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MPPT Integrate with Fuzzy Logic Control Compared with Conventional Techniques

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Abstract- Photovoltaic (PV), which functions on the concept of the photoelectric effect, is considered one of the environmentally beneficial Renewable Energy Sources (RES) that has a large deal of capacity and converts solar energy directly into electricity. Continually changing physical properties of PV systems are dependent on their surroundings. Therefore, it is crucial to regularly track the Maximum Power Point (MPP) in order to get the most power possible from PV. This paper discusses one artificial intelligence control tool, the fuzzy logic controller (FLC), as well as traditional hill climbing methods like perturb and observe (P&O) and incremental conductance (IC) for MPP tracking. Fuzzy controller application results in superior performance versus traditional methods. In comparison to other methods, the MPP stability produced by a fuzzy controller is higher. The amount of energy extracted from PV panels is also contrasted with other methods.

Keywords - Photovoltaic, Renewable energy sources, Maximum power point, Perturb and observe, Incremental conductance, Fuzzy logic controller.

I. INTRODUCTION

Due to the scarcity of fuel and the rising cost of fuel, the traditional methods of producing energy (such as nuclear, fossil fuels, and thermal) have become more expensive. In addition to being expensive, conventional energy sources have negative environmental effects, which contribute to global warming and the greenhouse effect. [1-2]. Solar power is currently considered one of the encouraging sources of energy. In photovoltaic technology, electricity is produced directly from solar radiation, and this source poses less environmental problems [3-4].

Solar energy has advantages over all conventional sources, however the generation through PV modules is not consistent; it varies depending on the weather (such as the amount of sunshine and the surrounding temperature) [5-6]. As a result, it became necessary to monitor the system constantly and to keep it running at MPP regardless of the weather. The maximum power from a PV module is produced at MPP current and voltage. Different MPPT techniques have been developed and put into use [7].

Each has its own drawbacks and perks. [8-9]. in this essay, a comparison of the control strategies of perturb and observe (P&O), incremental conductance (IC), and fuzzy logic control (FLC) is discussed. Controlling the duty cycle of the dc-dc converter is the major goal. Results indicate that the FLC-based MPPT system increases the system's stability and effectiveness. FLC does not require the exact model's data.

II. MODELLING OF PV SYSTEM

Thin semiconductor wafers (such as silicon or selenium) processed to create an electric field are used in the production of solar cells. A photon with energy equal to or greater than the band gap of the cell material can release an electron for an electric circuit in a solar cell with a P-N junction arrangement. Many solar cells can be coupled in series and parallel to provide more electricity [10-11]. Below is provided a solar array similar circuit.

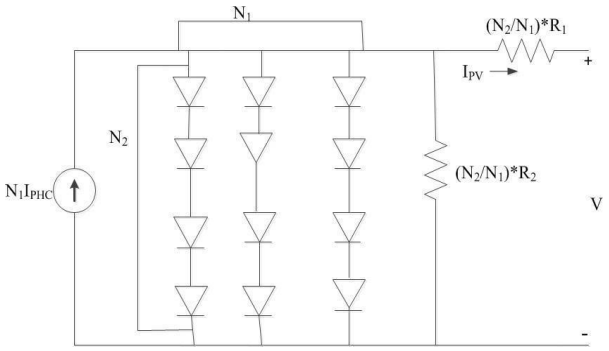

Fig 1. Equivalent circuit of solar array.

Where IPV = Output current of PV array, N1, N2 = Number of cell connected in parallel and series respectively, IPHC= Generated Photo current, IS = Diode reverse saturation current, V= Output voltage of PV array, R1, R2 = Series and Parallel resistance of PV cell, VT = Thermal voltage of PV cell, K= Boltzman constant (1.380*10-23) , q = electron charge (1.602*10-19) , T =

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Temperature of the P-N junction in Kelivn (K), CI = Current temperature coefficient of ISC, CV = Voltage temperature coefficient of VOC, S = Insolation, SSTC = Insolation at standard test condition, TSTC = Temperature at standard test condition.

