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Fuzzy Logic Controller for MPPT of Photovoltaic System

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Abstract - The solar energy is increasing the importance in the area of energy because it is free from dirt and stain; it is in pure form and is in large amount in the atmosphere. The science is improving day by day the PV system is also upgrading. The objective of the paper is to obtain the maximized power point tracing, to maximize the power output of the PV system for different irradiation and temperature, the MPPT technique is used is the fuzzy logic.

***Key Words*:** Fuzzy logic controller, MPPT

1. INTRODUCTION

The solar energy is playing a keen role in the area of renewable energy as seeing the need of energy; solar energy is the perfect option. The important part in the solar energy is to extract the maximum amount of solar energy in large amount; the only problem associated with it is low efficiency of the solar cell and deviation in its irradiance due to the atmosphere change. The only suitable path to overcome the low efficiency and deviated irradiance affecting output power is to use such a technique to maximize the output power point and keeping the power transfer at maximum level irrespective of the environmental condition.

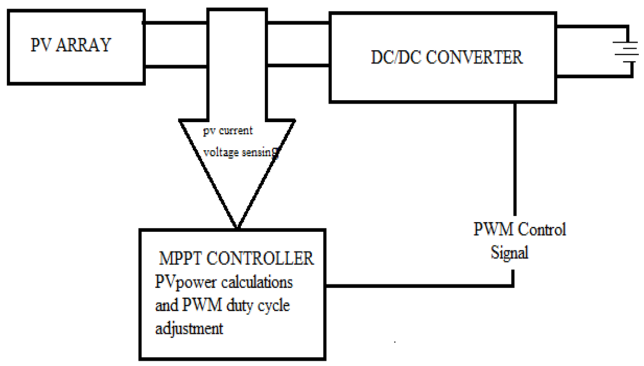

Fig 1: Diagram of PV System.

The above figure shows the PV system which is made of PV module, dc/dc converter and MPPT controller with battery, Number of solar modules are connected in series and parallel to form PV arrary.MPPT controller extract maximizes power to increase efficiency.[1,2,3]

2. PROBLEM ASSOCIATE

In Fig 2, the power curve of a PV panel is shown MPPT controller maintains the voltage V_{MPP} to that peak power P_{MPP} is achieved for specific isolation level and temperature current in increases as irradiance of sun increase.

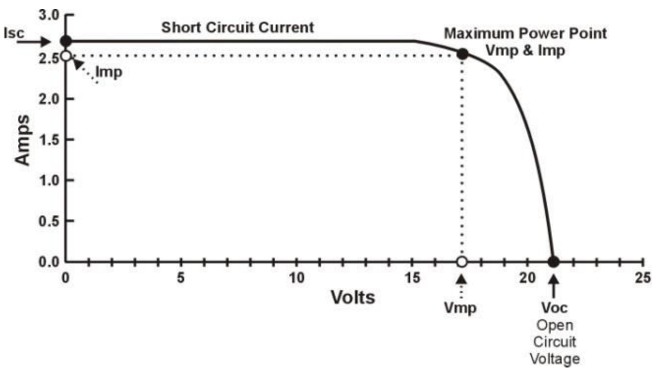

Fig 2: P-V vs. I-V curve characteristic

Various MPPT has different ways to calculate current imp voltage VMPP at maximizing power output for given temperature and isolation level

Many of the methods, temperature are assumed to be constant [1].

3. PERTURB AND OBSERVE TECHNIQUE

Mostly perturb and observe methods are observed in many papers Fig 3 shows increased voltage are the causes to increase power when a working point is on left of MPP and small power operating in right of MPP. One can see the increment in power, continuous perturbation operation should be same to attempt MPP once peak point is achieved reduction may take place in power for another perturbation.

The system oscillates about MPP when it is gained. Reduced size step makes attenuation in oscillations [4, 5].
This method is simple and easy to implement but the drawback is the operating point which toggle highly around peak point and cannot fix on the exact point.

