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Designof PV Cell Using Perturb &Observe and Fuzzy Logic Controller Based Algorithm

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ABSTRACT:*Photovoltaic energy is the most important energy resource since it is clean, pollution free, and inexhaustible. Due to rapid growth in the semiconductor and power electronics technique it is important to operate PV energy conversion system near the maximum power point to increase the output efficiency of PV Array. This paper aims to obtain the maximum power point tracking based on PV solar generation. Maximum Power Point tracking is important role of photovoltaic systems because it maximizes the power output from PV system for a different irradiation and temperature. It gives the I-V and P-V characteristics of different irradiation and temperature. It discusses maximum power point tracking P&O method with different temperature and radiation of their importance in the performance of the system. This method is used for Fuzzy Logic Controller with DC-DC buck-boost converter is a main part in the design of MPPT tracker and the design of converter plays a major role. Simulation results in MATLAB/SIMULINK are discussed and this shows that, photovoltaic system track the maximum power point accurately.*

KEYWORDS:*DC-DC buck boost converter, Fuzzy Logic controller, Incremental Conductance, Perturb and Observe algorithm*

I. INTRODUCTION

As conventional energy sources are becoming more expensive and cause growing environmentalconcerns, energy from natural resources like sunlight, wind and wave are globallywelcome to replace conventional sources. Photovoltaic (PV) generation is getting more importanceas a renewable source since it offers many advantages such as economical, not beingpolluting, less maintenance and eco-friendly. PV arrays produce electric power directly from sunlight by means of photovoltaic effect. The power obtained from the solar panel varies according to changing atmospheric conditions. Irradiance and temperature are the two important parameters that affect the power output of the solar array as it varies continuously. It can be observed that there is a unique maximum power point (MPP) at a particular environment as the relationship between current and voltage of the solar cell is nonlinear and this peak power point keeps changing with solar irradiance and ambient temperature [1].

The technique of extracting maximum power from the panel at all the time is known as Maximum Power Point Tracking (MPPT). There are different algorithms which can be used to extract maximum power all the time such as Perturb and Observance method (P&O),Incremental conductance method (INC), constant voltage method [2], fractional open circuit voltage, fractional short circuit method [3] and so on. To obtain high efficiency in PV generation system, load impedance must match with PV source impedance, and MPPT helps in achieving this. DC-DC converters like buck, boost, buck-boost are important component of this power system to obtain available maximum power across the load or battery. The output voltage and current of converter can be controlled by varying the duty cycle of power switch of DC-DC converter through MPPT algorithm. Fuzzy logic control is used to optimize the magnitude of the next perturbation.

II. EQUIVALENT CIRCUIT OF PV ARRAY

The solar cell is basically a p-n semiconductor junction that directly converts light energy into electricity based on photoelectric effects. PV cells grouped in larger units form a PV module and interconnection of more PV modules in a equivalent circuit shown in fig.1. The equivalent circuit of a PV cell which consists of a current source in parallel with a diode and a serially connected resistor describing an internal resistance to the current flow is demonstrated in fig.1.

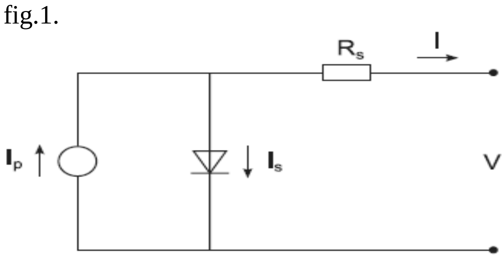

Fig.1. Equivalent circuit of PV cell

Typical solar cell I-V characteristics is expressed as follows:

$$I = Ip - Is(exp\left(\frac{V+IRs}{\varepsilon\, Vt}\right) - 1) \quad (1)$$

where Ip is photocurrent; Is ie reverse saturation current, V is the voltage applied on the diode; ε is the ideality factor; Vt is the thermal voltage and Rs is the equivalent series resistance of the PV array.

