Fuzzy Logic Based Maximum Power Point Tracking Algorithm for Photovoltaic Power Generation System

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Abstract

Energy is the most important factor for the economic development of a country. In order to cope with increased demand of energy, an efficient photovoltaic (PV) power generation system needs to be developed. The efficiency of PV module is very less and it shows nonlinear characteristics due to variation in solar irradiance and operating temperature. The efficiency of the PV system can be improved by operating the system at its maximum power point (MPP) which can be accomplished by adopting maximum power point tracking (MPPT) techniques. This paper addresses implementation of an fuzzy logic based MPPT method. MPPT tracking mechanism such as Perturb and Observe (P&O) MPPT algorithm and Fuzzy-MPPT (FMPPT) for PV power generation system are implemented in this work. The performance of FMPPT is compared with that of P&O MPPT. Since FMPPT can handle nonlinearity very well and can track the MPP more precisely and rapidly, it provides better performance than P&O technique in tracking of MPP.

Keywords: Photovoltaic, MPP, Perturb and Observe, Fuzzy-MPPT.

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1 Introduction

Solar PV power generation is one of the burning research fields these days. Steep growth in the application of PV has been driven by growing concern about climate change, Government incentives and reduction in PV system costs. In order to cope with increased demand of energy, an efficient photovoltaic (PV) power generation system with an effective maximum power point tracker needs to be developed. In a PV system, the conversion of solar energy to electricity is facilitated by means of a PV module and a power-electronic converter system with a control mechanism. The output power of a PV cell fluctuates to a large extent due to variation in solar irradiation and temperature. The current-voltage (I-V) and power-voltage (P-V) characteristics of PV cell are nonlinear. A PV module has an optimum operating point where power is maximum, known as maximum power point (MPP) which varies according to cell operating temperature and irradiation level [1]. PV modules have low energy conversion efficiency that can be increased only if a PV module can be operated at its MPP. When a direct connection is carried out between source and load, the output of PV module irregularly shifts away from maximum power point. The PV power can be made available for practical use by the help of an efficient device called maximum power point tracker which extracts the peak of the available PV power. This device must be constructed with a good MPPT algorithm and a controller with efficient control system [2]. MPPT uses DC-DC converters for regulating the solar input voltage to the maximum power point and providing impedance matching for the maximum power transfer to the load. Various methods of maximum power tracking in PV power applications have been reported in literature [3]. These techniques differ in many aspects such as required sensors, complexity, cost, range of effectiveness, convergence speed, hardware required for the implementation or popularity.

Perturb and observe MPPT algorithm is simple and easy to implement but it suffers from drawbacks like slow convergence speed and oscillation of output around the MPP in steady state. When the system is operating near a region around the maximum power point, the P&O algorithm suggests an increase in duty cycle or decrease in duty cycle depending on the change in PV voltage. If the operating point is at left side of MPP then an increase in duty will results in shift of operating point to the right side of MPP. This causes an oscillation of system output around the maximum power point in the steady state. In order to avoid this oscillation and obtain a stable and steady output at the output of PV power generation system, a fuzzy logic based maximum power point tracking algorithm has been implemented. Fuzzy logic based MPPT can handle non-linearity and uncertainty associated with PV systems. Fuzzy logic based MPPT has several advantages like they do not require pre-knowledge of the exact model of the PV panel and provide better performance. This paper explores ways of improving maximum power point tracking using fuzzy logic. The control algorithm uses the excellent knowledge representation and deduction capabilities of fuzzy logic to address the drawbacks of conventional methods.

The main aim of this paper is to investigate the concept of conventional Perturb and Observe (P&O) algorithm and fuzzy MPPT (FMPPT) technique to produce an improved MPPT controller. An intelligent maximum power point tracking technique using fuzzy logic controller is presented to track the MPP of the PV module. Performance analysis and comparison of results of P&O MPPT and FMPPT in a PV power generation system are evaluated using MATLAB/Simulink Software.

2 Modeling of PV Cell

Accurate modeling of a photovoltaic cell is an important requirement for designing an efficient PV power generation system since photovoltaic cell is the basic element of a PV system. A PV cell can be represented by a photon generated current source and a diode that represents p-n junction of a solar cell in parallel with the current source [4]. A series resistance and a shunt resistance are taken into account in order to represent various losses. The equivalent circuit diagram of single diode model of a PV cell [5, 6] is represented in Figure 1.

The output current from a PV cell can be represented as:

$$I_{pv} = I_{ph} - I_d - I_{sh} \tag{1}$$

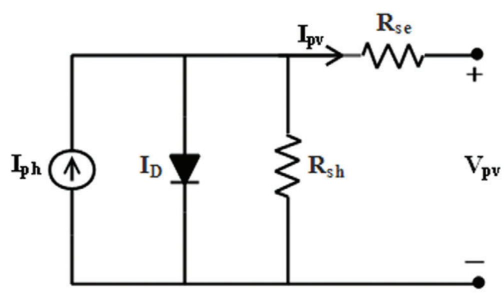

Figure 1 Equivalent circuit diagram of a PV cell.

Where, I_{ph} is the photon generated current in PV cell, I_d is the current through the diode, I_{sh} is the current through shunt resistance. Since a single solar cell typically produces a voltage only about 0.6 V–0.8 V so they need to be connected in series to form a module. The diode current is given by Shockley equation can be represented as:

$$I_d = I_o \left[exp\left(\frac{V_{pv}}{AV_T}\right) - 1 \right] \tag{2}$$

Where, V_{pv} is the diode voltage;
A is the diode ideality factor;
V_T is the thermal voltage of Diode;

STC refers to the standard test condition at which operating temperature is 25°C and solar irradiance intensity is 1000 W/m^2 with Air Mass 1.5.

