

A Fuzzy Logic Based Improved Maximum Power Point Tracking for Grid Integrated Solar Photovoltaic Power System

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ABSTRACT: This paper proposes a fuzzy control method for maximum power point tracking in photovoltaic (PV) power systems to solve a fast irradiation changing problem. A grid connected system needs a good response for variations in the solar irradiance and temperature. Incremental conductance is known as a very simple maximum power point tracking and is extensively disseminated. Fuzzy logic is also simple to investigate and provides fast dynamics. The suggested technique combines both fuzzy logic and IC. The currents are controlled in a synchronous orthogonal d,q frame using a decoupled feedback control. The proposed algorithm is better than that of the conventional incremental and conductance technique. The robust tracking capability under rapidly increasing and decreasing irradiance is verified from the simulation results. The results demonstrate that the proposed method gives effective, fast, and perfect tracking.

KEYWORDS: Fast-changing irradiation, maximum power point tracking (MPPT), Fuzzy logic control, and Incremental conductance.

I.INTRODUCTION

Due to the uncontrolled consumption of fossil-fuel, global warming is increasing alarmingly, we are witnessing fast environmental degradation and the fossil fuel is depleting at a higher pace hence the nonconventional energy sources such as solar, wind, tidal, and geothermal are becoming the alternative sources of energy. Out of all the renewable energy sources solar photovoltaic (PV) energy is widely used in low power applications. Due to the availability of state of art technology and rapid commercial development of nonconventional sources of energy reduce the cost increases the number of equipment suppliers and plant operators. It is the most promising field of current research and development for large scale application. As day by day the manufacturing cost of photo voltaic modules go down and hence we need cease the opportunity for large scale electrical power generation. Also the application of PV systems now increased immensely such as water pumping house hold and public lighting electric vehicles, hybrid power systems as power plants either in stand-alone and grid connected modules as solar cooker, defense and space applications

India being a tropical country along with some other countries with abundant solar energy, solar photovoltaic energy becomes an effective alternative to conventional energy resources. It is a source of clean energy without any running and maintenance cost .solar energy being a green energy has been used electrical energy generation. In all developed and some major developing countries across the globe solar PV energy sector is in boom and the market for solar pv technology is rising rapidly, even after having the above said advantages pv energy systems could not attain grid parity because of high initial investment the efficiency and performance of solar power systems are effected by intensity of solar radiation, load module temperature and PV cells aging and other factors. To have the optimal use of the solar photovoltaic systems it is essential to search maximum power point tracking (MPPT) methods to have

maximum power output in any working environment and then force the solar PV system to operate at that maximum power point MPPT is a highly essential element of a solar PV power system.

Because of the continuous change in the environmental condition-mainly the temperature and solar irradiance the PV characteristics curve exhibits a non-linear, time varying maximum power point problem. To extract continuous maximum power from PV arrays the mppt technique is used in conjunction with DC-DC converter or inverter. So far several MPPT techniques are found in the literature these are broadly classified into two types such as (a) the classical and (b) intelligent methods.

The voltage-power characteristic of a photovoltaic (PV) array is nonlinear and time varying because of the changes caused by the atmospheric conditions. The task of a maximum power point (MPP) tracking (MPPT) in a PV power system is to continuously tune the system so that it draws maximum power from the PV array. In recent years, the grid connected PV systems have become more popular because they do not need battery backups to ensure MPPT [1]. The two typical configurations of a grid-connected PV system are single or two stages. In two stages, the first is used to boost the PV array voltage and track the maximum power; the second allows the conversion of this power into high-quality ac voltage. The presence of several power stages undermines the overall efficiency, reliability, and compactness of the system besides increasing the cost [2] and [3]. The single stage has numerous advantages, such as simple topology, high efficiency, etc.

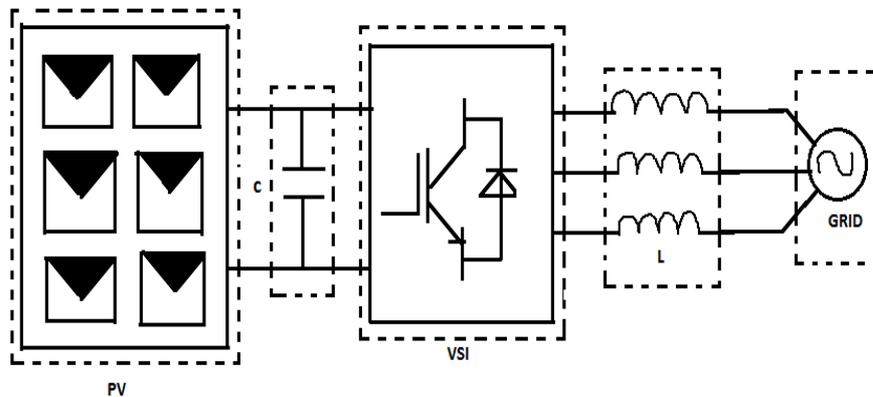


Fig 1: Typical configuration of a single-stage grid-connected PV system.