III. MPPT TECHNIQUES

1.1 Perturbation and Observation Methods

P & O algorithms are widely used in MPPT because of the simple structure and the few measured parameters which are required. They operate by periodically perturbing the array termed voltage and comparing the PV output power with that of the previous perturbation cycle. If the power is increasing, the perturbation will continue in the same direction in the next cycle, otherwise the perturbation direction will be reversed. This means the array terminal voltage is perturbed every MPPT cycle, therefore when the P&O is reached, P&O algorithm will oscillate around it resulting in a loss of PV power, especially in cases constant or slowly varying atmospheric conditions. This problem can be solved by improving the logic of the P & O algorithm to compare the parameters of the two preceding cycles to check when the P&O is reached, and bypass the perturbation stage.

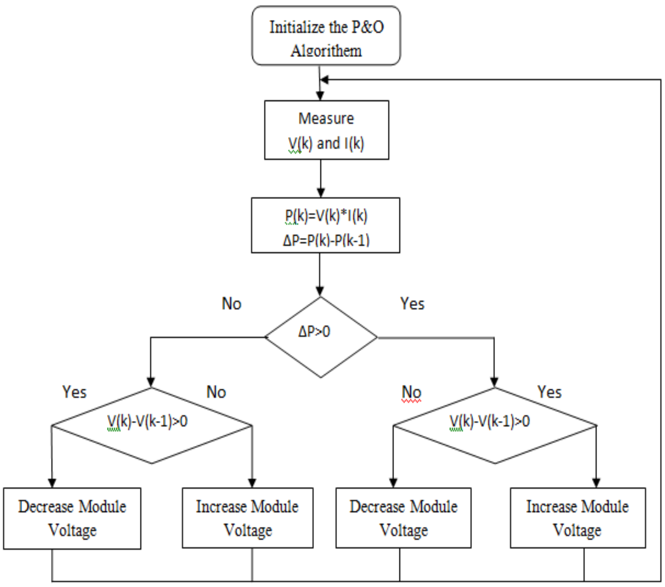

Fig.2 Flowchart of the P&O MPPT Method

Another way to reduce the power loss around the P&O is to decrease the perturbation step, however, the algorithm will be slow in following the P&O when the atmospheric conditions start to vary and more power will be lost. The implementation of P&O type MPPTs with increased refresh rates of current requires two things. First, the P&O algorithm should operate with high sampling rates and the sample values of voltage and current should reflects the tendency of the output power when increasing or decreasing the reference sign for the MPPT power converter. Second the response of time of the MPPT converter should be very fast while keeping the switching losses low. This can be done by comparing instantaneous, instead of average, values of the Vpv and peak current control that presents one-cycle speed of response for small variations in the reference current, to further to improve the performance of the system. The proposed MPPT system employs peak current control.

1.2 Incremental Conductance

The INC method is based on the necessity of establishing whether the array voltage is greater than or less than the value at the MPP. This is equivalent to the fact that when the array voltage is greater (less) than the peak power point voltage, dP/ dV is less (greater) than zero, which can be expressed as follows,

$\frac{dI}{dV} > -\frac{I}{V}$ when V<Vmpp (2)

$\frac{dI}{dV} < -\frac{I}{V}$ when V>Vmpp (3)

$\frac{dI}{dV} = -\frac{I}{V}$ when V=Vmpp (4)

Unlike P&O that oscillates around the MPP, the INC algorithm can determine when the MPP has been reached. Also, INC can track rapidly increasing and decreasing irradiance conditions with higher accuracy than P&O.One disadvantage is the increased complexity of implementation compared with P&O. This method increases computational time and slows down the sampling frequency of the array voltage and current [2].By taking into consideration of the sunlight density and cell temperature as well as adaptive perturbation length, this simple method, compared with conventional P&O and INC method, can achieve much faster tracking speed with minimum steady state oscillation which increases the overall system's performance and efficiency.