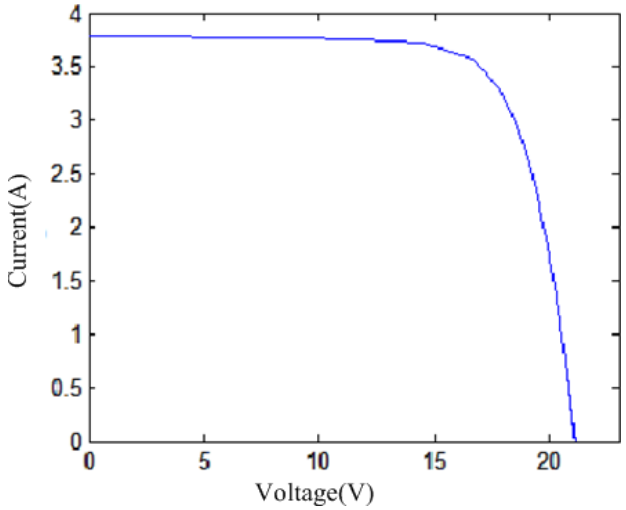

Fig 2. I-V Response of PV module.

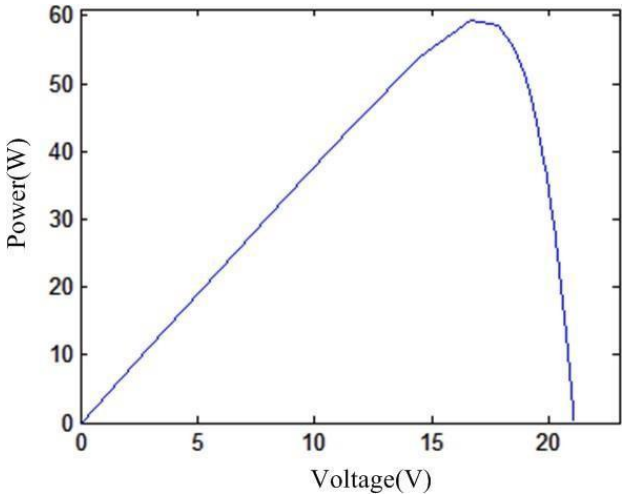

Fig 3. P-V Response of PV module.

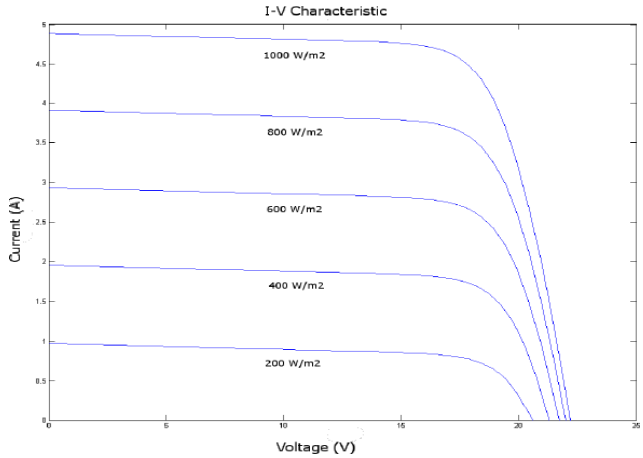

Fig 4. I -V Response of PV module at different Insolation.

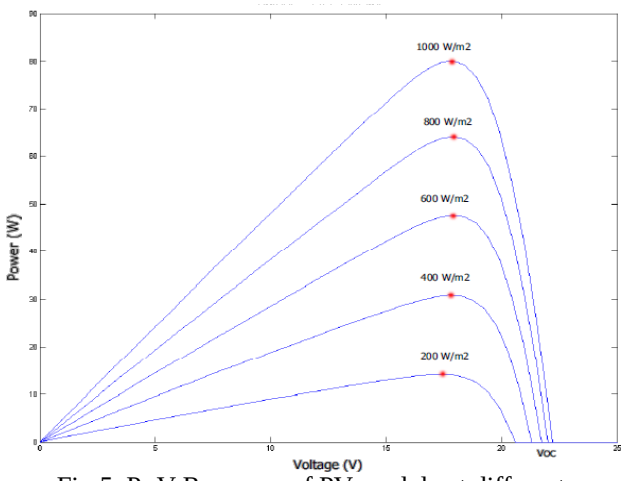

Fig 5. P -V Response of PV module at different Insolation.