Thermal voltage can be calculated using following equation: $V_t = \dfrac{N_s kT}{q}$ (3)

The output current equation of the PV module can be written as

$$I = I_{ph} - I_d = I_o \left[exp\left(\frac{V}{AV_T}\right) - 1 \right] - \frac{V + IR_s}{R_{sh}} \tag{4}$$

Where, R_s is the equivalent series resistance;
R_{sh} is the equivalent shunt resistance;
N_s is the number of series connected PV cell;

The photo current in Equation (4) is dependent on solar irradiance and temperature. The relation between photon generated current, solar irradiance and temperature can be represented as

$$I_{ph} = [I_{ph,ref} + \ K_I \left(T - T_{ref}\right)] \frac{G}{G_{ref}} \tag{5}$$

Where, I_{ph} is the photon generated current at Standard Test Condition (STC);
G is the solar irradiation intensity on the surface of PV cell in W/m^2;
G_{ref} is the irradiation intensity at STC = 1000 W/m^2;
K_{Isc} is the short circuit current temperature coefficient of solar cell;

The relationship of diode saturation current with temperature can be expressed as

$$I_o = I_{o,ref} \left(\frac{T_{ref}}{T}\right)^3 exp\left[\frac{qE_g}{Ak}\left(\frac{1}{T_{ref}} - \frac{1}{T}\right)\right] \tag{6}$$

Table 1 Parameters of data sheet of Sun Power E18 305 PV module

Parameters	Values
STC Power Rating	305 W
No. of Cells in Series	96
Rated Current (I_{mpp})	5.58 A
Rated Voltage (V_{mpp})	54.7 V
Short Circuit Current (I_{sc})	5.96 A
Open Circuit Voltage (V_{oc})	64.2 V
Temperature Coefficient of Current	3.5 mA/K

The reverse saturation current at STC can be written as:

$$I_{o,ref} = \frac{I_{sc,ref}}{exp\left(\frac{V_{oc,ref}}{AV_{t,ref}}\right) - 1} \tag{7}$$

Where, $I_{sc,ref}$ is the solar cell short-circuit current at STC;
$V_{oc,ref}$ is the Solar cell open circuit voltage at STC;
E_g is the band-gap energy in the PV cell;

In this work, Sun Power E18 305 module is modelled and simulated because a single module can be used to meet the power need of a room due to its high power rating and efficiency. The parameters of manufacture's data sheets are presented in Table 1.

3 Maximum Power Point Tracking

Maximum power point tracker is an electronic device that extracts maximum possible power from solar module. When the PV module is used in a system, the operating point is decided by the load to which it is connected. Since the solar irradiation and the temperature varies throughout the day, the operating point of the solar module shifts [7]. In order to receive maximum power, the load must adjust itself accordingly to track the MPP which can be accomplished by the use of a maximum power point tracker. MPP tracker varies the electrical operating point of the module by changing the duty cycle of the DC-DC converter to match the load impedance with PV module impedance. It ensures that maximum amount of generated power is transferred to load.

A standalone PV power generation system that meets small load demand is mainly consists of PV module, boost converter and MPPT mechanism. When solar module is irradiated, it generates an unregulated DC voltage. This voltage is fed to the DC-DC boost converter in order to regulate it. Maximum power is transferred to load when the load impedance matches with the source impedance. The impedance matching is done by changing the duty cycle of the boost converter which results in the adjustment of the load impedance according to the power output of the PV module. A general block diagram of the PV system is presented in Figure 2.

When load is coupled to the PV module directly, then the operating point of load is defined by the intersection of its I-V curve with load line as shown in Figure 3.

There are two operating point A and B for two different values of load resistance. Powers at these two points are less than the maximum power. This indicates that the operating point of PV module depends on load. When load varies, the operating point shifts. MPPT technique pulls the operating point of the load to the MPP [8].

The expression for source impedance (R_i) can be written as:

$$R_i = \frac{V_{in}}{I_{in}} = \frac{(1-D)V_0}{\left(\frac{I_0}{1-D}\right)} = (1-D)^2 \frac{V_0}{I_0} \tag{8}$$

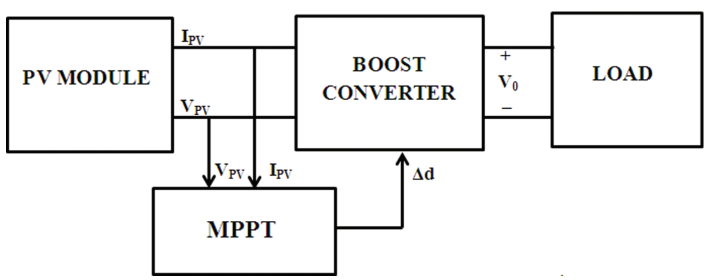

Figure 2 Block diagram of PV power generation system.

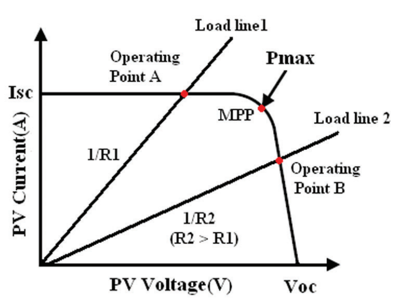

Figure 3 I-V curve showing different operating point.

$$R_i = (1 - D)^2 R \tag{9}$$

The impedance at maximum power point can be calculated from the following equation.

$$R_{MPP} = \frac{V_{MPP}}{I_{MPP}} \tag{10}$$

Where, R is the load impedance, R_{mpp} is the characteristic impedance of PV module. The R_i should be same as R_{mpp} at an given operating condition for maximum power transfer.

MPPT techniques are categorized by its features like simplicity, type of control strategies, convergence speed, cost effectiveness and number of sensors required. Among different MPPT techniques, in this paper, Perturb and Observe (P&O) MPPT and fuzzy logic based MPPT are investigated by considering simplicity, ease of implementation and number of sensors required.