4. MPPT USING FUZZY LOGIC CONTROLLER

The Fuzzy logic controller has the number of advantages. It is conceptually easy to understand. The mathematical concepts behind fuzzy reasoning are simple, flexible tolerant of imprecise data, it can model nonlinear functions of arbitrary complexity.

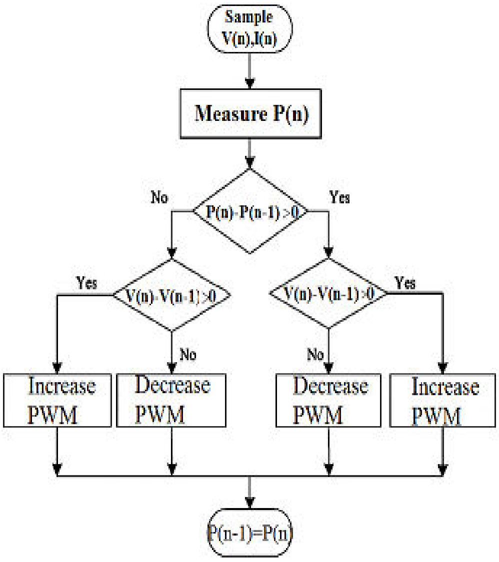

Fig 3: Perturb and Observe Method flowchart

Three stages of fuzzy logic are fuzzification, Rule base Table lookup and defuzzification. In fuzzicification, the numerical variables are converted into linguistic variables based b on a membership function as shown in Fig 4.

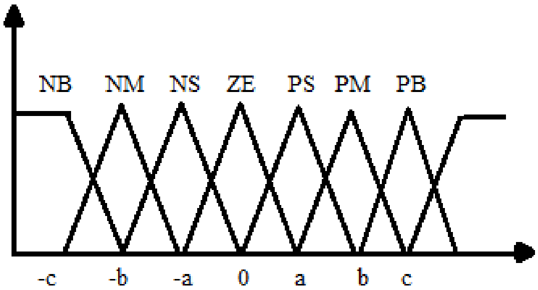

Fig 4: Memberships functions

The five fuzzy levels are mostly used, NB (negative big), NS (negative small), ZE (zero), PS (positive small), PB (positive big). The membership function is sometimes made less symmetric to give more importance to specific fuzzy levels [6, 7]

The inputs to the MPPT fuzzy logic controller are mostly an error signal (E) and a variation in error (ΔE). The (E) and (ΔE) can be calculated as shown in equation (1) and (2).

$$E\,(n) = P\,n - (n-1)\,n - V(n-1) \quad (1)$$

$$\Delta E\,(n) = E\,(n) - E\,(n-1) \quad (2)$$

Where E (n) is the instantaneous error, ΔE (n) is the instantaneous variation of error, p (n) is the instantaneous PV array's power, and v (n) is the instantaneous PV array's voltage.

Once (E) and (ΔE) are calculated and converted to the linguistic variable, the fuzzy logic controller gives a suitable change in the duty ratio (Δ D) to the power converter, based on the Rule Base Table as shown in Table 1.

Table -1: Base Rule

E \ ΔE	NB	NS	ZE	PS	PB
NB	ZE	ZE	NB	NB	NB
NS	ZE	ZE	NS	NS	NS
ZE	NS	ZE	ZE	ZE	PS
PS	PS	PS	PS	ZE	ZE
PB	PB	PB	PB	ZE	ZE

The linguistic variables are associated with (ΔD) for the various combinations of (E) and (ΔE) at various atmospheric conditions. The variations in the duty ratio also depend on the power converter being used.

Fuzzy Rules are designed to gain zero error signal (E=0) at the steady state of the MPP. The main purpose of the rule is to bring the operating point to the MPP by increasing or decreasing the duty ratio, depending on the position of the operating point from the MPP. If the operating point is toggle from the MPP, the duty ratio will be increased or decreased.