The P-V and I-V response of solar cell clear that to enhance the efficiency of PV system; it is required to operate system at MPP for specific current and voltage.

III. MPPT TECHNIQUES

A specialised circuit known as the MPPT is used to consistently ensure that the operating point is at the maximum power point or very close to it. Voltage and current fluctuate in response to changes in temperature and insolation, hence an MPPT is required to track a single point, or MPP, at which PV modules function at their most efficient levels. This MPP is controlled by a controller to a DC-DC converter, which essentially controls the converter's duty cycle. Below is a solar system using the MPPT technology?

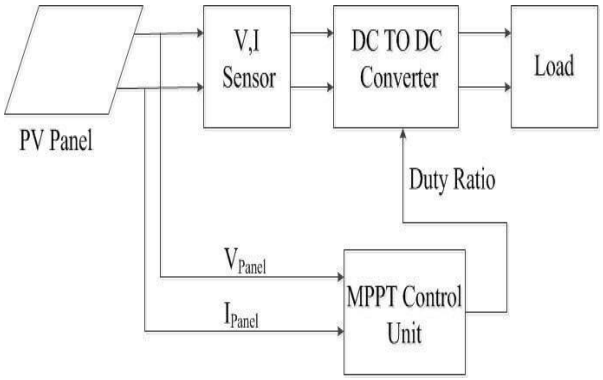

Fig 6. PV Module with MPPT Unit.

There are various MPPT algorithm has been discussed in literature. Here a comparative study of P&O, IC and Fuzzy logic control technique is done; implementation through DC-AC converter is also done.

1. Perturb and observe (P&O):
It is simplest and most discussed MPPT technique to implement [12]. A perturbation is applied in the panel voltage and then power is tested. If the perturbation is in

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same direction of power than consider it otherwise change the direction. These steps are repeated until MPP is obtained. The flow chart of P&O is given below-

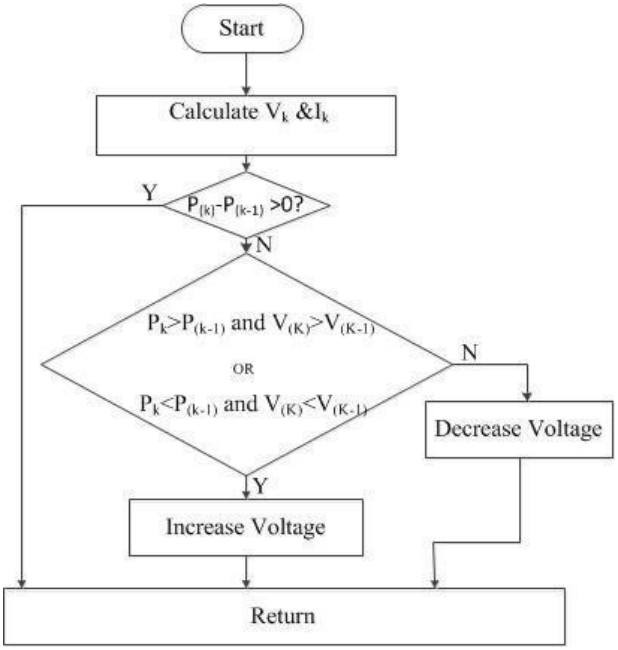


Fig 7. Flow chart of P&O.

2. Incremental Conductance (IC):

The basic idea of this MPPT technique is depend on the slope of the derivative of power versus voltage which is zero, positive and negative at MPP, left of MPP and right of MPP respectively. In this technique the incremental conductance is compare with instant conductance [13]. On the basis of the result there is a decrement and increment in reference voltage until MPP is obtain while P&O is naturally oscillate around the MPP. The flow chart is given as-