3.1 Perturb & Observe MPPT Technique

The Perturb and Observe (P&O) method will perturb the system by either increasing or decreasing the duty cycle of converter. If the perturbation leads to an increase or decrease in PV module power, the subsequent perturbation is made in the same or opposite direction. In this manner the maximum power tracker continuously track the peak power condition. In this technique present perturbation is decided by the sign of previous perturbation. If the power is incremented by last perturbation, then the perturbation should be in same direction. Otherwise the direction of perturbation is reversed [9, 10] as shown in Figure 4. The perturbations are repeatedly carried out until the MPP is reached. In order to keep the power variation small, the perturbation size is also kept small. The P&O algorithm is presented in Figure 5.

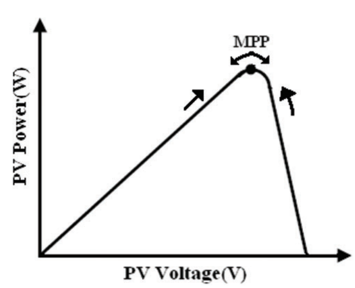

Figure 4 P-V characteristics showing perturbation direction.

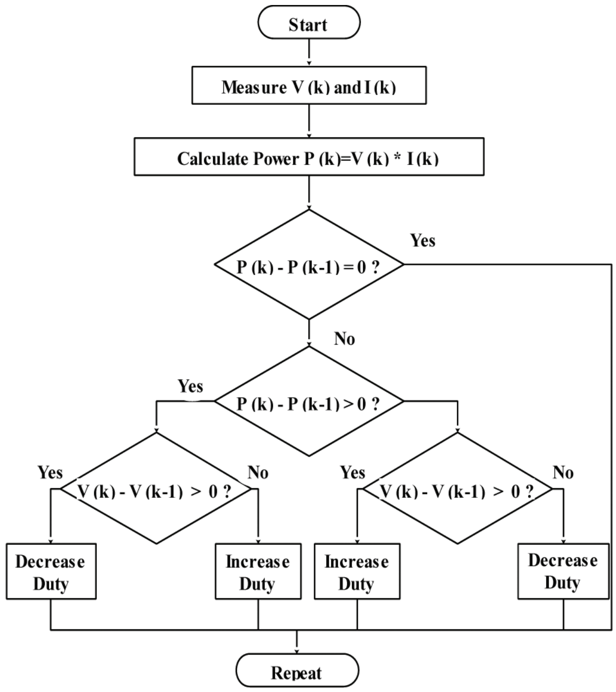

Figure 5 Flow chart of P&O algorithm.

3.2 Fuzzy MPPT Technique

Fuzzy logic based intelligent MPPTs have been gained more attention because of their capability to handle nonlinearity associated with the system. Due to lack of precise modeling of PV modules and uncertainty in the performance of PV system due to varying irradiance and temperature, the fuzzy MPPT (FMPPT) is found to be more suitable for tracking of MPP than conventional algorithms in PV Systems. FMPPT can deal with uncertainty such as unmodeled physical quantities, nonlinearity and unpredictable changes in operating point of the PV system. This MPPT technique enhances the choice of the variable step size of the duty cycle and therefore improves the performances of photovoltaic system. The concept of this algorithm is to compute the variable step according to the slope value of Power-Voltage characteristic for photovoltaic module. Then, it provides the appropriate value of duty cycle.

The fuzzy controller consists of three functional blocks namely fuzzification, rule inference and defuzzification [11, 12]. In the proposed system, the input variables of the FLC are error (e) and the change in error (ce) whereas the output of FLC is change in duty cycle. Design considerations and effectiveness of the fuzzy MPPT algorithm depend on the selected input and the output variable selected. The output variable of the FMPPT algorithm is usually duty ratio command for adjusting the operating point of the PV module in order to maximize the power output. The most commonly used input variables for FMPPT are slope of P-V curve of the PV module and changes in this slope.

Since slope vanishes at the MPP, the both inputs can be calculated as follows:

$$e(k) = \frac{P_{pv}(k) - P_{pv}(k-1)}{V_{pv}(k) - V_{pv}(k-1)} \tag{11}$$

$$ce = e(k) - e(k-1) \tag{12}$$

Where, P_{pv} and V_{pv} represent the power and voltage in P-V curve respectively.

In fuzzification process, input variables e & ce and output variable Δd are converted into linguistic variables by assigning values of membership function. These variables are expressed in different fuzzy levels: NB (negative big), NS (negative small), ZE (zero), PS (positive small), PB (positive big).

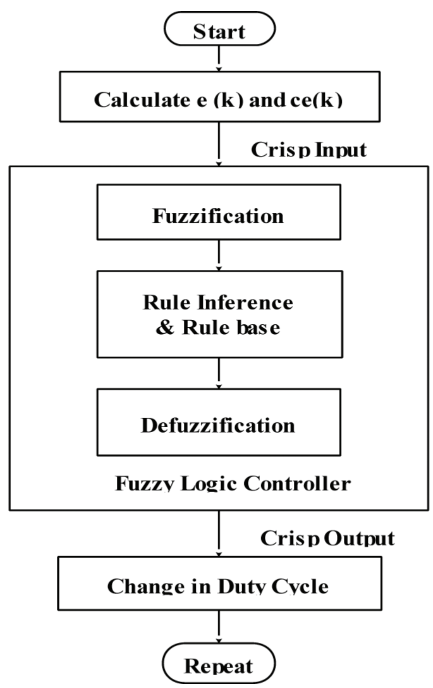

Figure 6 Flow chart of fuzzy logic based MPPT.