In this paper, the main component of the single-stage grid connected PV system is the three-phase voltage source inverter (VSI). Typically, simple inductors L are used as a filter interfacing inverter and mains, Fig 1 shows LCL filter provides advantages in costs and dynamics since smaller inductors can be used. However, in a grid-connected system, an LCL filter may cause resonance, which is a disaster for the system's stability [4]. Hence, control systems involving LCL filters are inevitably more complicated. The voltage-oriented control (VOC) method used for VSI employs an outer dc link voltage control loop and an inner current control loop to achieve fast dynamic response. The performance of the power flow depends largely on the quality of the applied current control strategy. In this paper, the current control has been implemented in a rotating synchronous reference frame d, q because the controller can eliminate a steady-state error and has fast transient response by decoupling control.

Many algorithms have been developed for the MPPT of a PV array [5]-[8]. Among the MPPT techniques, the Incremental Conductance method is the most popular because of the simplicity of its control structure. Yet, in the presence of rapidly changing atmospheric conditions, the IC MPPT algorithm can be confused due to the fact that it is not able to distinguish the variations of the output power caused by the from those caused by the irradiance variation[9]-[11]. Recently, improved IC MPPT algorithms for rapidly changing environmental conditions have been proposed by this method [12], [13].

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In this paper, in order to generate the correct MPP reference voltage under rapidly changing irradiation, a robust MPPT controller has been proposed. In this algorithm, the d-axis grid current component reflecting the power grid side and the signal error of a Fuzzy outer voltage regulator is designed to reflect the change in power caused by the irradiation variation. Hence, with this information, the proposed algorithm can greatly reduce the power losses caused by the dynamic tracking errors under rapid weather changing conditions. The superiority of the newly proposed method is supported by simulation results

II. SYSTEM DESCRIPTION AND MODELING

Fig. 1 shows the basic structure of a single-stage three-phase grid-connected PV system studied in this paper. This system consists of a PV array, an input filter capacitor C, a three-phase VSI, an output filter inductor L, and grid. The PV modules are connected in a series-parallel configuration to match the required dc voltage and power rating. The input capacitor supports the solar array voltage for the VSI. The three-phase pulse width-modulated inverter with a filter inductor converts a dc input voltage into an ac sinusoidal voltage by means of appropriate switch signals to make the output current in phase with the utility voltage and obtain a unity power factor.

Solar Cell and PV Array Model:

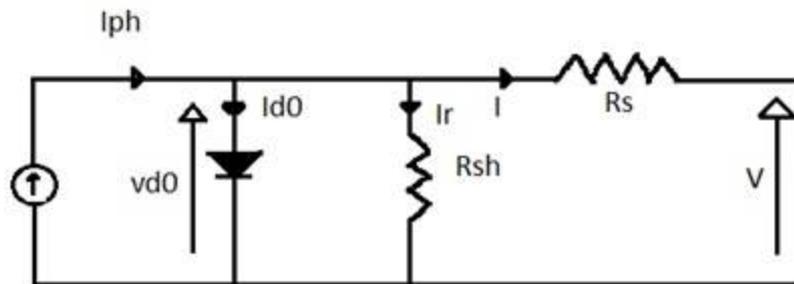


Fig 2: solar cell electrically equivalent circuit

A PV generator is a combination of solar cells, connections, protective parts, supports, etc. In the present modeling, the focus is only on cells. Solar cells consist of a p-n junction [14]-[16]; thus, the simplest equivalent circuit of a solar cell is a current source in parallel with a diode. The output of the current source is directly proportional to the light falling on the cell (photocurrent). During darkness, the solar cell is not an active device; it works as a diode, i.e., a p-n junction. It produces neither a current nor a voltage. Thus, the diode determines the I-V characteristics of the cell. For this paper, the electrical equivalent circuit of a solar cell is shown in Fig. 2 The output current I and the output voltage of a solar cell are given by Here, I_{ph} is the photocurrent, I_0 is the reverse saturation current, I_{d0} is the average current through the diode, n is the diode factor, q is the electron charge ($q = 1.6 \times 10^{-19}$), k is the Boltzmann's constant ($k = 1.38 \times 10^{-23}$), and T is the solar array panel temperature.

$$I = I_{ph} - I_{d0} - \frac{V_{d0}}{R_{sh}} \quad (1)$$

$$I_{ph} - I_0 \left(\exp \left(\frac{qV_{d0}}{n.k.t} \right) - 1 \right) - \frac{V_{d0}}{R_{sh}} \quad (2)$$

$$V = V_{d0} - R_s I \quad (3)$$

R_s is the intrinsic series resistance of the solar cell; this value is normally very small. R_{sh} is the equivalent shunt resistance of the solar array, and its value is very large. In general, the output current of a solar cell is expressed by

$$I = I_{ph} - I_0 \left(\exp \left(\frac{q}{n.k.t} (V + R_s I) \right) - 1 \right) - \left(\frac{V + R_s I}{R_{sh}} \right) \quad (4)$$