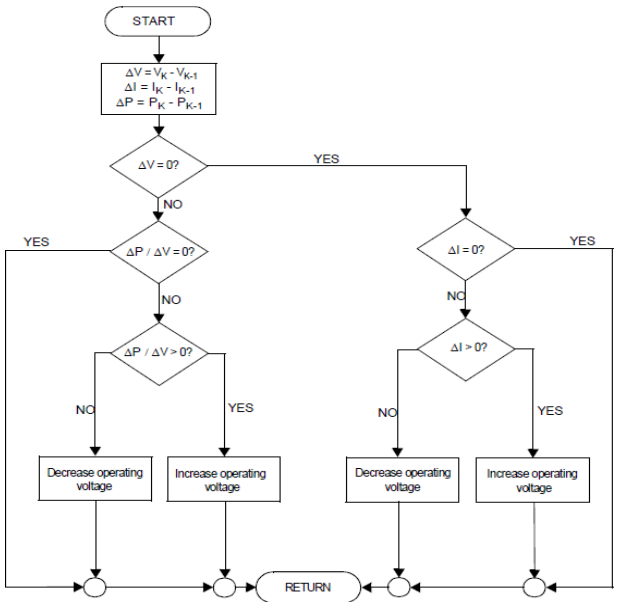


Fig 8. Flow chart of IC.

3. Fuzzy logic control (FLC):

It is a new technique to obtain the peak power by controlling MPP in the system [14]. It consists of three parts:

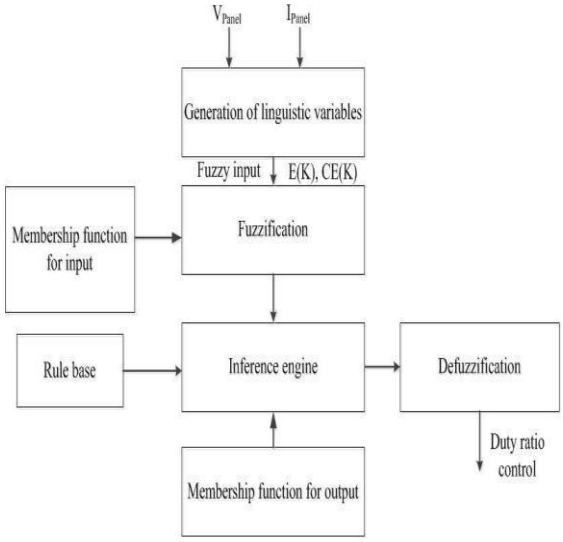


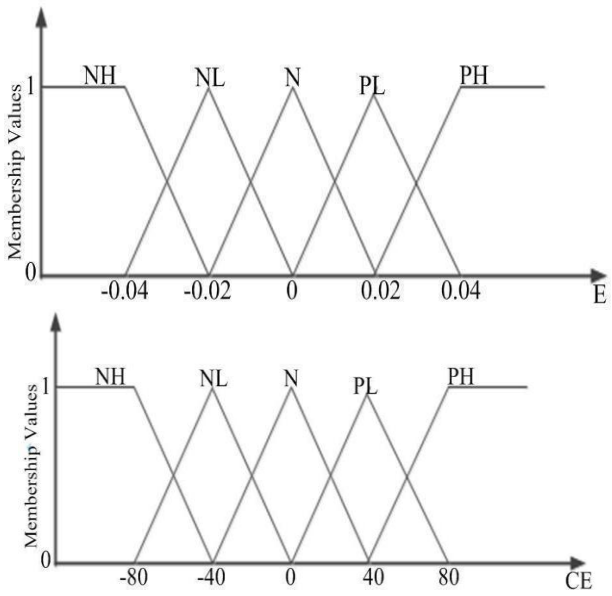
Fig 9. Computational flow diagram of FLC.

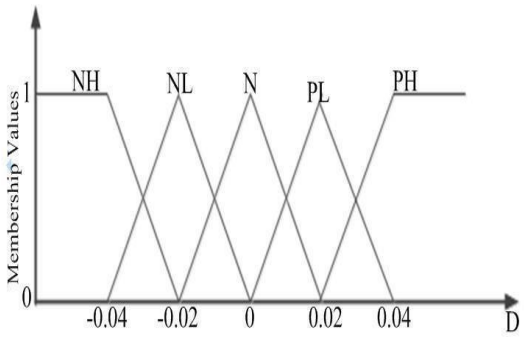
3.1 Fuzzification: The real parameter are converted into the fuzzy variable [15]. In this proposed work two input variable are taken i.e. error (E) and change in error (CE). The expression for E and CE at instant K is given below.

$$E(K) \quad \frac{P_{PV}(K) - P_{PV}(K-1)}{I_{PV} - I_{PV}(K-1)}$$

$$CE(K) = E(k) - E(K-1) \qquad (4)\ (5)$$

The input E(K) demonstrates that at instant 'K' the working point is lies on left and right of the MPP and CE(K) shows the track of movement of this point.





