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MPPT USING FUZZY LOGIC CONTROL

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ABSTRACT

This paper describes a fuzzy logic controller (FLC) based on MPPT method used for the PV system under constant and varying climatic conditions. The proposed FLC MPPT has ability to differ the PV operating voltage and goes for maximum power for PV panel to produce. The proposed MPPT performance as compare to various membership function (MF) is analyzed for the optimization of MPPT. The simulation results indicated that the FLC based MPPT is better as compare to unadventurous perturb.

I. INTRODUCTION

Maximum available power or MPPT is a great challenge if it is extracted in efficient and speedy manner. It can approaches the energy demand at big levels. If the constraints of a system can be obtained in a definite manner then there would be a relatively straight forward problem of its control model-based reaches such as PID and pole placement could be used. However, in real-time industrial systems, it is often the case that there exist considerable difficulties in obtaining an accurate model. Even when the model is sufficiently accurate, there are many other uncertainties for example due to the precision of the sensors, noise produced by the sensors, environmental conditions of the sensors, and nonlinear characteristics of the actuators. In such cases, model-free approaches are generally preferred both for modelling and control purposes. The most common model-free approaches are the use of fuzzy logic systems (FLSs). This work will explore the effectiveness of intelligent and digital control techniques for PV system efficiency optimization. This work will use experimental data to investigate the potential of solar energy in India and the effects of the harsh environment on PV systems efficiencies.

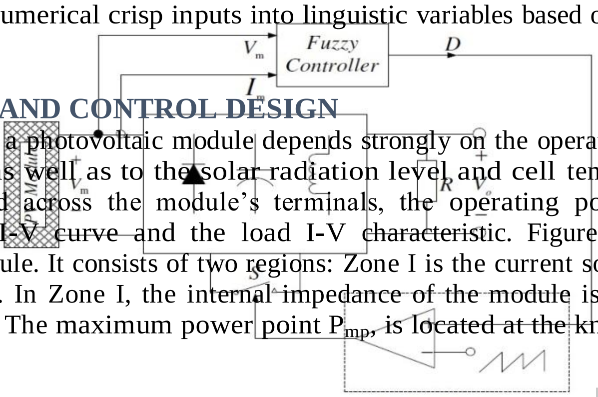
II. DIFFERENT METHODS USED IN PV ARRAY BASED ON MPPT

MPPT algorithms are necessary in PV applications because the MPP of a solar panel varies with the irradiation and temperature, so the use of MPPT algorithms is required in order to obtain the maximum power from a solar array. Over the past decades many methods tofind the MPP have been developed and published. These techniques differ in many aspects such as required sensors, complexity, cost, range of effectiveness, convergence speed, correct tracking whenirradiation and/or temperature change, hardware needed for the implementation orpopularity, among others. Among these techniques, the P&O and the InCondalgorithms are the most common. These techniques have the advantage of an easy implementation but they also have drawbacks,these drawbacks are overcome by using fuzzy logic controller.

Both P&O and INC algorithms are based on the “hill climbing” principle, which consists of moving the Operation point of the PV array in the direction in which power increases. . In the case of the Hill-climbing, perturbing the duty cycle of the power converter implies modifying the voltage of the DC link between the PV array and the power converter, so both names refer to the same technique. In this method, the sign of the last perturbation and the sign of the last increment in the power are used to decide what the next perturbation should be. The drawbacks of these techniques are mainly two. As a consequence it is not possible for the algorithms to determine whether the change in the power is due to its own voltage increment or due to the change in the irradiation. To overcome these problem we use fuzzy logic controller. Fuzzy logic controller deal with imprecise inputs, does not need an accurate mathematical model and can handle nonlinearity. Microcontrollers have also helped in the popularization of fuzzy logic control. The fuzzy logic consists of three stages: fuzzification, inference system and defuzzification. Fuzzification comprises the process of transforming numerical crisp inputs into linguistic variables based on the degree of membership to certain sets.