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The resistances can be generally neglected, and thus, it can be simplified to

$$I = I_{ph} - I_0 \left(\exp\left(\frac{q}{n.k.t} \cdot V\right) - 1 \right) \quad (5)$$

If the circuit is opened, the output current $I = 0$, and the open-circuit voltage V_{oc} is expressed by

$$V_{OC} = \left(\frac{n.k.t}{q}\right) I_n \left(\frac{I_{ph}}{I_0} + 1\right) \approx \left(\frac{n.k.t}{q}\right) I_n \left(\frac{I_{ph}}{I_0}\right) \quad (6)$$

If the circuit is shorted, the output voltage $V = 0$, the average current through the diode is generally neglected, and the short circuit current I_{sc} is expressed by using

$$I_{sc} = I = \frac{I_{ph}}{(1+R_{sh})} \quad (7)$$

Finally, the output power P is expressed by

$$P = VI = \left(I_{ph} - I_{do} - \frac{V_{do}}{R_{sh}}\right)V \quad (8)$$

VSI Model:

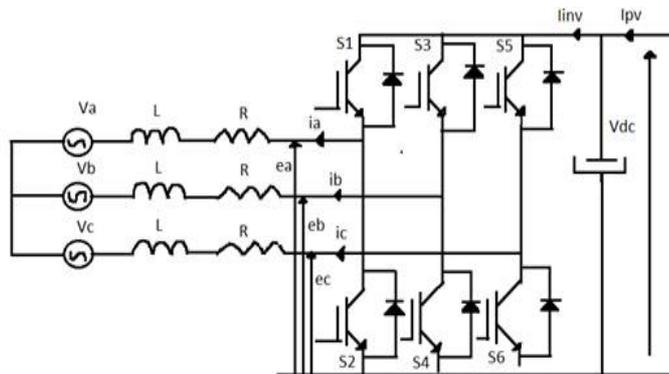


Fig 3: Three-phase VSI.

The VSI connected to the grid through an L filter is shown in Fig. 3. In this section, a dynamic analytical model of the VSI is developed in its original three-phase abc frame. Then, this model is transformed into a synchronous reference frame. Before analyzing the three-phase VSI, some assumptions are proposed.

- 1) The three-phase voltages are sinusoidal and symmetrical, and their representations are depicted .
- 2) The switches operate at constant frequency. The switching frequency is much higher than the line frequency
- 3) The inductors L are linear and balanced. Saturation is not a concern.
- 4) The whole conduction losses are represented by three symmetrical resistors R
- 5) The absence of the zero sequence in the currents into a three wire system.

$$\begin{cases} v_a = V_m \cos(\omega t) \\ v_b = V_m \cos\left(\omega t - \frac{2}{3}\pi\right) \\ v_c = V_m \cos\left(\omega t + \frac{2}{3}\pi\right) \end{cases} \quad (9)$$

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Based on the aforementioned assumptions, the model of the VSI in the stationary ABC frame is established as

$$e_a = L \frac{di_a}{dt} + i_a R + V_a + V_n N \quad (10)$$

$$e_b = L \frac{di_b}{dt} + i_b R + V_b + V_n N \quad (11)$$

$$e_c = L \frac{di_c}{dt} + i_c R + V_c + V_n N \quad (12)$$

$$I_{pv} = C \frac{dV_{dc}}{dt} + I_{inv} \quad (13)$$

By doing the sum of the three equations in, one can obtain the relation

$$V_n N = \frac{1}{3}(e_a + e_b + e_c) \quad (14)$$

For pulse width modulation (PWM) inputs, the aforementioned model can be separated into low and high-frequency components using the Fourier analysis. The high-frequency model is concerned with the switching behavior of the inverter and is almost neglected. The low-frequency model, with the switching functions d^* being replaced by continuous duty ratios d_k ($k = 1, 3, 5$) $\in [0, 1]$, is much more considered[17]

$$T_{dqo}^{abc} = \frac{2}{3} \begin{bmatrix} \cos\omega t & \cos(\omega t - \frac{2}{3}\pi) & \cos(\omega t + \frac{2}{3}\pi) \\ \sin\omega t & \sin(\omega t - \frac{2}{3}\pi) & \sin(\omega t + \frac{2}{3}\pi) \\ \frac{1}{2} & \frac{1}{2} & \frac{1}{2} \end{bmatrix} \quad (15)$$