(c)

Fig 10. Membership function for (a) input E, (b) input CE, (c) output D.

3.2 Inference Engine: The fuzzy input obtain by fuzzification were associated with rules in this part. It is necessary to fuzzify the crisp input to achieve the respective linguistic value before rules are evaluated. The rules are given in matrix form. The consideration for linguistic variables is: NH (Negative Huge), NL (Negative Lesser), N (Nil), PL (Positive Lesser), PH (Positive Huge).

Table 1. Rule Base

CEE	NH	NL	N	PL	PH
NH	N	N	NH	NH	NH
NL	N	N	NL	NL	NL
N	NL	N	N	N	PL
PL	PL	PL	PL	N	N
PH	PH	PH	PH	N	N

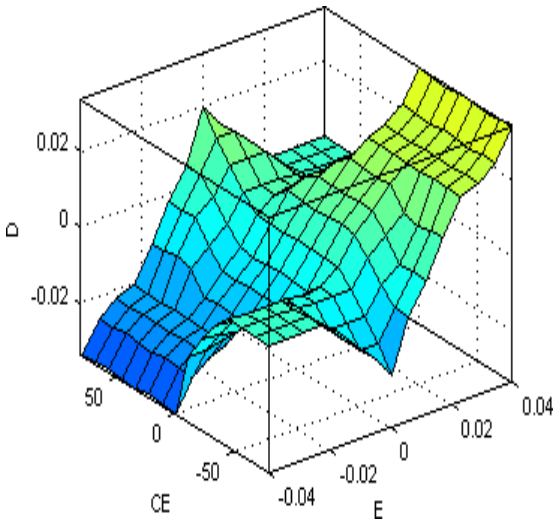


Fig 11. 3-D diagram of rule base.

3.3 Defuzzification: It is required to convert the fuzzy information obtain from inference engine into realistic term this process is known as defuzzification. It can be done by two method Centre of area (COA) and Max criterion method. Here COA method is used.

IV. SIMULATION MODEL

The proposed model shown in Fig. 11 is simulated through MATLAB/SIMLUINK software. The PV module is connected with MPPT control unit. The output of MPPT control unit (i.e. change in duty ratio or pulse generated for triggering of boost converter) is applied for controlling action of DC-DC converter. The output of DC-DC converter can be processed through DC-AC converter for supply to the load.

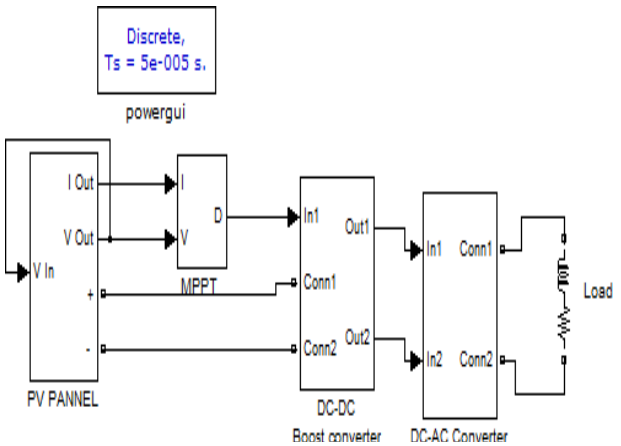


Fig 12. Simulation diagram in MATLAB/SIMULINK.

V. SIMULATION RESULT

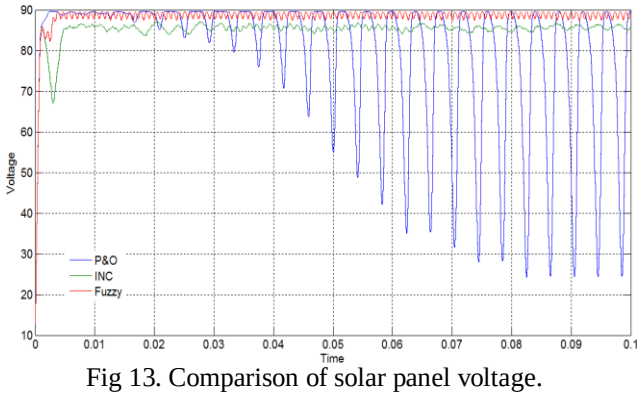


Fig 13. Comparison of solar panel voltage.