III. CONVERTER AND CONTROL DESIGN

The power produced from a photovoltaic module depends strongly on the operating voltage of the load to which it is connected, as well as to the solar radiation level and cell temperature. If a variable load resistance R is connected across the module's terminals, the operating point is determined by the intersection of module I-V curve and the load I-V characteristic. Figure 1 illustrates the operating characteristic of a PV module. It consists of two regions: Zone I is the current source region, and Zone II is the voltage source region. In Zone I, the internal impedance of the module is high, while in Zone II the internal impedance is low. The maximum power point P_{mp}, is located at the knee of the power curve.



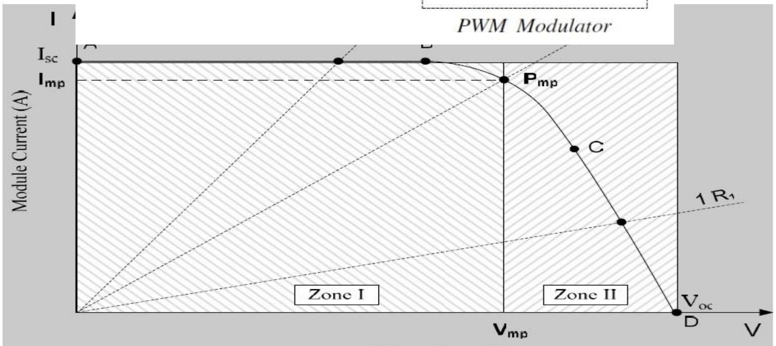


Figure 5.3 Behavioural curve of MPP for different converter operation

According to the maximum power transfer theory, the power delivered to the load is maximum when the source internal impedance matches the load impedance. The load characteristic is a straight line with a slope of I /V = 1/ R. If R is small, the module operates in the region AB only and behaves like a constant current source at a value close to I_{sc}. If R is large, the module operates in the region CD behaving like a constant voltage source, at a value almost equal to V_{oc}.

Table 1 Parameter for boost converter

parameters	values
Inductance (L)	161 mH
Capacitance (C)	1200 µF
Switching frequency (f_s)	3000 Hz
Load Resistance (R_L)	12 ohm

The general structure of a fuzzy logic controller is presented in Figure-2 and comprises of four principal components fuzzification interface , knowledge base, inference engine and defuzzification interface. Fuzzification interface converters input data into suitable linguistic value using a membership function.in knowledge base consists of database with the necessary linguistic definitions and the control rule set. Inference engine simulates a human decision making process in order to interface the fuzzy control action from the knowledge of the control rules and the linguistic variable definitions. Defuzzification interface converters an inferred fuzzy controller output into a non-fuzzy control action.Inference engine simulates a human decision making process in order to interface the fuzzy control action from the knowledge of the control rules and the linguistic variable definitions. Defuzzification interface converters an inferred fuzzy controller output into a non-fuzzy control action.

Figure 2. Basic configuration of a fuzzy logic controller

The basic scheme of a fuzzy logic based maximum power point tracker is shown in Figure-3. The dc-dc converter is represented by a "black box" from which only the terminals corresponding to input voltage V_m, input current $I_m$from the PV module, and the controlled switch S are extracted. As observed, only two state variables are sensed; the input voltage and input current.

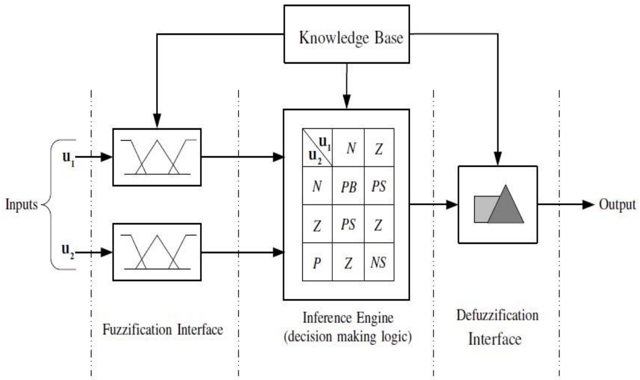


Fig.3 Fuzzy control scheme for maximum power point tracker

The fuzzy logic controller scheme is a closed loop system.The two values are used to calculate the input power. From these measurements, the fuzzy logic controller provides a signal proportional to the converter duty cycle which is then applied to the converter through a pulse width modulator. The modulator uses the value of D to perform Pulse Width Modulation (PWM), which generates the control signals for the converter switch.