It is noted that the model is time varying and nonlinear. In order to facilitate the control, the model can be transformed into a synchronous orthogonal frame rotating at the angular frequency of the utility ω [18]. With this time-varying transformation, given by , the positive sequence components at the fundamental frequency become constant. Finally, the whole dynamic model in the dq frame

$$\begin{bmatrix} \frac{di_d}{dt} \\ \frac{di_q}{dt} \\ \frac{dV_{dc}}{dt} \end{bmatrix} = \begin{bmatrix} -\frac{R}{L} & \omega & \frac{d_d}{L} \\ -\omega & -\frac{R}{L} & \frac{d_q}{L} \\ -\frac{d_d}{C} & -\frac{d_q}{C} & 0 \end{bmatrix} \begin{bmatrix} i_d \\ i_q \\ V_{dc} \end{bmatrix} + \begin{bmatrix} -\frac{1}{L} & 0 & 0 \\ 0 & -\frac{1}{L} & 0 \\ 0 & 0 & \frac{1}{C} \end{bmatrix} \begin{bmatrix} V_d \\ V_q \\ I_{pv} \end{bmatrix} \quad (16)$$

Where

- id, iq d- and q-axis grid currents, respectively;
- vd, vq d- and q-axis grid voltages, respectively;
- dd, dq d- and q-axis duty ratios.

III. MPPT USING FUZZY LOGIC CONTROL

MPPT using Fuzzy Logic Control gains several advantages of better performance, robust and simple design. In addition, this technique does not require the knowledge of the exact model of system. The main parts of FLC, fuzzification, rule-base, inference and defuzzification. In the proposed system, the input variables of the FLC are the change in PV array power (ΔP_{pv}) and the change in PV voltage (V_{pv}) and the change in PV current (I_{pv}), whereas the output of FLC is the magnitude of the change of Duty cycle. The Duty cycle of PWM is the command for controlling the current drawn from the PV. The equations for P_{pv} and V_{pv} , I_{pv} are given as follows: Δ

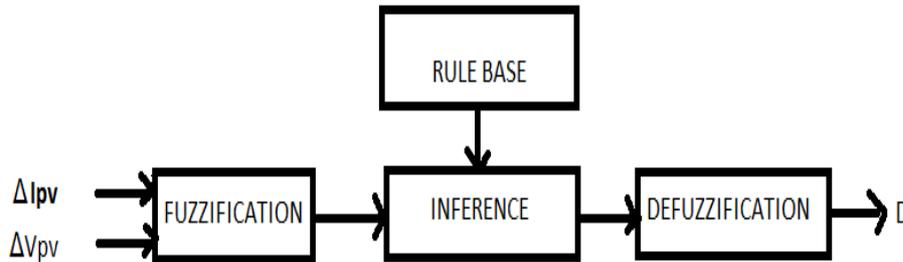


Fig 4: The Fuzzy Logic Controller

$$\begin{aligned}
 P_{pv}^k &= V_{pv}^k \cdot I_{pv}^k \\
 \Delta P_{pv}^k &= P_{pv}^k - P_{pv}^{k-1} \\
 \Delta I_{pv}^k &= I_{pv}^k - I_{pv}^{k-1} \\
 \Delta V_{pv}^k &= V_{pv}^k - V_{pv}^{k-1}
 \end{aligned}$$

IV. FUZZY LOGIC CONTROLLER DESIGN

There are various algorithms that have been used to track maximum power point, this work proposed fuzzy controller to track MPP of PV system. Fuzzy logic deals with uncertainty in engineering by attaching degrees of certainty to the answer to a logical question. Commercially, fuzzy logic has been used with great success to control machines and consumer products. Fuzzy logic systems are simple to design, and can be understood and implemented by non-specialists in control theory. Additionally, they have been performing well under sudden changes in the irradiation. The proposed algorithm controls the duty cycle (D) of the switching signal.

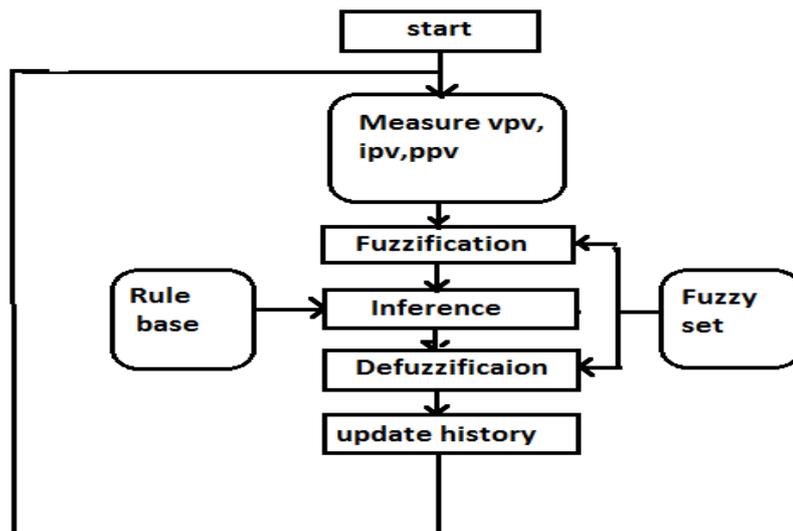


Fig 5: FUZZY ALGORIHEM

The proposed fuzzy controller has two inputs; change in PV voltage (ΔV), change in current (ΔI). three stages: fuzzification, inference, and finally defuzzification. Membership functions with a triangular shape have been used Mamdani-type system with two inputs and one output has been developed [15]. The range of signals has been

