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MODELING AND SIMULATION OF PHOTOVOLTAIC SYSTEM WITH BOOST CONVERTER USING FUZZY LOGIC CONTROLLER

Pankaj Kapadeeya[1], Prof R.P.Sukhadia[2]
[1]PG Scholar, [2]Assistant Professor, Electrical Department, LDRP-ITR, Gandhinagar, Gujarat, India

ABSTRACT: This paper proposes a method of Maximum Power Point Tracking using Fuzzy Logic Controller for Photo Voltaic Systems. The electric power supplied by a photovoltaic power generation system depends on the solar radiation and temperature. Designing efficient PV systems heavily emphasizes to track the maximum power operating point. The Boost converter increases output voltage, it is depends on the duty cycle of switch device. The proposed controllers are adjusting the duty cycle of the DC-DC converter switch to track the maximum power of a solar PV array. Fuzzy Logic Controllers provide attractive features such as fast response, accuracy and good performance. This switching pattern can reduce the switching losses, voltage and current stress of the switching device. Mathematical modeling of the system and the results of simulations in MATLAB/SIMULINK software are presented to investigate the correctness of the results. Finally performance comparison between Incremental conductance and Fuzzy logic controller method has been carried out which has result shown the effectiveness of Fuzzy controller to draw more energy, decreases fluctuations and fast response, against change in variable weather condition. The final result show the fuzzy logic controller exhibits a better performance compared to Incremental conductance.

I. INTRODUCTION

As the cost of traditional fossil fuels continues to rise, the cost of electricity generated by traditional means also increases. However as technology and manufacturing processes improve the cost of alternative energy sources such as solar energy decreases [1]. Because of the demand for electric energy and environmental issues such as pollution and these effects of global warming, renewable energy sources are considered as an option for generating clean energy. Technologies Photovoltaic (PV) energy has increased interest in electrical power applications. It is crucial to operate the PV energy conversion systems wear the maximum power point to increase the efficiency of the PV system. In this paper, a fuzzy logic controller (FLC) is developed to assign priority to the installed system loads such that all critical loads receive a higher priority than the non-critical loads, and so when there exists a shortage of available energy the critical loads are first met before attempting to power the non-critical loads. This energy dispatch controller is also optimized to maintain a higher battery charge so that the controller is better able to power critical loads during an extended period of unfavorable weather conditions or low solar insolation. In this study, the simultaneous optimization of the membership functions and rule base of a fuzzy logic controller is carried out. The MPPT is a process which tracks maximum power from array and by varying the ratio between the voltage and current, increase the output power of the system. There are many different MPPT techniques based on different topologies and varying complexity, cost and production efficiency, these techniques are use for increase the efficiency of PV system [3]. In this paper, presents a comparative study of two MPPT algorithm techniques in order to optimize the efficiency of the solar PV system. Incremental conductance and Fuzzy logic controller techniques applied to a dc-dc Boost converter device. The proposed techniques are well adjusting the duty cycle of the boost converter switch to track the maximum power and increase efficiency of a solar PV array.[5] In this paper, intelligent controller techniques using fuzzy logic controller is associated to an increase energy conversion efficiency and compare to Incremental conductance method. The proposed controller method is simulated by using Matlab/Simulink simple Matlab Tool. The Simulation and analysis of incremental conductance and fuzzy logic controller are presented.

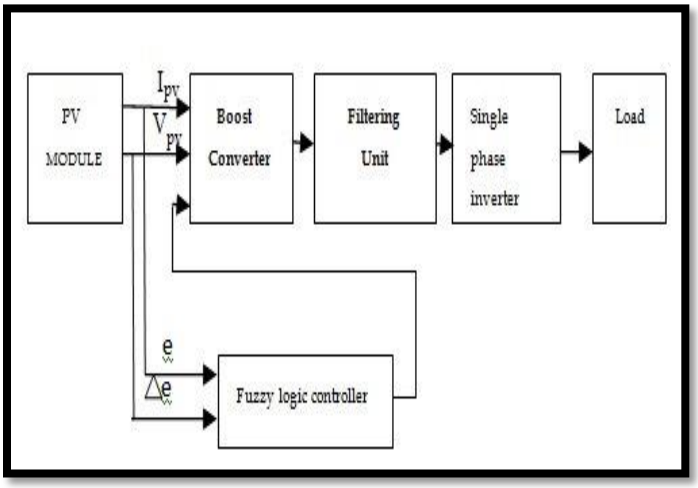

Fig: 1.1 Typical Diagrams of MPPT & Fuzzy Logic Controller in a PV System

Recently FUZZY logic has been applied for tracking the maximum power point of PV systems in because it has the advantages of being robust, design simplicity and minimal requirement for accurate mathematical model. One of the most popular algorithms of MPPT is P&O (Perturb and Observe) technique; however, the convergence problem and oscillation are occurred at certain points during the tracking. To enhance the performance of the P&O algorithm Fuzzy logic converter and Boost converter to the MPPT control.