In this work triangular membership functions are considered which presumes that for any particular input there is only one dominant fuzzy subset. The membership functions for e, ce and Δd are shown in Figure 7. Modeling of FMPPT depends upon heuristic defining rules and fuzzy rule base is a combination of if-then rules that are used for fuzzified inputs. Fuzzy rules are found based on experimental knowledge about the problem or characteristics of PV system. The number of the rules depends upon the number of linguistic variables in input Membership functions. In this study, the fuzzy rules include 25 fuzzy control rules. Fuzzy inference system performs composition operation that formulates a logical decision based on fuzzy rules by which a control output is generated. Mamdani fuzzy inference method has been used

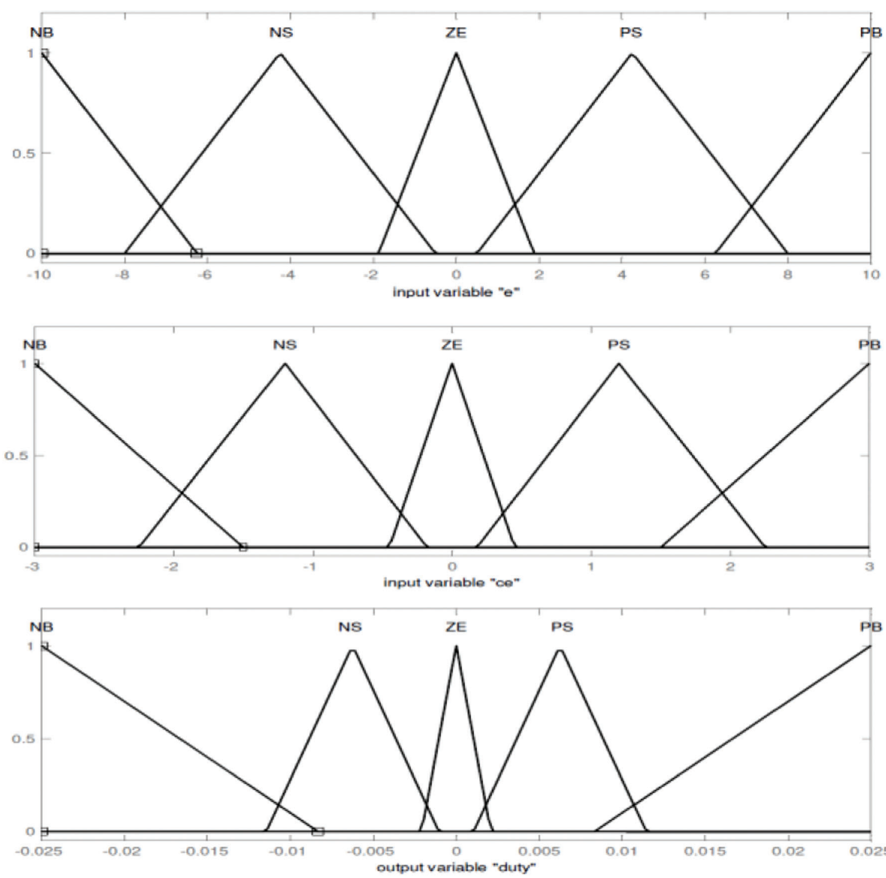

Figure 7 Membership function of e, ce and Δd.

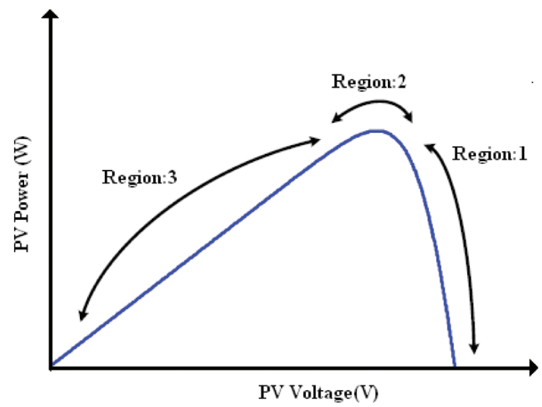

Figure 8 P-V curve of PV module indicating different regions for fuzzy rule set.

Table 2 Control rule base of FMPPT

e\ce	NB	NS	ZE	PS	PB
NB	ZE	PB	PB	PB	PB
NS	PB	PS	PS	ZE	ZE
ZE	PS	ZE	ZE	ZE	NS
PS	ZE	ZE	NS	NS	NB
PB	PB	ZE	NS	NB	ZE

in this work with Max-Min composition operation. According to Figure 8, the fuzzy rule database is divided into three regions.

Region-1

- The slope of PV curve i.e. $e(k)$ is negative in this region. This indicates that the operating point of the PV module is located right side of MPP and the duty ratio should be increased in order to track the MPP. The $ce(k)$ is used to determine magnitude of duty cycle to be increased.
- If $e(k)$ is *NS* and $ce(k)$ is positive, it will mean that the operating point is approaching MPP from the right side. So at this time the output is set to *ZE* in order to prevent the system from oscillation.

Region-2

- In this region $e(k)$ is *ZE* which indicates that the operating point is close to MPP. Hence the principle should be to maintain same duty ratio under such conditions.
- If $ce(k)$ is *NB*, the operating point is approaching the MPP from the left side. So the duty ratio is decreased. In order to prevent the operating

point from moving to right side of MPP, the control rule should be *PS* to suppress the change of magnitude of duty cycle to opposite direction.

Region-3

- When $e(k)$ is positive, the operating point is located on the left side of the MPP. So the duty cycle should be decreased. The $ce(k)$ is used to determine the magnitude of duty ratio to be decreased.
- When $ce(k)$ is negative at this point, the operating point is approaching the MPP from the left side. At this time, the controller should set the output to *ZE* in order to prevent reduction in duty cycle and oscillation of the system around the operating point.