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determined based on simulated data. The membership T functions of the fuzzy logic controller inputs and output. Input Signals: Ppv, and Vpv, Ipv are voltage, current and power signals from PV panel. The voltage signal is saved in a memory in order to subtract current and previous values to be entered into fuzzy controller block. Fuzzy logic controller block calls the fuzzy system and passes the inputs to it. The output of fuzzy controller is also passed directly to the converter from the fuzzy system by this model the disadvantage of the perturb and observe method to track the peak power under fast varying atmospheric condition is overcome by IC method [21]. The IC can determine that the MPPT has reached the MPP and stop perturbing the operating point. If this condition is not met, the direction in which the MPPT operating point must be perturbed can be calculated using the relationship between dI/dV and $-I/V$. This relationship is derived from the fact that dP/dV is negative when the MPPT is to the right of the MPP and positive when it is to the left of the MPP. In the proposed design, the universe of discourse for the first input variable (error) is assigned in terms of several linguistic variables by using seven fuzzy subsets, which are denoted by LN (large negative), MN (medium negative), SN (small negative), S (zero), SP (small positive), MP (medium positive) and LP (large positive). The membership functions for the variable are shown in Fig. 6. Fig. 7 shows the universe of discourse for the second input variable, which is classified into 3 fuzzy sets, namely, Negative (N), Zero (Z) and Positive (P). Based on the knowledge of the authors [23], the fuzzy system rules can be designed as shown in table 1. Error and change of error are the inputs while accurate are the output. The fuzzy inference of the proposed FLC is based on the Mamdani's method which is associated with the max-min composition.

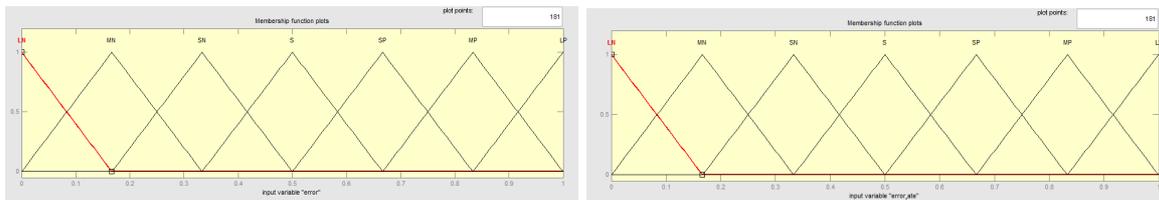


Fig 6: Membership functions of the input variable error Fig.7. Membership functions of the Input variable error, at e

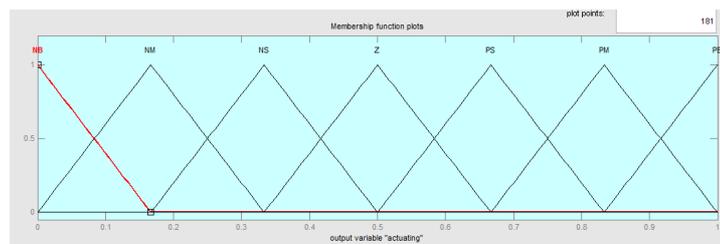


Fig 8: Membership functions of the Output variable actuating

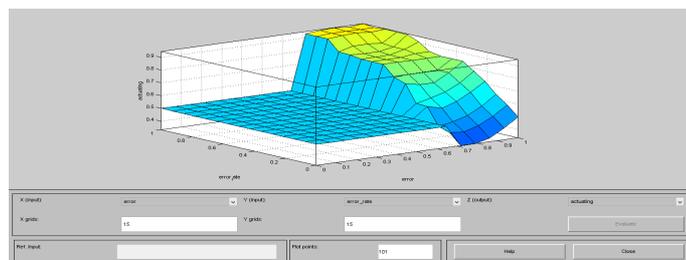


Fig 9: Mamdani control surface, output variable

Figure (6),(7),(8) shows the performance of fuzzy fuzzification, inference, rule base and defuzzification membership functions and Figure (9) shows the performance of Mamdani control surface

RULE NO	E (IF)	CE(AND)	ACCURATE (THEN)
1	LP	LP	PB
2	LP	MP	PB
3	LP	SP	PB
4	LP	S	PM
5	LP	SN	PM
6	LP	MN	PS
7	LP	LN	S
8	MP	LP	PB
9	MP	MP	PB
10	MP	SP	PM
11	MP	S	PM
12	MP	SN	PS
13	MP	MN	S
14	MP	LN	NS

Table.1 Rules for the proposed FLC

This rule table is variable error and variable error, ate membership function ships and variable actuating membership functions rules.