II. MODELING OF PV SYSTEM

A solar PV cell basically is a p-n semiconductor junction. When exposed the light on the solar panel, a dc current varies linearly with the solar PV irradiance. The equivalent electrical circuit of an ideal PV cell can be treated as a current source parallel with a diode shown in Fig. 1.2.

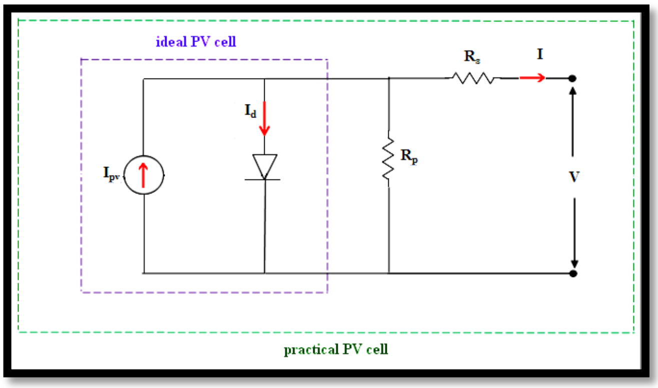

Fig.1.2.Equivalent electrical circuit of a solar cell

The output current can be measured by subtracting the diode currents and current through resistance from the light generated current. From this circuit, the output current of the cell is expressed as,

$$I = Ipv - Id - I_{Rsh} \quad (1)$$

$$I = Ipv - I_0 \left[\exp\left(\frac{V+IRs}{a}\right) - 1\right] - \left(\frac{V+IRs}{Rp}\right) \quad (2)$$

Where, $a = \frac{NS.A.K.Tc}{q} = Ns.A.V_T$

Where, N saw numbers of cells connected in series. The output current of the solar panel is I. The light generated current is Ipv. Saturation currents through diodes are I_0. The voltage at output of panel is V, Series resistance of cell is Rs, which represents the internal resistance of cell and it is considered as 0.55 Ω. The Boltzmann's constant is K (1.38 X 10^{-23} J/K). Ambient temperature (in Kelvin) is T and charge constant is q (1.607 X 10^{-19}C).

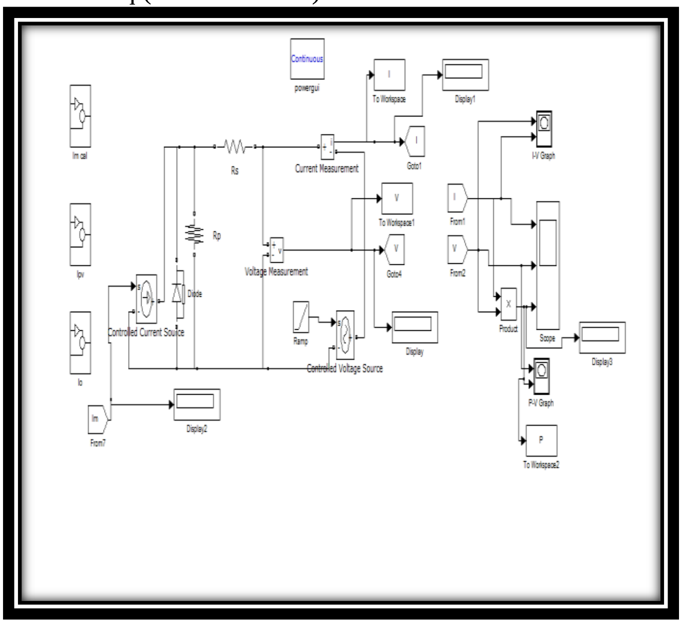

Fig 1.3: Simulink model of a PV device

Table 1.1: Parameters of the PV module at 25^0C, 1000 W/m^2 [6]

Imp	2.88 A
Vmp	17 V
Pmp	49 W
Isc	3.11 A
Voc	21.8 V
Rs	0.55 Ω
Kv	-72.5×10^{-3} V/K
Ki	1.3×10^{-3} A/K
Ns	36