The output of FLC is a change in the duty cycle of the DC-DC converter. The process of defuzzification converts linguistic value of output into a crisp output value. The input to defuzzification process is an aggregated output fuzzy set and the output is a single number. Many defuzzification techniques have been proposed in the literature. The most commonly used method is the Center of Gravity (COG) or centroid defuzzification method [13]. In this method, the defuzzifier determines the center of gravity (centroid) and uses that value as the output of FLC. For a continuous aggregated fuzzy set, the centroid is given by:

$$\Delta d = \frac{\sum_{i=1}^{n} W_i \, \Delta d_i}{\sum_{i=1}^{n} W_i} \tag{13}$$

Where, Δd is a crisp value, W_i is the weighting factor and Δd_i is a value corresponding to the membership function of Δd

The output of FLC is the change in duty cycle (Δd) and is expressed as

$$d(k) = d(k-1) + s.\,\Delta d \tag{14}$$

Where, s is the output scaling factor of fuzzy MPPT controller.

4 Modeling of DC-DC Converter

DC-DC boost converter is most simple and popular converter configuration for delivering higher load voltages from a low input voltage. This converter is capable of stepping up of voltage and meeting the load demand. In this work, boost converter working in continuous conduction mode (CCM) is considered. Boost converter is a switched mode power converter which contains a diode, a MOSFET and two energy storing element, an inductor and a capacitor as shown in Figure 9. The inductor present in the input side reduces the input

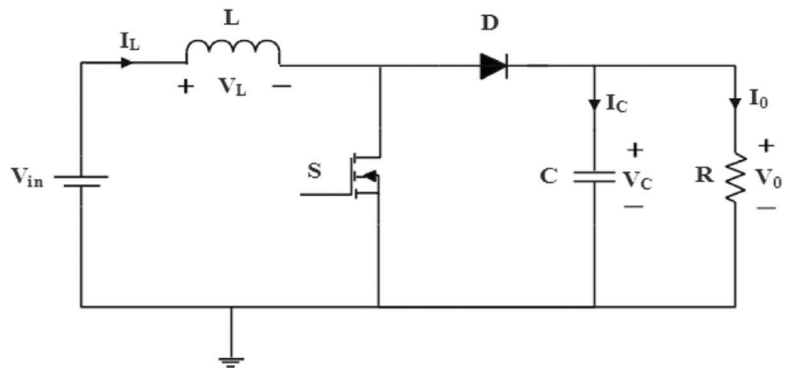

Figure 9 Schematic diagram of non-isolated Boost converter.

current ripple and capacitor is place at the output which helps to reduce output voltage ripple. The detailed circuit operations are discussed in [14, 15].

The circuit operation is divided into two modes. In mode-1 when the switch S is closed for DT_s time period, the inductor is charged through the source and stores the energy. During mode-2 i.e. when the switch S is open for period *(1–D)*, the energy stored in the inductor is transferred to output. Thus the output voltage V_0 is greater than the input voltage. The DC output to input transfer function is given by

$$\frac{V_0}{V_{in}} = \frac{1}{1 - D} \tag{15}$$

Where, D is the duty cycle of switch S

4.1 Design Procedure of Boost Converter

The design of DC-DC boost converter plays an important role for regulation of output voltage and processing of power. The choice of active and passive components will have a huge impact on overall performance of the converter [16, 17]. Efficiency, physical size, output power and cost of the boost converter will rely on the components that are selected. The design of DC-DC boost converter proceeds through following steps.

a) The first step is to determine the input dc voltage range, desired output voltage and output power of the converter stage.
b) The switching frequency of the converter is then defined in second step. Determination of switching frequency depends on the size of converter and overall switching loss.

Table 3 Designed Parameters of Boost Converter

Parameters	Values
Input Voltage	50–60 V
Output Voltage	120 V
Rated Power	305 W
Switching Frequency (f_s)	1 KHz
Input Capacitance	1 mF
Load Resistance (R)	50 Ω
Inductance (L)	1 mH
Capacitance (C)	3 mF

c) The last step is to calculate the minimum value of inductor and capacitor to operate the boost converter in continuous conduction mode (CCM).

The minimum value of inductor and capacitor to ensure continuous conduction mode can be calculated from the following formulas.

$$L_{\min} = \frac{V_{in}D}{\Delta i_L . f_s} \tag{16}$$

$$C_{\min} = \frac{D}{R\left(\Delta V_0/V_0\right) f_s} \tag{17}$$

Where, R is Load resistance, f_s switching frequency, $(\Delta V_0/V_0)$ is the percentage of output voltage ripple. This value should be between (1–10)%. Δi_L is the inductor current ripple. The designed parameters of boost converter are listed in Table 3.

5 Simulation Results and Discussion

The modeled PV power generation system using P&O MPPT and FMPPT has been simulated in MATLAB/Simulink Software. In this work, PV model of Sun Power E18 305 solar module is modeled and current-voltage (I-V) characteristics, power-voltage (P-V) characteristics of PV module have been obtained. The performance of the system is analyzed under both steady state and transient state. A comparison has been addressed between two MPPT control techniques. The operating temperature and the solar irradiation level of the PV module are set to be 25°C and 1000 W/m^2 respectively. Figure 10(a) represents I-V characteristics of PV module at standard test condition. From the simulation results, the short circuit current and open circuit voltage is found to be 5.96 A and 64.08 V respectively. The P-V characteristics

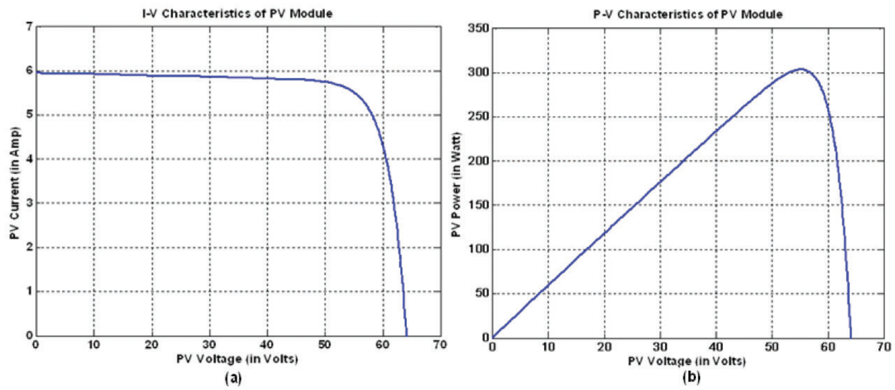

Figure 10 (a) I-V and (b) P-V characteristic of PV module.

of solar module is depicted in Figure 10(b). The maximum power point of the module is located at 303.42 W with corresponding maximum PV output current and voltage of about 5.496 A and 55.2 V respectively.