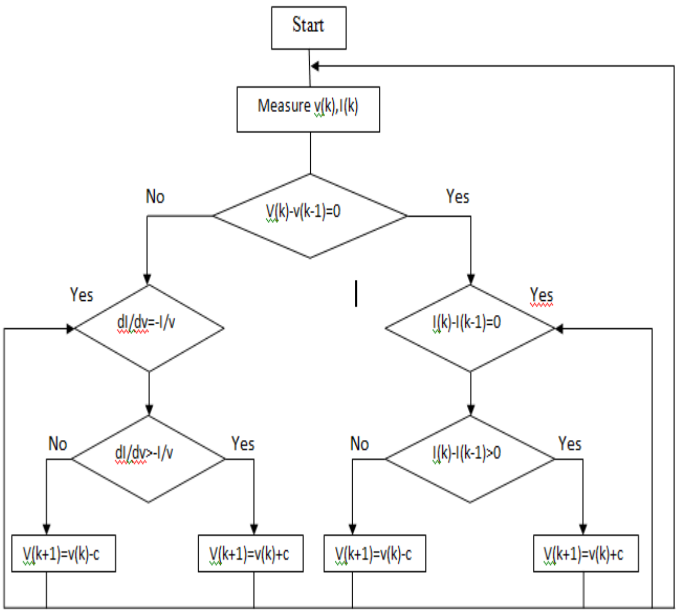

Fig.3 Flowchart of the INC MPPT Method

IV. FUZZY LOGIC MPPT CONTROLLER

In the last decade MPPT for PV arrays have been influenced by the good research content. The best advantage of FLC is it does not need the awareness of PV module system. Moreover, it can be used for linear and nonlinear system as well. The fuzzy controller functional block for implementation of this algorithm is as shown in fig.4. The fuzzy logic based MPPT techniques is shown fig. 7 with two inputs and one output. The input variables are current and current -1 stage and output variable is duty cycle. Membership functions (MF) of input variables, output variable and the proposed FLC algorithms are shown in fig.5, fig.6, respectively. Very small (VS), Small (S), Medium (M), High (H), Low (L) and Very Low(VL).

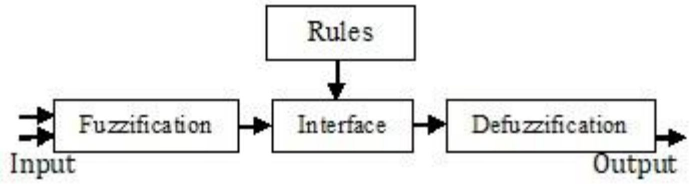

Fig. 4 Block diagram of fuzzy logic controller

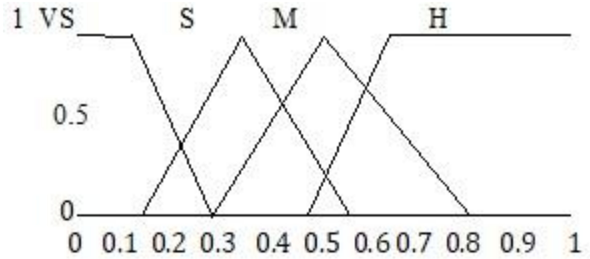

Fig.5 MF of input variables

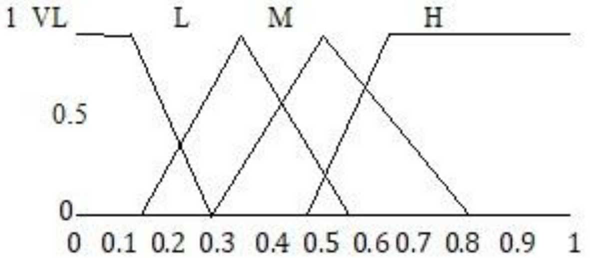

Fig.6 MF of output variables

Fig.7 The proposed Fuzzy logic algorithm

The fuzzy control rules as given in Table-I was done with Mamdani Methods and the defuzzification was done with the centre of gravity method to calculate the out of FLC (duty cycle).

Table 1. Fuzzy Control Rules

P(T- 1)\ P(T)	VS	S	M	H
VS	VL	L	M	L
S	L	M	H	M
M	M	M	M	H
H	H	M	H	M

V. DC-DC BUCK BOOST CONVERTER

In DC-DC buck-boost converter, the output voltage Vo is higher than the input voltage Vin when duty cycle is above 50%. The output voltage Vo is less than the input voltage Vin when duty cycle is below 50%. The output voltage polarity of buck –boost converter is opposite to input voltage polarity. The power circuit diagram of DC-DC buck-boost converter is shown in Fig. 8. Single inductor, single diode and single switch are used to design buck-boost converter.