RESULTS:-

After the simulation, we obtained the following results,

Simulation Results of solar panel

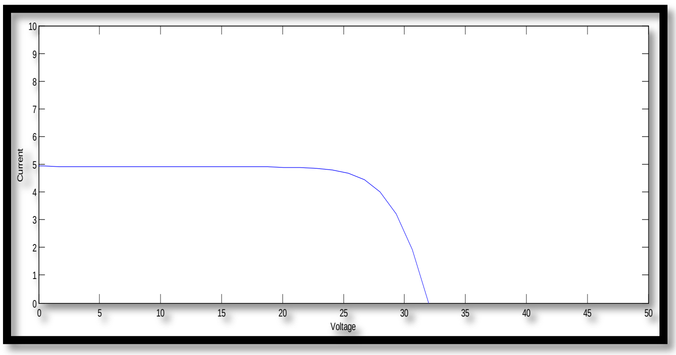

Fig 1.4-I-V Characteristic

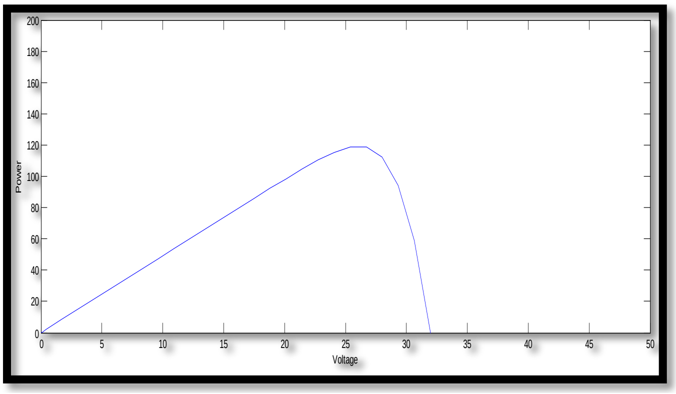

Fig 1.5-P-V Characteristic

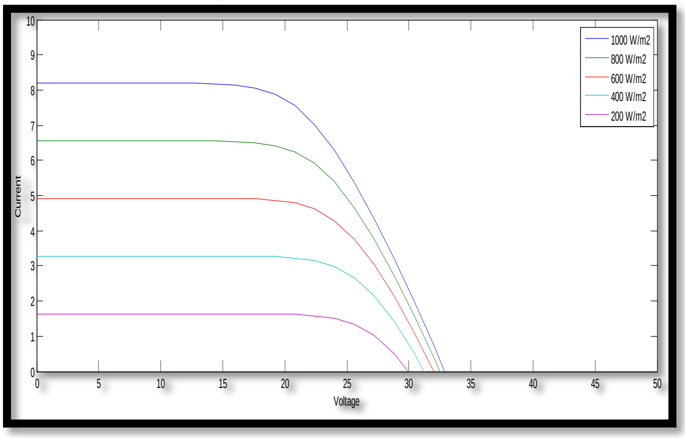

Fig 1.6-Diiferent Radiation I-V Characteristic

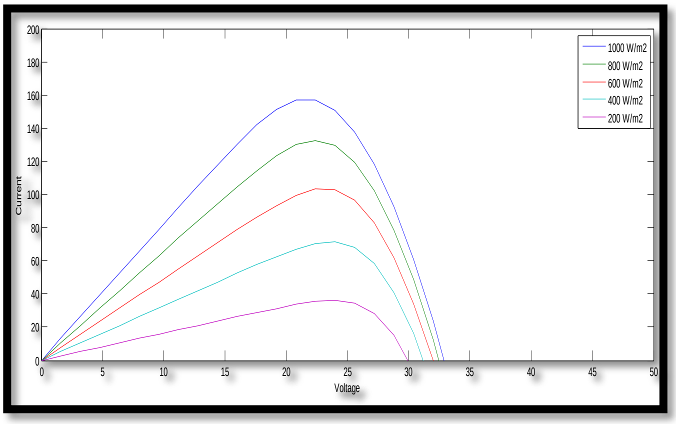

Fig 1.7-Diiferent Radiation P-V Characteristic

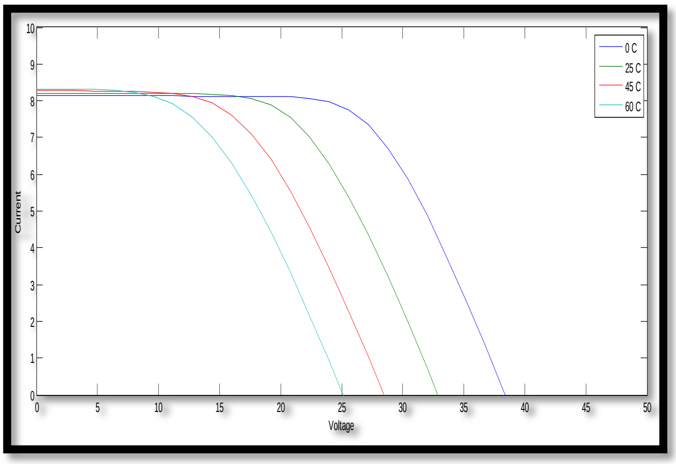

Fig 1.8-Diiferent Temperature I-V Characteristic

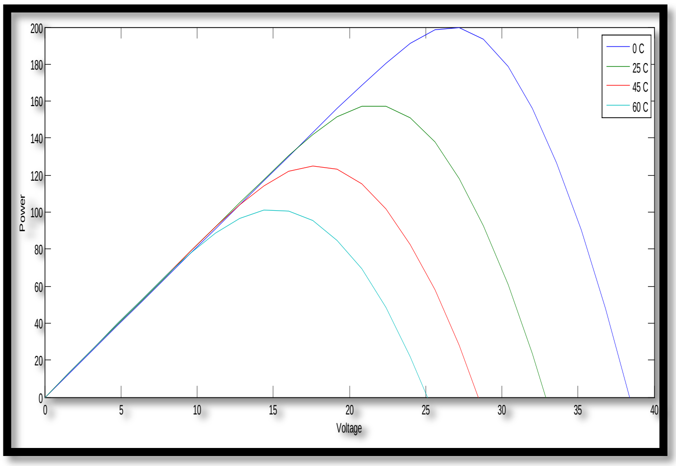

Fig 1.9-Diiferent Temperature P-V Characteristic

III. DC-DC BOOST CONVERTER

A Boost converter is a step-up DC-DC power converter, which is converting a low input voltage to a high output voltage. In this situation the output current is lower than source current. It is implemented in this proposed system by using a diode and MOSFET [2]. The converter operation can be divided into two modes, mode first begins, when the transistor is switched on, the current increases linearly in the boost inductor, and the diode is off state, mode second begin, when the transistor is switched off, the energy stored in the inductor is discharge through the diode to the source load [9]. The classical relationship between input and output voltages of a boost converter at steady state condition is given by

$$\frac{Vo}{Vi} = \frac{1}{1-D} \qquad \text{............ (1)}$$

