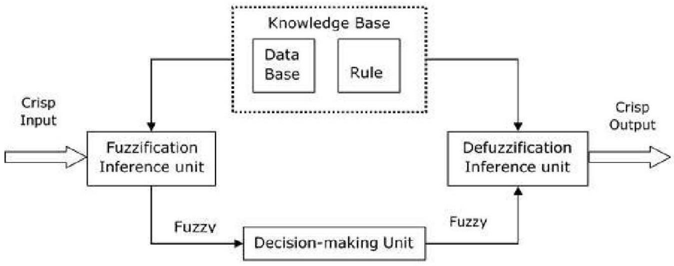

Fig 3.4: Fuzzy logic block diagram

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IV. MATLAB/SIMULINK MODELS

A.MATLAB/Simulink model of solar PV module without MPPT Technique:

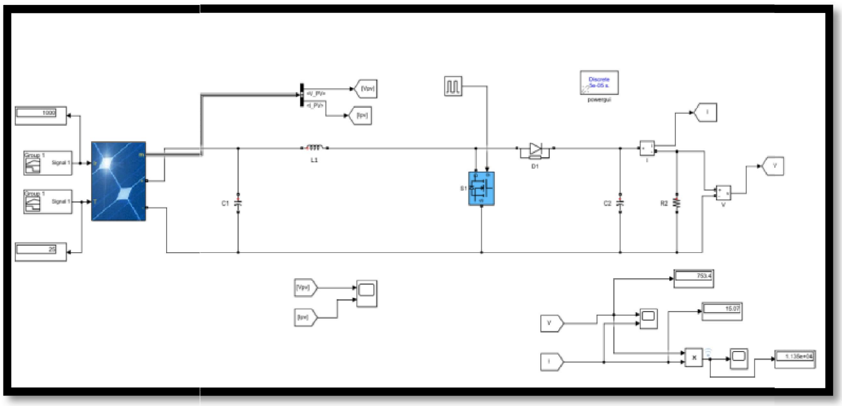

Fig 4.1: MATLAB/Simulink model of solar PV module without MPPT Technique

B. MATLAB/Simulink model of solar PV module by using P&O MPPT technique:

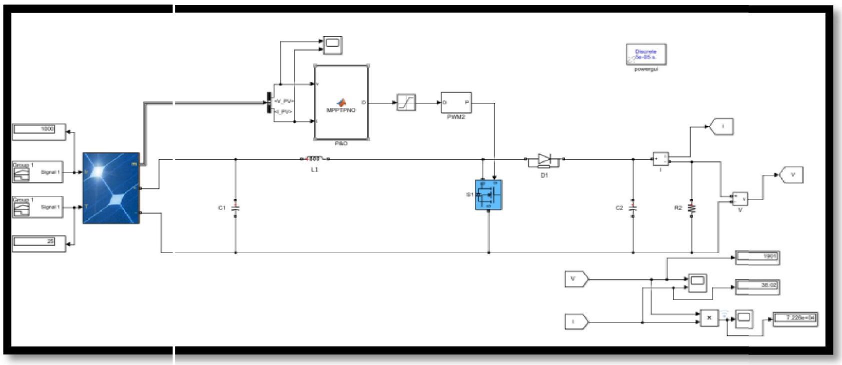

Fig 3.2: MATLAB/Simulink model of solar PV module by using P&O Technique

C. MATLAB/Simulink model of solar PV module by using INC MPPT technique:

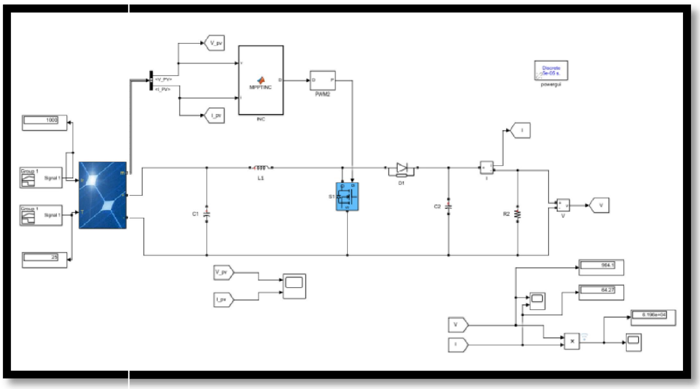

Fig 4.3: MATLAB/Simulink model of solar PV module by using INC Technique

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D. MATLAB/Simulink model of solar PV module by using FLC MPPT technique:

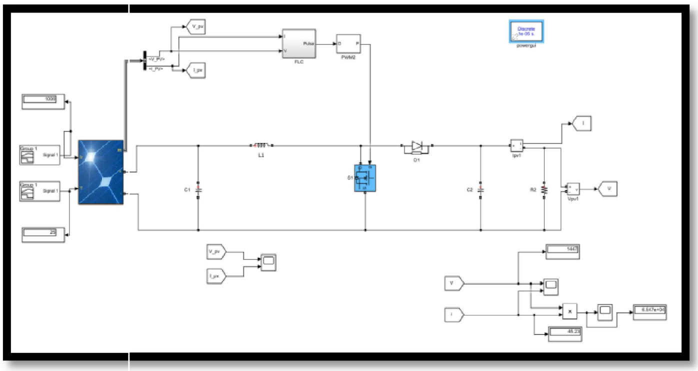

Fig 4.4: MATLAB/Simulink model of solar PV module by using FLC Technique

V. RESULTS

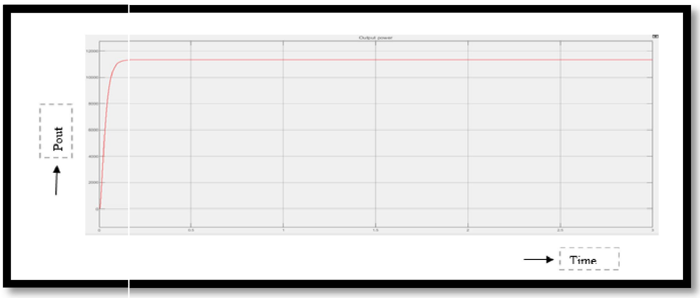

Fig 5.1: Output Power Waveform without MPPT

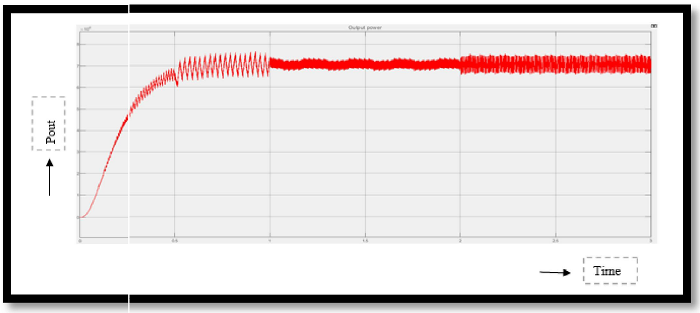

Fig 5.2: Output Power Waveform by using P&O MPPT Technique

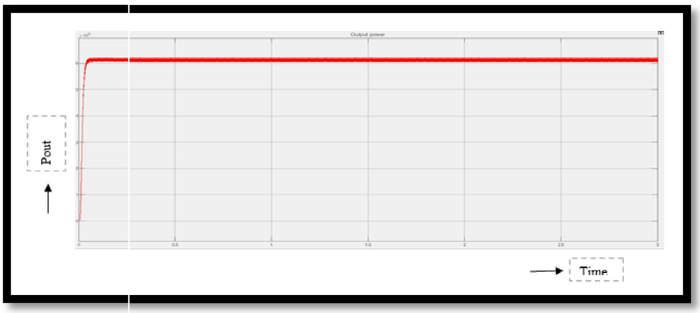

Fig 5.3: Output Power Waveform by using INC MPPT Technique

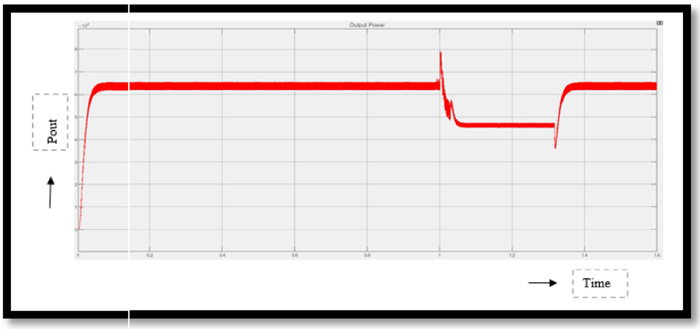

Fig 5.4: Output Power Waveform by using FLC MPPT Technique

Table 5.1: Comparison between different MPPT techniques based on input & output voltage and output power

Parameter	Input Voltage (volts)	Output Voltage (volts)	Output Power (watts)
Without MPPT	750	764	1.135*10^4
P&O	713	1901	6.5*10^4
INC	723	965	6.2*10^4
FLC	720	1447	6.6*10^4

Table 5.2: Comparison between different MPPT Systems

Items	P&O	INC	FLC
Dynamic Response	Poor	Medium	Medium
Transient Function	Bad	Bad	Good
Steady Oscillation	Large	Moderate	Small
Static Error	High	High	Low
Control Accuracy	Low	Accurate	Accurate
Tracking Speed	Slow	Slow	Fast
Overall Efficiency	Medium	Medium	High
System Complexity	Simple	Simple	Medium
Temperature Characteristics	Poor	Poor	Good

VI. CONCLUSION

In this work, we have examined three different MPPT methods depending on the PV system. Based on the simulation findings, FLC (Fuzzy Logic Controller) outperforms the other three methods. MPPT approaches employed by the project are ranked as follows: FLC, INC, and P&O, from best to worst.

Parameter	P&O	INC	FLC
Output Power(watts)	6.5*10^4	6.2*10^4	**6.6*10^4**

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