In Figure 11(a) and 11(b), the I-V curve and P-V curve of solar module under constant temperature with varying irradiation is presented respectively. From the simulation results it can be inferred that when irradiation increases, the output current and voltage of the PV module increases. This results in net increase in PV output power with increase in irradiation at constant temperature. At particular light intensity, there is a unique maximum output power for photovoltaic cell, which is called maximum power point. The simulation result shows that the output power of photovoltaic module changes with the operating temperature and light intensity.

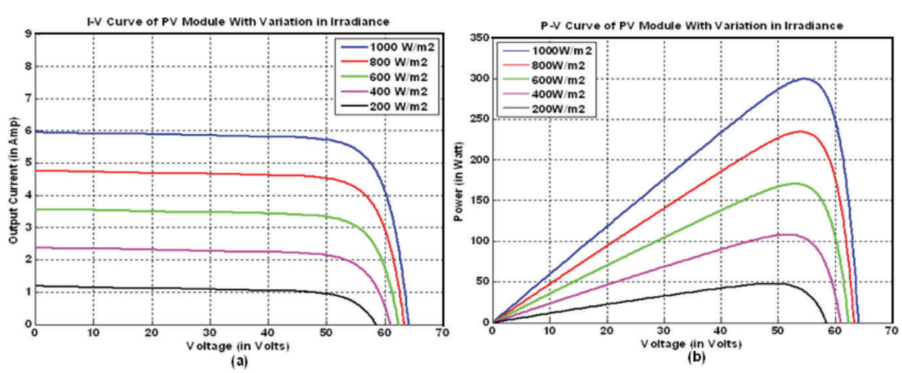

Figure 11 (a) I-V and (b) P-V characteristics with varying irradiance.

5.1 PV System with P&O MPPT

In this MPPT technique the step size is fixed and chosen to be 0.001. A pulse width modulator is employed within the MPPT controller in order to generate train of pulses to drive the Switch of converter. The Figure 12(a) and 12(b) represent the output voltage and power curve of PV module respectively. From these two figures it can be observed that the responses are nonlinear in nature and a fluctuating output voltage with a high ripple is noticed which is regulated by means of a boost converter. The average PV module output power and voltage value obtained from the simulations are 300.21 W and 54.46 V respectively. In Figure 13(a) and 13(b), the regulated output power and voltage across the load of PV system are shown. These plots explain that the P&O MPPT algorithm is able to track the maximum power point thereby transferring power generated by the PV module to load resistance. It can be

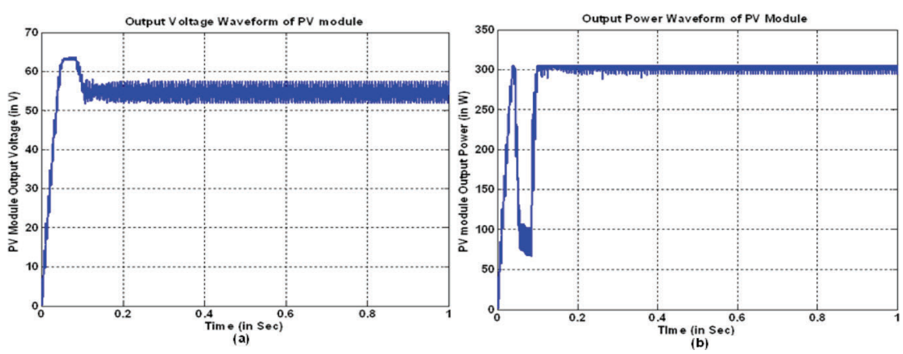

Figure 12 PV module output (a) voltage and (b) power response with P&O MPPT.

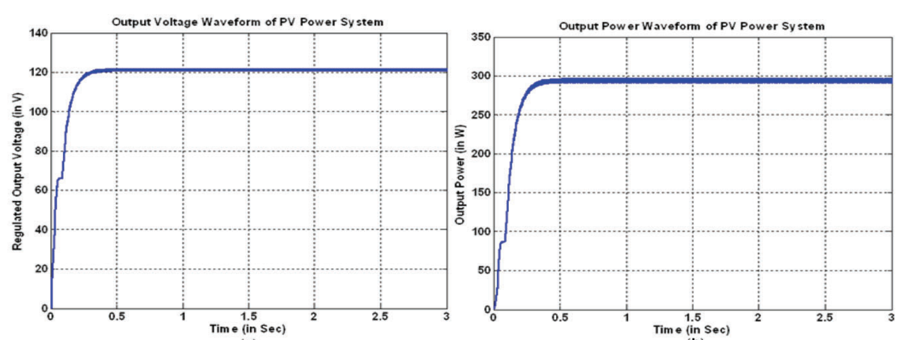

Figure 13 Output (a) voltage and (b) power response of PV system with P&O MPPT.