Where, the duty cycle D is between 0 and 1.

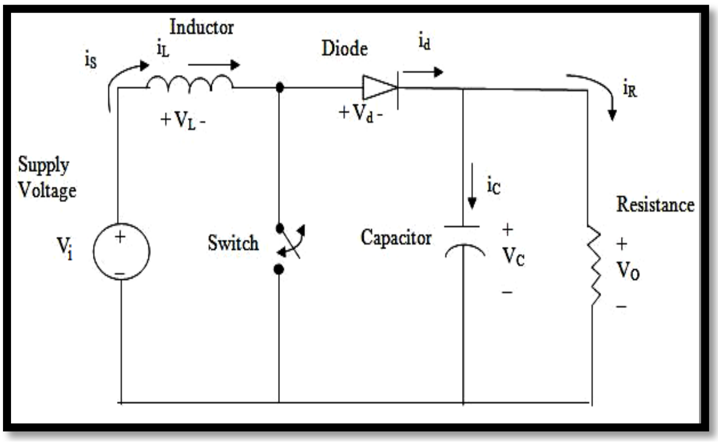

Fig. 2.1 Boost converter circuit

Design Calculation:-

The Boost converter parameter values are calculated by the following formulae.

1. Duty cycle, k = 1-Vs/Vo
2. Ripple current, ΔIL= VS∗k Lf
3. Inductance, L= Vs∗K(1−K) ΔIL ∗f
4. Ripple voltage, ΔVc = Io ∗k C∗f
5. Capacitance, C = Io ∗k ΔVc ∗f

Parameter	**Value**	**Symbol**
Input voltage	200-900 V	V_s
Output voltage	1100 V	V_0
Switching frequency	20 kHz	F_s
Inductance	0.00698 H	L
Capacitance	2 µF	C
Load resistance	10 **Ω**	R

TABLE 2.1 Operating Values of Boost Converter

IV. FUZZY LOGIC MAXIMUM POWER TRACKING CONTROLLERS

The PV fuzzy logic controller consists of three main modules: the fuzzification process, the inference engine, and the defuzzification process. The relationship between these three main components is shown in Fig.3.1, which shows a block diagram of the traditional Fuzzy Logic Controller requires the expert knowledge of the process operation for the FLC parameters setting and the controller can be only as good as the expertise involved in the design. FLC with a fixed parameter is inadequate in applications when the operation conditions change in wide range and the available expert knowledge is not relatable. To make the controller less dependent on the expert knowledge, FLC could be introducing [5].