Many researchers purposes many methods to gain the output of inference Mamdani, Sugeno are the same know methods. Commonly Mamdani's method is used.

5. PROPOSED FUZZY LOGIC CONTROLLER

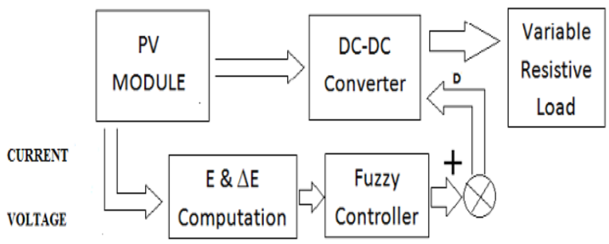

Fig 5: Block diagram of Fuzzy Logic Controller

MPP has several drawbacks, among them; the P&O method shows slow tracking speed and oscillations about MPP. In this paper the performance of FLC is compared with that of P&O method to show FLC's superiority in tracking MPP over other conventional methods [8, 9]

The simulation model is shown in Fig.6. Simulation is performed from 0 to 4 sec if step size of input variable is very small, the accuracy in tracking MPP is high but tracking speed becomes too slow.

On the other hand, if the step size is increased, the accuracy deteriorates (oscillation about a mean point occurs) but tracking speed increases. Both accuracy and speed of tracking cannot be achieved simultaneously in this method. But in the fuzzy method, these two can be achieved simultaneously.

6. SIMULATION MODEL OF FLC

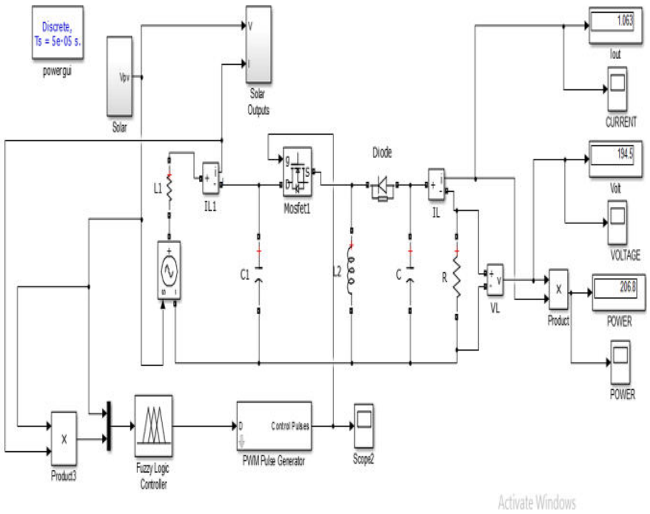

Fig 6: Simulation Model of fuzzy logic controller.