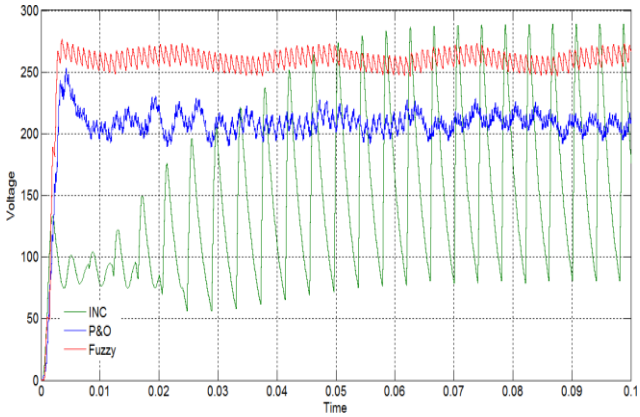


Fig 14. Comparison of DC-DC converter voltage.

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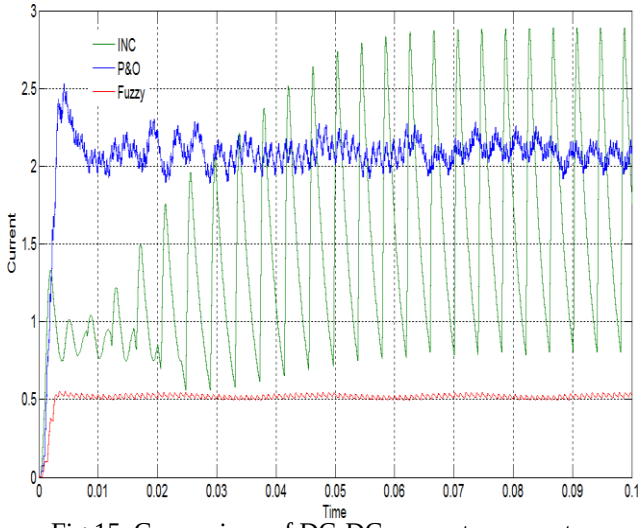

Fig 15. Comparison of DC-DC converter current.

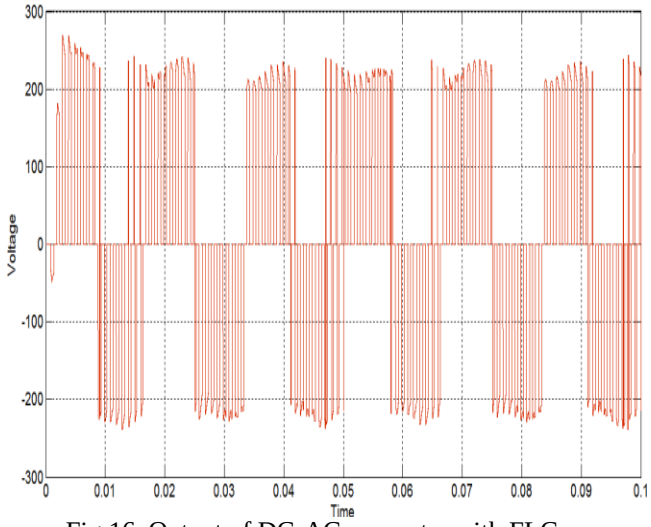

Fig 16. Output of DC-AC converter with FLC.

VI. CONCLUSION

A comparative study of three MPPT control unit (P&O, IC and Fuzzy logic) is presented in this paper. Comparison is done on the basis of panel voltage, output of DC-DC converter. Result shows that Fuzzy logic controller gives better response than conventional hill climbing techniques in terms of maximum power point traction. This FLC based MPPT system can be implemented to the grid with DC-AC converter Which can work as a fundamental unit for intermittent system.

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