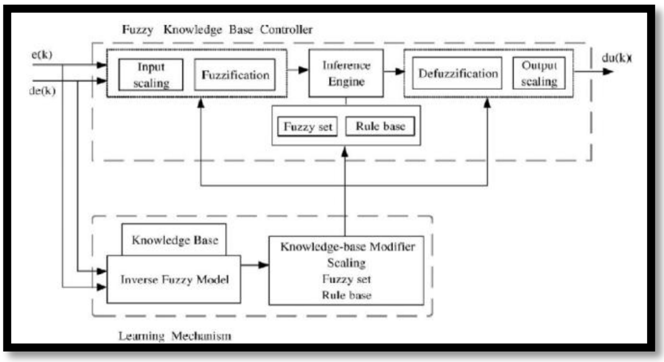

Fig: 3.1 Typical Diagram of Fuzzy Logic Controller

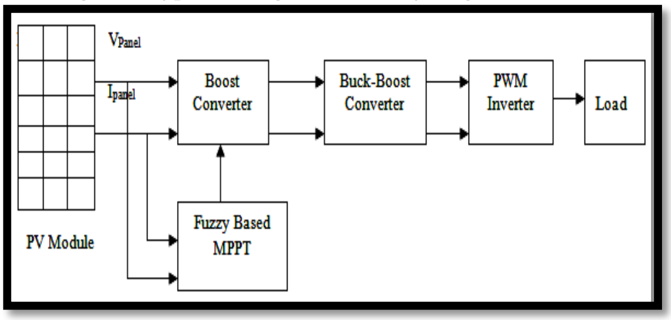

Fig. 3.2 Typical diagram of Fuzzy based MPPT in PV system

The input variables of MPPT are the PV module output voltage and current. In this paper implemented the fuzzy logic based P&O MPPT algorithm. A fuzzy logic based MPPT control is implemented to generate the optimal voltage reference from the PV system by modulating the duty cycle applied to the boost converter. The output voltage and current of the PV panel are measured and fed to the fuzzy based control unit for MPP tracking. Based on the change of power with respect to change of voltage dp/dv and Δdp/dv, fuzzy determines the voltage reference and compared with the modulating signal and generate pulse, which is applied to the gate pulse of IGBT. The Buck-boost Converter is used to maintain the constant output voltage. The output voltage is controlled by using PI Controller. The DC source is converted into three phase AC by using PWM Inverter [11]. The passive filter is used to reduce the harmonics in output voltage.

FUZZIFICATION

The input membership functions take the inputs to the controller (after they have been normalized by some value suitable for the membership functions) and produce a degree of membership for each fuzzy set in the membership function. Membership function values are assigned to the linguistic variables, using seven fuzzy subsets: NB(Negative Big), NM (Negative Medium), NS (Negative Small), PM (Positive Medium) and PB (Positive Big). The triangular shape of the membership function of these arrangements presumes that for any particular input there is only are domain fuzzy subset. The input error (e) & change of error (e) for fuzzy logic controller can be calculated from the maximum power point. Fuzzy associate memory for the proposed system is given by Table-1.

Fuzzy Associated Memory

E	ΔE						
	NB	NM	NS	ZE	PS	PM	PB
NB	NB	NB	NB	NM	NM	NS	ZE
NM	NB	NB	NM	NM	NS	ZE	PS
NS	NB	NM	NM	NS	ZE	PS	PM
ZE	NM	NM	NS	ZE	PS	PM	PM
PS	NM	NS	ZE	PS	PM	PM	PB
PM	NS	ZE	PS	PM	PM	PB	PB
PB	ZE	PS	PM	PM	PB	PB	PB

Table-1 Fuzzy Associated Memory

DEFUZZIFICATION

Once the degrees of membership of the outputs have been found via the inference engine, the defuzzification process takes these values and translates them into an output dispatch signal. Once fuzzification is over, output fuzzy range is located .since at this stage a non-fuzzy value of control is available a defuzzification [6] is used for defuzzification in the proposed scheme.