The operation modes of buck-boost converter can be divided into two modes, one when switch is turn ON and another when switch is turned OFF. When switch S is turned ON, inductor is charged by input voltage Vin through switch S. Figure9. explains the mode of operation when switch S is turned ON. In practical buck-boost converter circuits, the switch and diodes has finite internal resistance. Due to this internal resistance forward voltage drop takes place. Voltage drop across diode and switch is Vd. Load voltage V_l is expressed as:

$$Vl = Vin - Vd \quad (5)$$

When Switch S is turned OFF, inductor is discharged through load and diode. Figure 10. explains the mode of operation when switch S is turned OFF. Fig. 11. shows the characteristics waveform of DC- DC buck-boost converter.

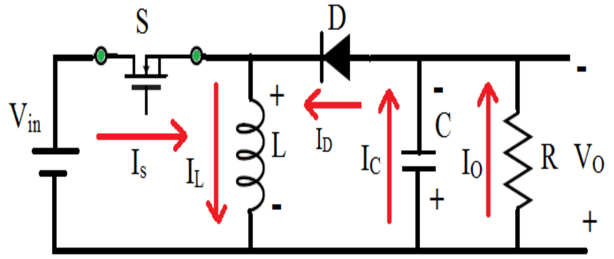

Fig.8. Power Circuit diagram of DC-DC buck-boost converter

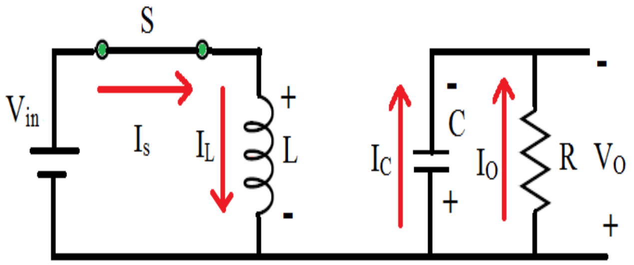

Fig.9. Equivalent circuit of buck-boost converter when switch is ON

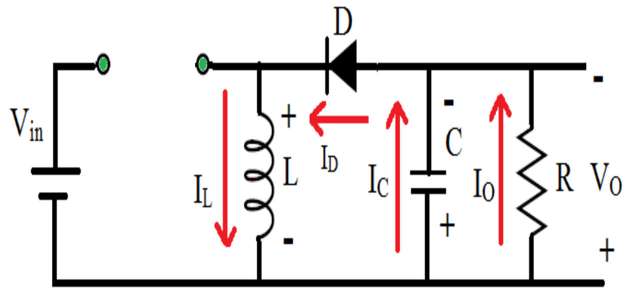

Fig.10. Equivalent circuit of buck-boost converter when switch is OFF

Thus:

$$VL = -Vd - Vo \quad (6)$$

$$(Vin - Vd)D + (-Vd - Vo)(1 - D) = 0 \quad (7)$$

$$Vo = \frac{D\,Vin}{(1-D)} - \frac{Vd}{(1-D)} \quad (8)$$

$$\frac{Vo}{Vin} = \frac{D}{(1-D)} - \frac{Vd}{Vin}\frac{1}{(1-D)} \quad (9)$$

If voltage across diode and switch is negligible then, Vd = 0,

$$\frac{Vd}{Vin} = \frac{D}{(1-D)} \qquad (10)$$

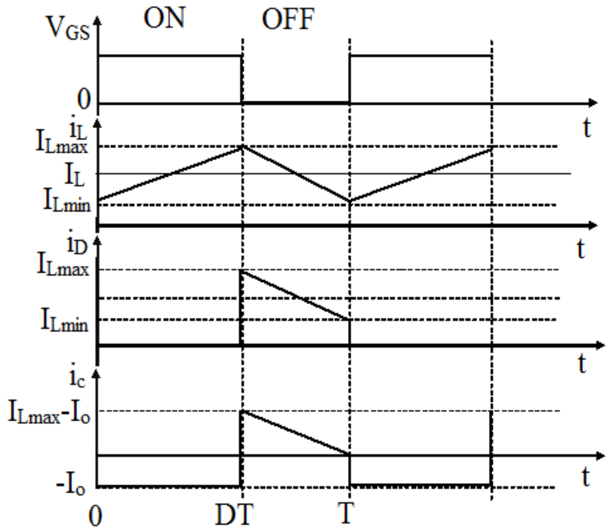

Fig.11. Characteristics waveform of buck-boost converter

VI. SIMULATION AND RESULTS

6.1 PV array characteristics

The mathematical model of solar PV panel as shown in fig. The inputs to the solar PV panel are temp. and solar irradiation.