IV. SIMULATION AND EXPERIMENTAL RESULT

In this dissertation work, a comparison has been made in terms of some important parameters by applying various techniques to extract maximum power from PV array under rapidly varying irradiances levels.

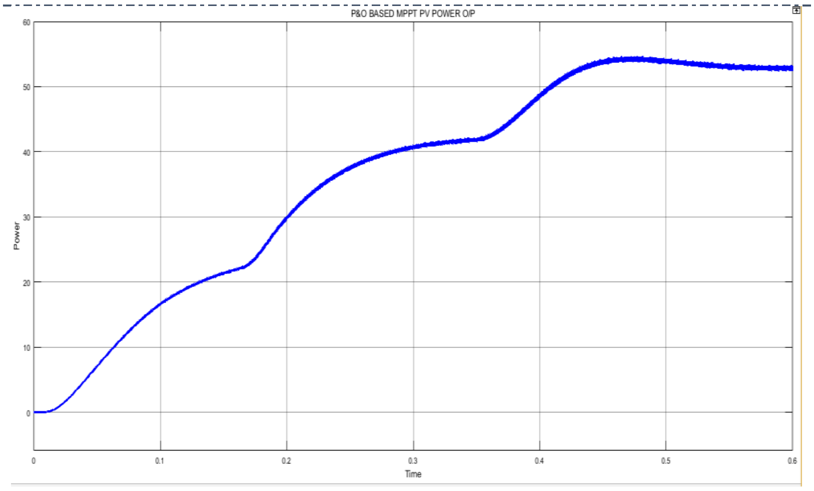


Fig.4.1 P&O based MPPT PV output power

P&O algorithm provoke perturbation by acting (decrease or increase)on the PWM duty cycle and observing the effect on the output PV power. From fig 4.1 maximum output power at 250 w/m2 is 4.65 watt, at 500 w/m2 it is 17.64 watt, at 750 w/m2 it is 40.73 watt and at 1000 w/m2 it is 52.07 watt.

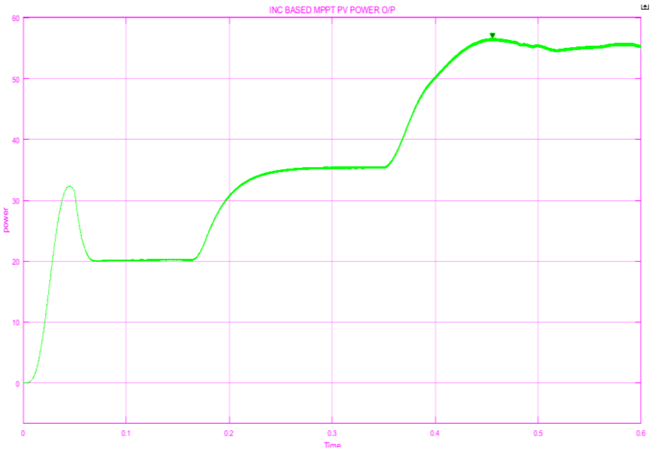


Fig. 4.2 INC based MPPT PV output power

It can be seen from the figure 4.2 that the theoretical maximum power value is 60 W. while the tracking efficiency of the INC method is 55.34 W. The INC method tracking efficiency is higher than P&O method, as a results of its independent to the solar radiation level. Thus this algorithm usually used at high and fast radiance variations