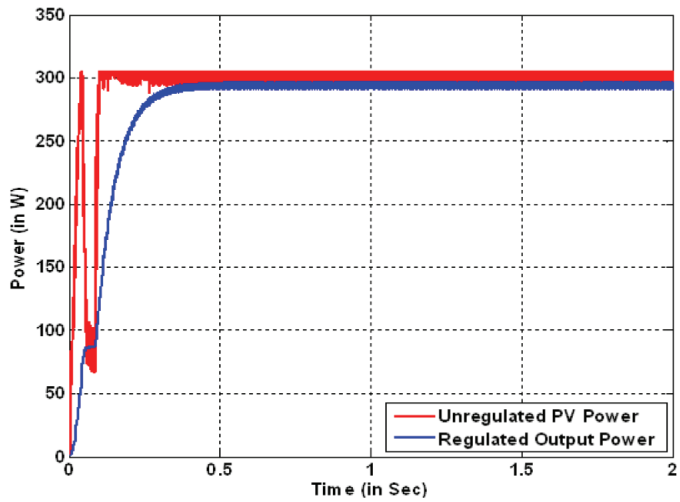

Figure 14 Comparison of unregulated PV module power and regulated power at the output of PV power generation system using P&O MPPT controller.

seen that designed converter provides a good regulation over rapid voltage fluctuation with very less ripple.

Figure 14 shows a comparative analysis between output power of PV module and the output power at the load of the PV system using P&O algorithm. The figure explains that the modeled P&O MPPT and boost converter together providing a better control over PV output power. Even if initially the output power of PV module changes greatly and keep fluctuating, the converter can effectively regulate this change.

5.2 PV System with Fuzzy MPPT

In fuzzy based MPPT method, the step size of iteration is not constant rather it varies depending on the control rules. The simulation results of the PV system with FMPPT are presented in the Figure 15 and Figure 16. Figure 15 shows the unregulated output power and voltage at the output of PV module respectively. Large fluctuations are observed in the response. The average PV module output power is found to be 298.37 W and the module output voltage is of about 51.86 V.

It can be observed from Figure 16 that implementation of Fuzzy logic controller greatly enhanced the response by yielding a stable response. Response of Fuzzy based MPPT is not oscillatory. This indicated that the

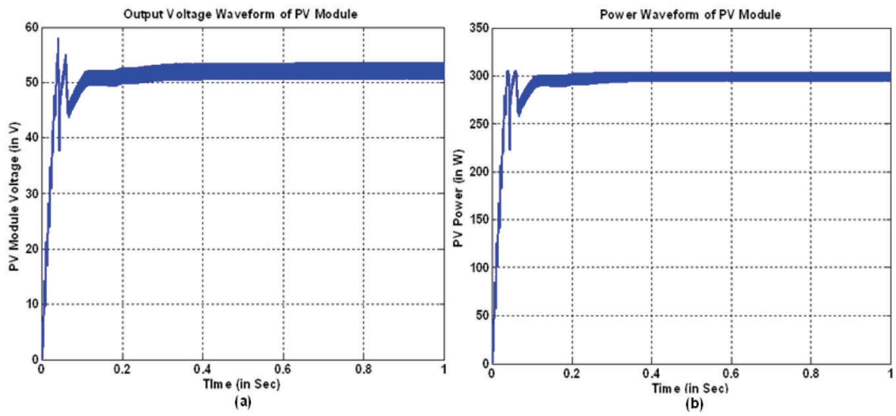

Figure 15 PV module (a) output voltage and (b) power response with FMPPT.

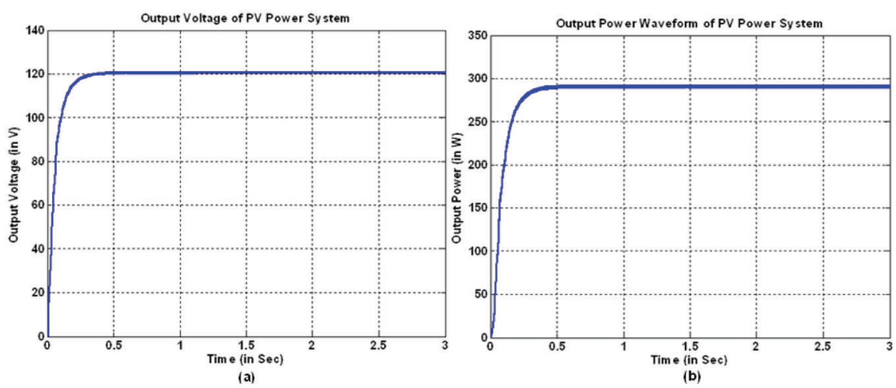

Figure 16 Output (a) voltage and (b) power response of PV system with fuzzy MPPT.

designed rule base for fuzzy logic controller is providing a better control to track the maximum power point.

Figure 17 shows a comparative analysis between output power of PV module and the output power at the load of the PV system using fuzzy MPPT controller. From Figure 17 it can be observed that how well the designed converter and fuzzy logic based MPPT deals with non-linearity of the PV module.

5.3 Comparison between P&O MPPT and Fuzzy MPPT

The comparative analysis of two MPPT control strategies for controlling the output power of the PV power generation system are based on nature

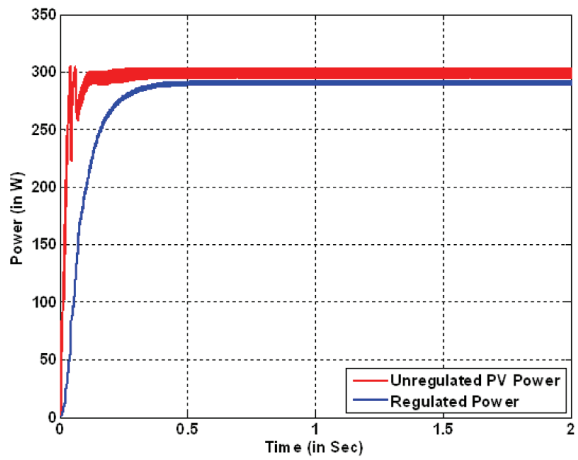

Figure 17 Comparison of unregulated PV module power and regulated power at the output of PV power generation system using FMPPT controller.

of response, convergence speed and ripple in output voltage of the system. Figures 18–20 show the comparison between output response of the PV system with P&O MPPT and fuzzy MPPT.