V. INCREMENTAL CONDUCTANCE MPPT ALGORITHM

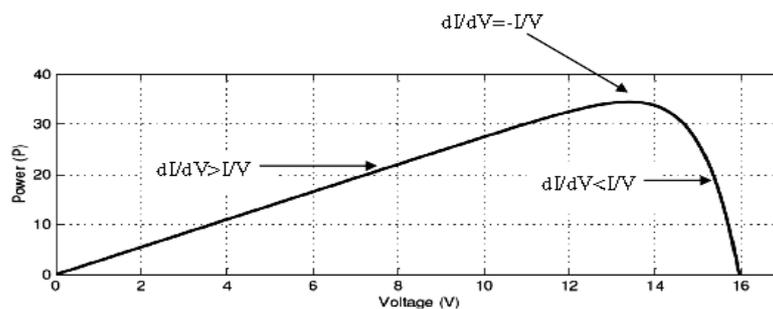


Fig 10: Graph Power versus Voltage for IC Algorithm

This method exploits the assumption of the ratio of change in output conductance is equal to the negative output Conductance Instantaneous conductance. Fig.10.Shows the incremental conductance method is based on the fact that the slope of the PV array power curve is zero at the MPP, positive on the left of the MPP, and negative on the right [21]. The incremental conductance method also uses voltage and current sensors to sense the output voltage and current of the PV array.

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$$\begin{cases} \frac{dP}{dV} = 0, \text{ at MPP} \\ \frac{dP}{dV} = > 0, \text{ left of MPP} \\ \frac{dP}{dV} = < 0, \text{ right of MPP} \end{cases} \quad (17)$$

$$\frac{dP}{dV} = \frac{d(IV)}{dV} = I + V \frac{d(I)}{dV} \frac{d(I)}{dV} \quad (18)$$

$$\begin{cases} \frac{d(I)}{dV} + I/V = 0, \text{ at MPP} \\ \frac{d(I)}{dV} + I/V > 0, \text{ left of MPP} \\ \frac{d(I)}{dV} + I/V < 0, \text{ right of MPP} \end{cases} \quad (19)$$

The left hand side is the instantaneous conductance of the solar panel. When this instantaneous conductance equals the conductance of the solar then MPP is reached [22]. Hence the error due to change in irradiance is eliminated. However the complexity and the cost of implementation increase. As we go down the list of algorithms the complexity and the cost of implementation goes on increasing which may be suitable for a highly complicated system. This method utilizes the incremental conductance (dI/dV) of the photovoltaic array to compute the sign of the change in power with respect to voltage (dP/dV). The IC method computes the maximum power point of IC (dI/dV) to the array conductance (I/V) when there are the same ($I/V = dI/dV$) the output voltage is the mpp voltage.

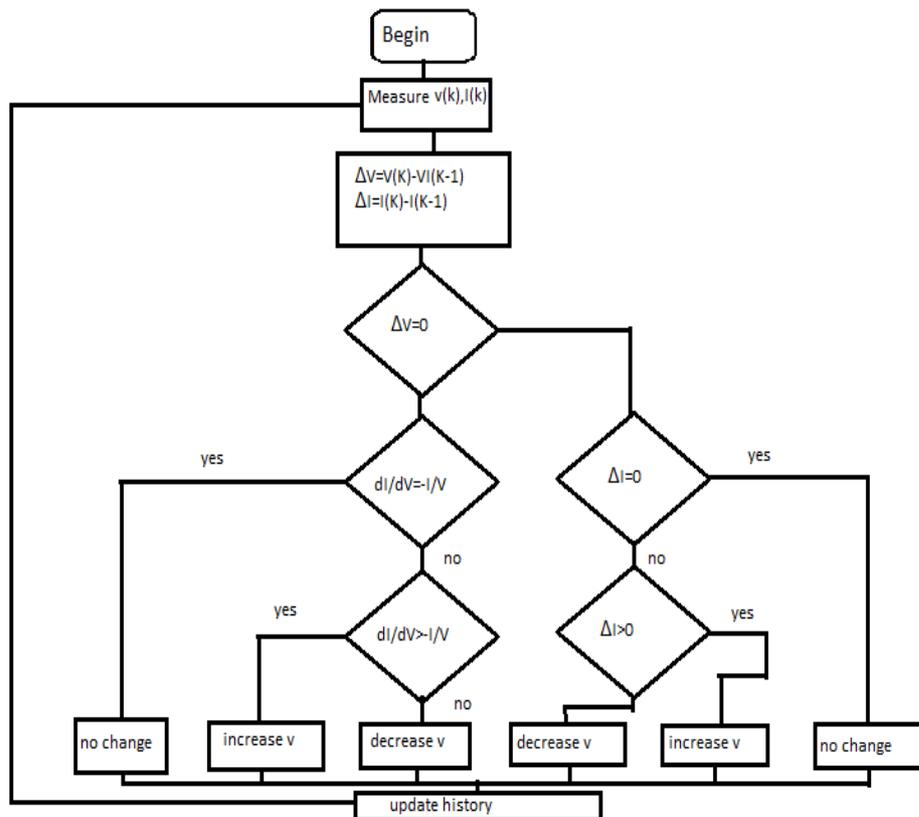


Fig 11: INCREMENTAL ALGORITHM

VI. PV POWER CALCULATION

In the synchronous rotating frame d, q, the active and reactive powers of a three-phase grid-connected VSI are given by

$$\begin{cases} P = \frac{3}{2}(V_d i_d + V_q i_q) \\ Q = \frac{3}{2}(V_d i_q - V_q i_d) \end{cases} \quad (20)$$