7. SIMULATION RESULTS OF PERTURB AND OBSERVE TECHNIQUE

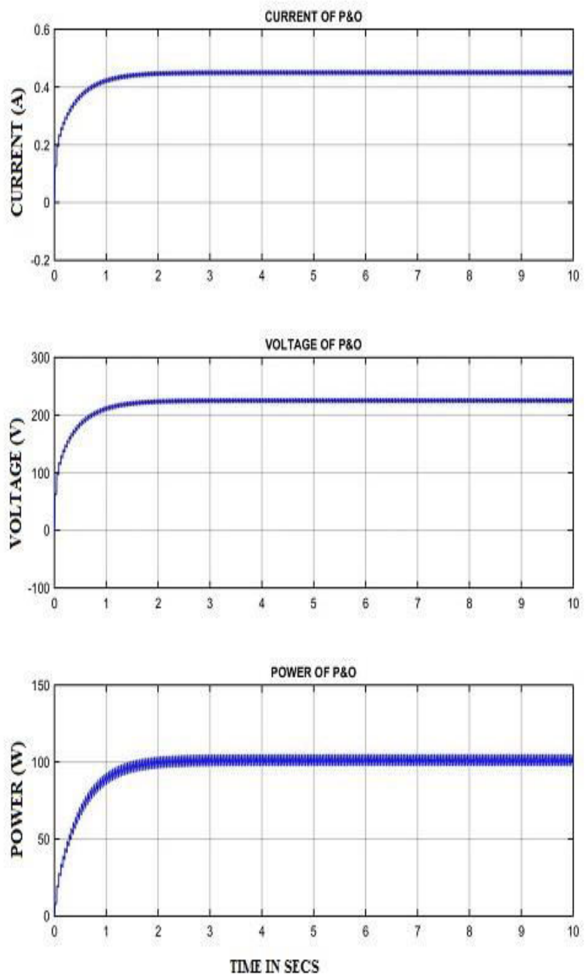

Fig 7: Output Current, Voltage and Power of FLC

8. SIMULATION RESULTS OF FUZZY LOGIC CONTROLLER

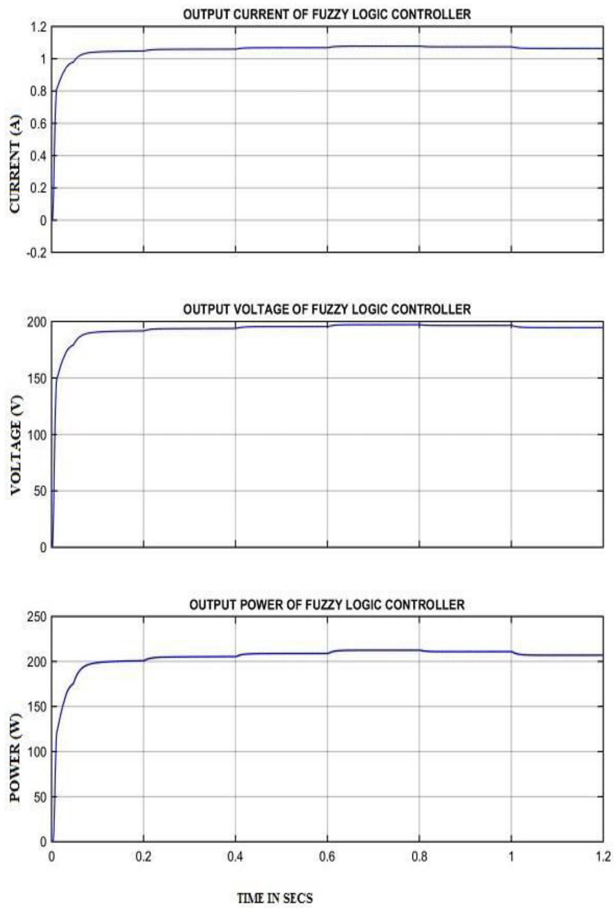

Fig 8: Output Current, Voltage and Power of P&O

Fig 7 shows the plot of the Output voltage, Output Current and Output Power of the solar PV using Perturb and Observe MPPT technique. The simulation was given time-varying input of solar irradiation and at 1000 W/m2 irradiation and the temperature 25 C the output voltage is 197.4 Volts, the Output current is 0.493 Amps and Output Power is 97.42 Watts.

Figure 8 shows the plot of the Output voltage, Output Current and Output Power of the solar PV using Fuzzy Logic MPPT technique. The simulation was given time varying input of solar irradiation and at 1000 W/m2 irradiation and the temperature 25 C the output voltage is 194.5Volts, Output current is 1.06 Amps and Output Power is 206.8 Watts.

9. CONCLUSION

Fuzzy logic toolbox of simulink is used to achieve the FLC. The specialty of this FLC is that the rule base is very simple which increases the speed of computation of the processor. That is why the proposed FLC can track the MPPT very fast and accurately even if the environment changes abruptly. The performance of the proposed controller is compared with that of a conventional

P&O controller and the worth of the fuzzy controller is obvious. This controller can be used in any real PV system with the help of a digital signal processor to get good results. Form the comparison. From the obtained test results it can be concluded that fuzzy logic technique is more efficient and produces optimized duty cycle for PV array MPPT technique.

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