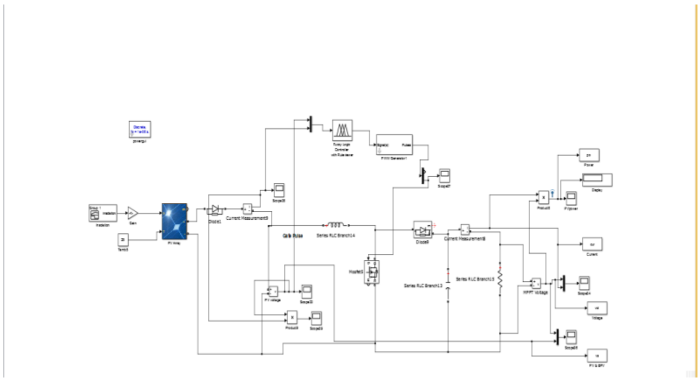


fig. 4.3 Simulation dig. of PV array with fuzzy control

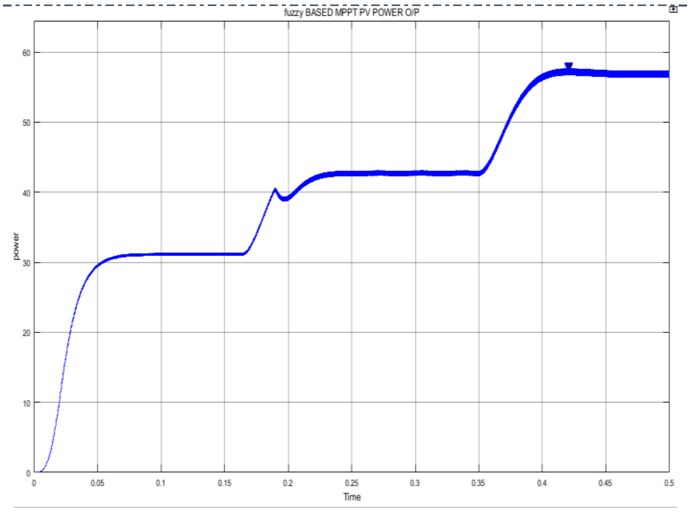


Fig. 4.4 fuzzy based MPPT PV power output

As seen from figure 4.4, the proposed response is much faster than that of INC and P&O algorithms. From graph maximum power at 250 w/m2 irradiance is 6.6 watt which is higher than P&O but less in comparison of INC algorithm .So INC is better and faster than fuzzy under low irradiance conditions. Output power at 750 w/m2 irradiance is 42.86 watt and at 1000 w/m2 it is58.07 watt. It can be deduced that the fuzzy controller is faster from above techniques under transitional state, and present also much smoother signal with less fluctuation in steady state.

TABLE-2 Comparison of various techniques at various irradiance levels

Irradiance (w/m^2)	**P&O**	**INC**	**FUZZY TYPE 1**
1000	**50.07 W**	**55.34 W**	**58.07 W**
750	**40.13 W**	**41.70 W**	**42.86 W**
500	**17.64 W**	**27.38 W**	**22.14 W**
250	**4.65 W**	**13.13 W**	**6.65 W**

V. CONCLUSION

The aim of this paper is to develop a method to optimize the energy extraction in a photovoltaic power system. The concept of PV module maximum power point tracking has been presented and various methods of addressing existing challenges are explored. A fuzzy logic based algorithm for tracking the maximum power is proposed in this work. In order to formulate and implement the algorithm, a system model is needed. The various components and subsystems are analyzed, modeled, validated, and combined together to produce a complete maximum power point tracker model .Efforts have been made to achieve the maximum power point in least possible time.

Simulation results show that the proposed fuzzy logic algorithm has better average efficiency of under rapidly varying conditions and in the presence of measurement noise. The results show that compared to other MPPT techniques, it provides improved performance in terms of Oscillations about the maximum power point, speed and sensitivity to parameter variation. This is possible since fuzzy logic controller rules can be assigned separately for the various regions of operation resulting in effective small-signal and large-signal operation..

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