If the three-phase grid voltage is ideally sinusoidal without any harmonics, then in the d, q frame, the grid voltage vector is given by in practice, the grid voltage is non sinusoidal due to harmonics. Therefore, both V_d and V_q will not be constant but have slight ripples whose frequencies and magnitudes depend on the harmonic components. However, in steady state, the average value of V_q is still equal to zero. Its active power depends on the d-axis current, and the reactive power depends on the q-axis current. Furthermore, in order to achieve unity power factor fundamental current flow, the q component of the command current vector is set to zero

$$\begin{cases} V_d = V \\ V_q = 0 \end{cases} \quad (21)$$

In practice, the grid voltage is non sinusoidal due to harmonics. Therefore, both V_d and V_q will not be constant but have slight ripples whose frequencies and magnitudes depend on the harmonic components. However, in steady state, the average value of V_q is still equal to zero. Its active power depends on the d-axis current, and the reactive power depends on the q-axis current. Furthermore, in order to achieve unity power factor fundamental current flow, the q component of the command current vector is set to zero Assuming lossless power transmission between solar array and grid line, the relationship of instantaneous active power exchanged between the PV array and the grid is given by

$$\begin{cases} P = \frac{3}{2}(V_d I_d) \\ Q = \frac{3}{2}(V_q I_q) \end{cases} \quad (22)$$

Assuming lossless power transmission between solar array and grid line, the relationship of instantaneous active power exchanged between the PV array and the grid is given by