V. MODELING AND SIMULATION

The simulations of the MPPT show that the system is stable. The oscillations about the computed optimal operating point are due to the switching action of the DC/DC converter. The designed PV module and DC-to-DC converter module can connected to fuzzy logic controller module to tracking the maximum power point using switching techniques as shown in Fig: 4.1.

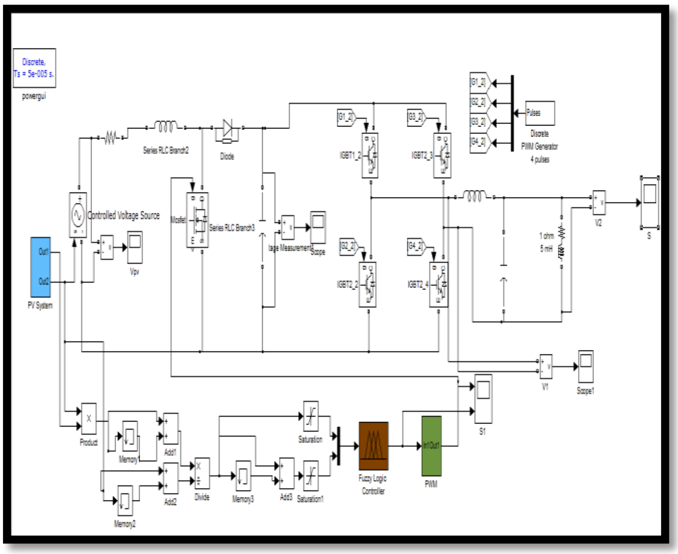

Fig 4.1- Modeling of PV System Using FLC

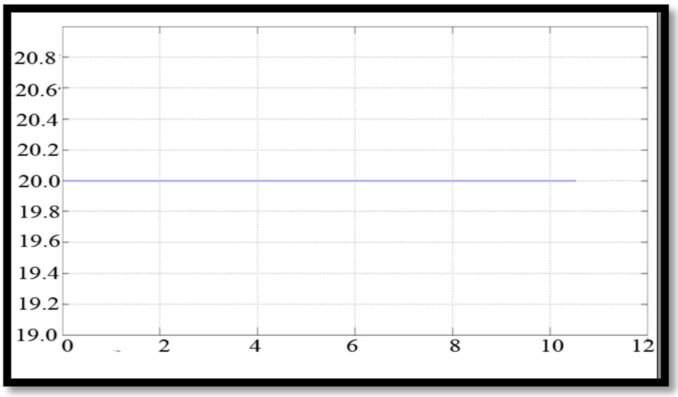

Fig 4.2- Input Voltage Waveforms

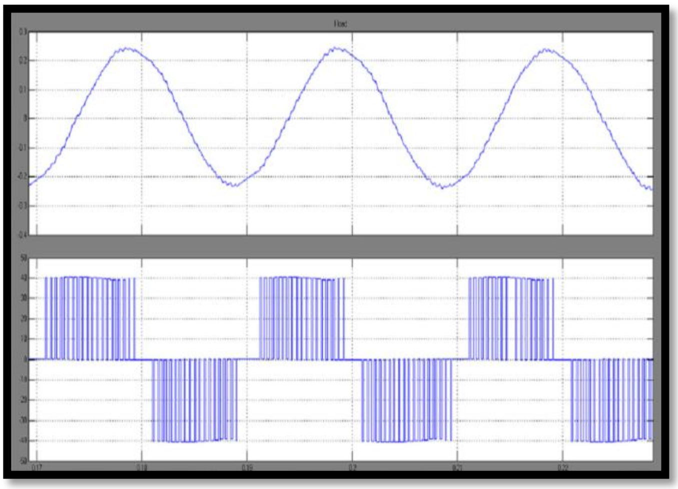

Fig 4.3- Output Current &Voltage Waveforms

VI. CONCLUSION

This paper has presented the fuzzy logic controller for controlling maximum power point tracking of a photovoltaic system. The proposed algorithm in PV module and FLC was simulated. The simulation results show that this system is able to adapt the fuzzy parameters for fast response and good transient performances. The Fuzzy Logic controller Increase output power, less fluctuation and fast Response, against change in weather conductions. The Fuzzy controller is superior compared to Incremental conductance. In addition, the result of the simulation shows the increased efficiency of the system because of reducing the switching losses in the system. This system can provide high efficiency and low switching losses.

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