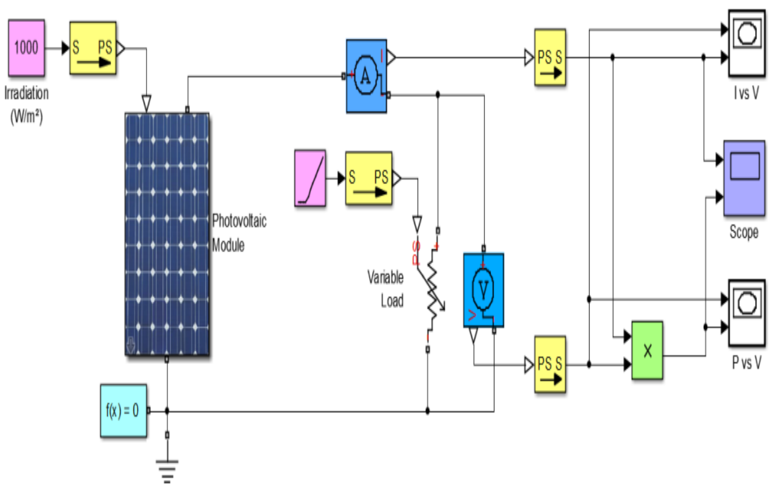

Fig.12. Implemented PV cell model in MATLAB Simulink

6.2 Simulation Model of P&O MPPT Algorithm

The perturb and observe algorithm state that the operating voltage of the PV panel is perturbed by a small increment. If ΔP is positive, then we are going in the direction of MPP & perturbing in the same direction. If ΔP is negative we are going away from the direction of MPP & sign of perturbation is changed.