From the plots obtained from simulations it can be observed that Fuzzy logic based method can track the MPP more precisely and rapidly than the

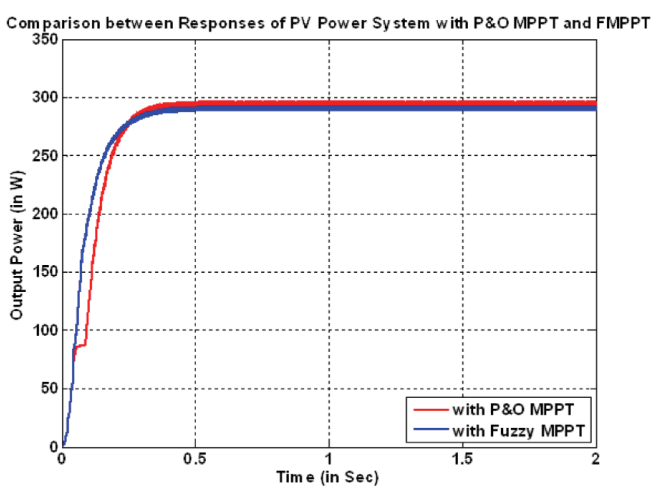

Figure 18 Comparison between output power response of PV system with P&O and FMPPT.

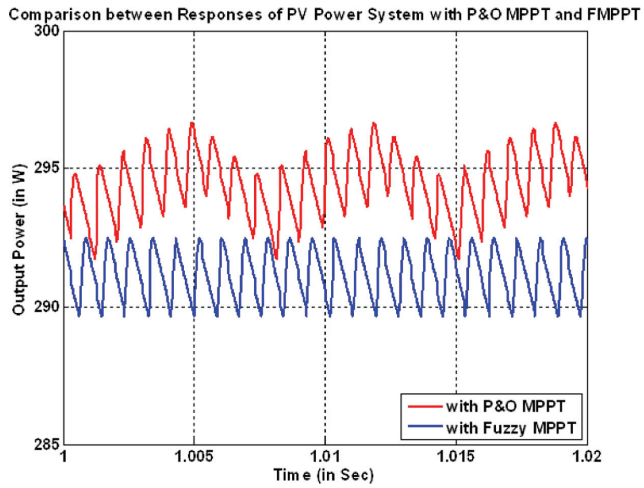

Figure 19 Comparison based on output ripple.

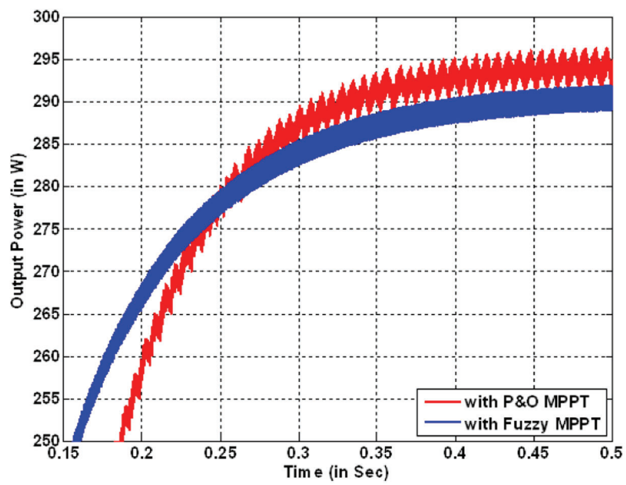

Figure 20 Comparison based on nature of response.

conventional P&O MPPT in PV Systems. The nature of response in the Perturb and Observe MPPT is oscillatory because the algorithm makes the system to oscillate about the MPP due to fixed perturbation size. In P&O method, if step size of input variable is very small, the accuracy in tracking MPP is sufficient but tracking speed becomes too slow. On the other hand if the step size is increased to imitate the rapidly changing weather conditions, accuracy deteriorates and unexpected results occur due to oscillation around the MPP although tracking speed increased. But in the case of proposed FLC whatever the step size of input variable it best suited to track MPP continuously and accurately. FMPPT provides a stable response as the fuzzy controller provides a variable perturbation size according to the situation. Since ripple in the output depends on the converter model, MPPT controller has no effect on ripple. Steady state error is less in P&O in comparison to fuzzy MPPT. Speed of response is faster in FMPPT than P&O MPPT that has slow convergence speed.

6 Conclusion

Designing of a fuzzy logic based maximum power point tracker that can act according to various situations have been presented in this paper. The simulation results of PV module depicts that the output characteristics of PV cell is nonlinear and its output power fluctuates to a large extent by solar irradiance and temperature. MPPT control techniques are implemented in order to operate the PV module at its maximum operating point at which maximum power generated can be transferred to the load connected across the output terminal of boost converter. Two MPPT techniques namely perturb and observe MPPT and fuzzy logic based MPPT have been implemented to track the MPP. The performances of these MPPT techniques were evaluated and compared. From the simulation result it can be concluded that the fuzzy logic based maximum power point tracker provides better MPP tracking and it has faster convergence speed. Although P&O algorithm is easy to implement, unlike fuzzy MPPT, they cannot cope with rapidly varying environmental condition. In Perturb and Observe algorithm, step size is fixed. When the operating point converges to MPP, system oscillates around the maximum power point due to a fixed increment or decrement in duty cycle. In contrast, FMPPT provide a stable response in tracking of MPP due to its variable step size even if there is variation in PV module characteristics. Simulation results prove superior performance of fuzzy logic based intelligent maximum power point tracking technique.

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