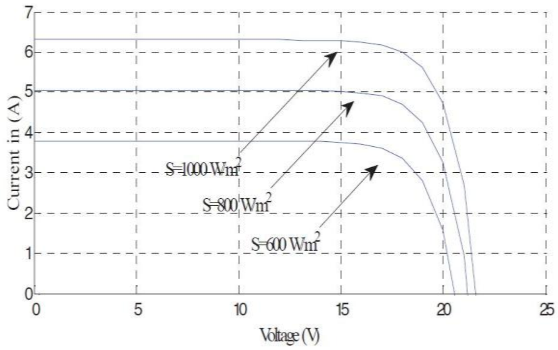

Fig.13 IV characteristics of PV module

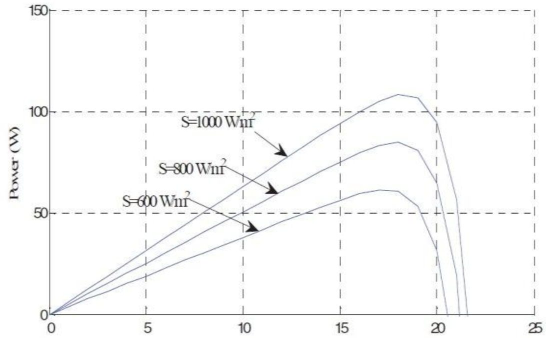

Fig.14 PV Characteristics of PV module

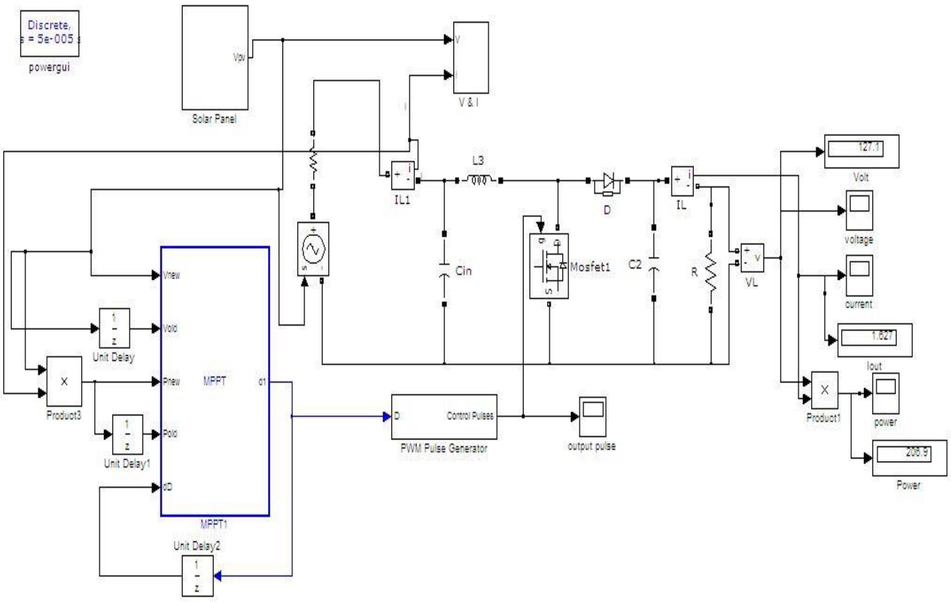

Fig.15 Solar with P&O MPPT Technique

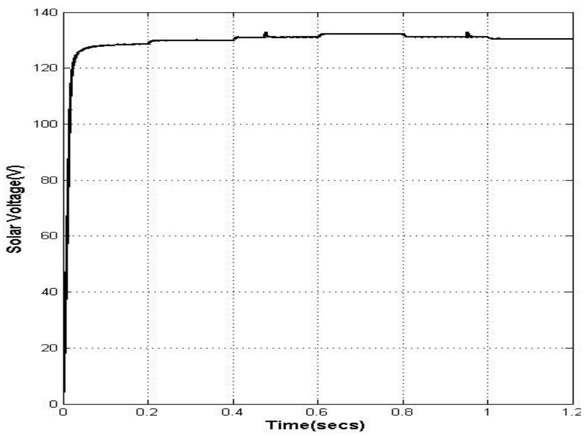

Fig.16 Solar Output Voltage

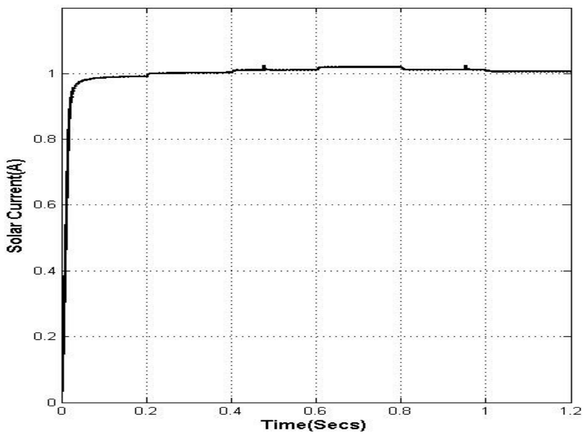

Fig.17. Solar Output Current

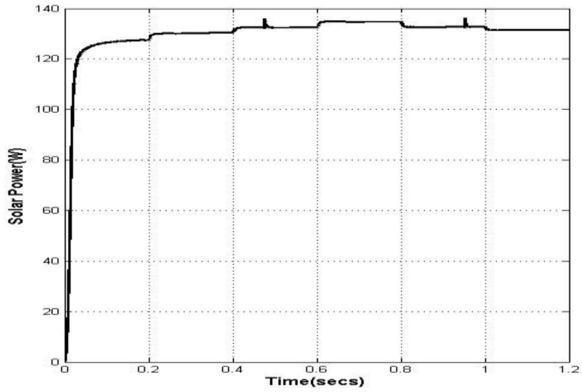

Fig.18. Solar Output Power

6.3 Simulation of Fuzzy Logic Technique

The FLC MPPT algorithm as shown in Figure has two inputs and one output. The two input variables are E (t) and ΔE (t) and the output variables is duty cycle (D). The input variables are converted to unitary units. The membership functions (MF) of input variables, output variable and the proposed FLC algorithms. Negative Big (NB), Negative Small (NS), Zero Error (ZE), Positive Small (PS), Positive Big (PB).

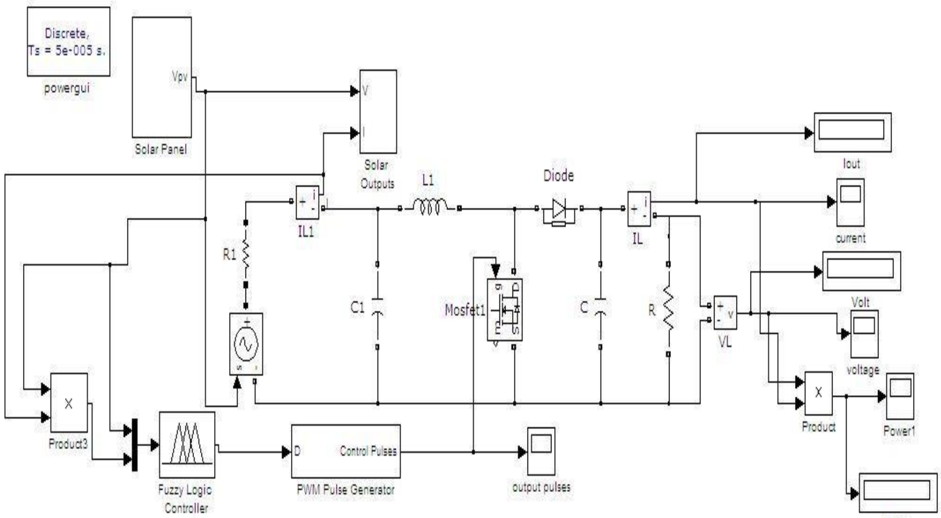

Fig. 19. Solar With Fuzzy Logic MPPT Technique

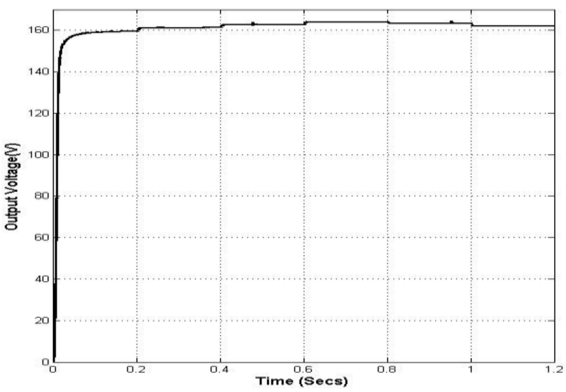

Fig.20. Fuzzy Output Voltage

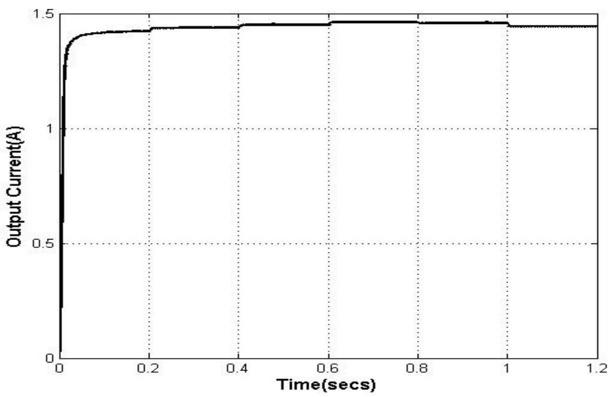

Fig.21. Fuzzy Output Current

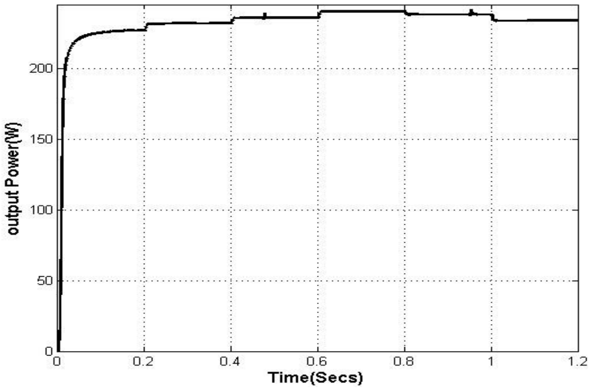

Fig. 22. Fuzzy Output Power

VII. CONCLUSION

The PV and IV characteristics of PV module using solar panel has been designed by using MATLAB Simulink.While plotting PV and IV characteristics of solar isolation and temperature of the cell is taken careof . The MPPT technique using buck-boost,P& O and fuzzy logic controller, all these techniques has been implemented in MATLAB Simulink environment purely for the comparison. From the obtained test resultsit can be concluded that fuzzy logic technique is more efficient and produces optimized duty cycle for PV array MPPT technique.

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