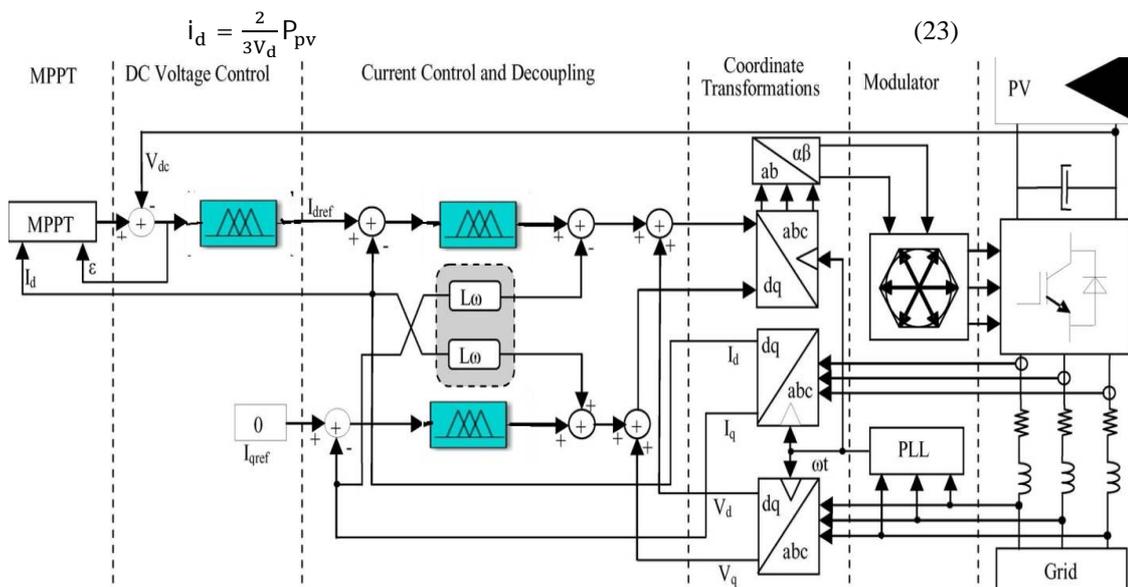


Fig 12: Grid-connected PV system with the proposed MPP tracker

VII. SIMULATION RESULTS

This section presents the simulation results of the classical IC and the proposed method in order to validate the performance of the control scheme. Computer simulation has been done using *MATLAB/SIMULINK* simulation package. The full diagram of the control methodology and the modulation is shown in Fig. 11. The characteristics of Solarex MSX88 PV module are used for the PV array model in the simulation. In the simulation study, the fuzzy logic based MPPT control is simulated and compared with the conventional IC technique under the operating condition assuming the constant temperature and varying isolation. The performance of MPPT using the FLC and the simple IC techniques is verified by operating them under the Variation of irradiance. The full diagram of the control methodology and the modulation is shown in Fig.12. The characteristics of solarex MSX 88 module provides 88 W of nominal maximum power and a 22-V open-circuit voltage at an irradiation of 1 kW/m² and an ambient temperature of 25 °C. The PV array in simulation is composed of eleven series connected modules. The sampling period used for MPPT algorithm is chosen as 0.2s, and voltage increments of Inc1 = 0.5 V and Inc2 = 0.1 V are used. In order to verify the effect of rapidly changing irradiation, an irradiation ramp change was used. A 20-s period for the increasing and decreasing ramps was selected. This irradiation change starts from 200 W/m², stops at 1000 W/m², waits at this level for 80 s, and decreases again back to 200 W/m² with a constant slope. The performance of the PV system using FLC and IC algorithms under fast changing of irradiance. Figs. 13 and 14 show the simulation results of the steady state and dynamic responses of the classical IC method. The results verified that the MPPT method has very poor performance under dynamic response. In Fig. 16 and under a decrease of irradiation (50–70 s), we can see that the voltage of PV array varies between V and $V + \Delta v$ since it decreases the PV array power in the two directions of conductance. This is because the power change caused by irradiation decrease in sunshine is greater than the variation caused by the voltage conductance. Fig. 14 shows the terminal voltage of the PV array compared with the theoretical MPP voltage. Fig. 13 shows the theoretical power and the maximum power obtained from the proposed MPPT. We can see the control system efficiently tracks the maximum power at any conditions. As can be seen from Figs. 16 and 17, during the irradiation change, the classical IC method has a poor instantaneous efficiency, while the proposed method tracks the MPP with the instantaneous efficiency as in the steady-state operation. The MPPT using FLC gives the results better than the IC in several areas of the tracking curve.

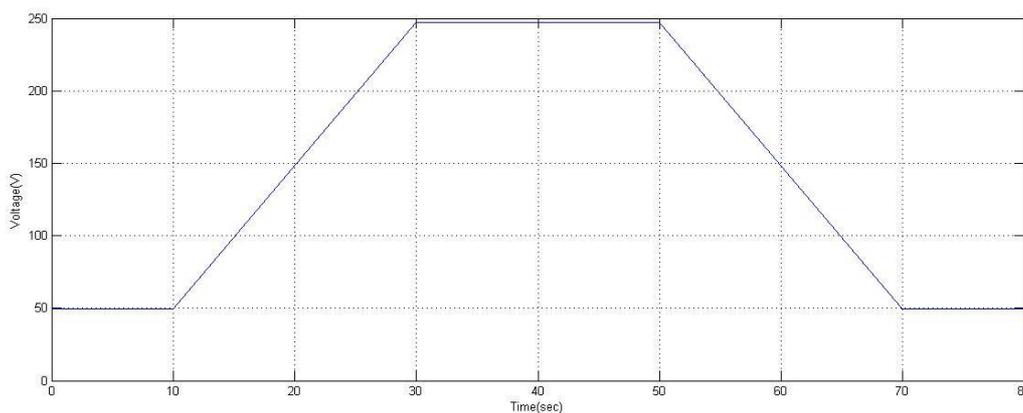


Fig 13: PV array voltage with the Fuzzy MPPT and Theoretical mppt

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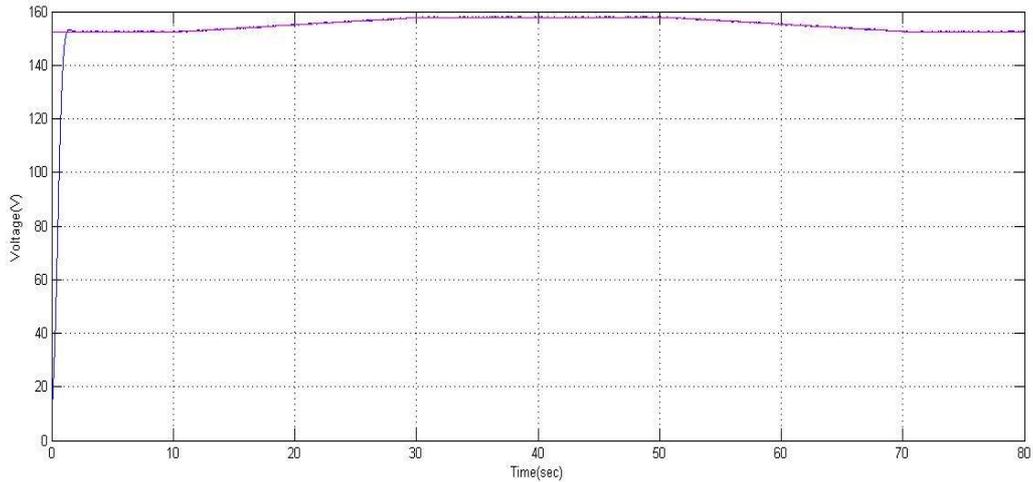


Fig.14: PV array voltage with IC MPPT and theoretical mppt

Figure (13),(14) shows performance of MPPT of PV voltage using fuzzy and IC the fuzzy is the better stable operating compare that the IC method. The voltage is in the fuzzy method is more stable.

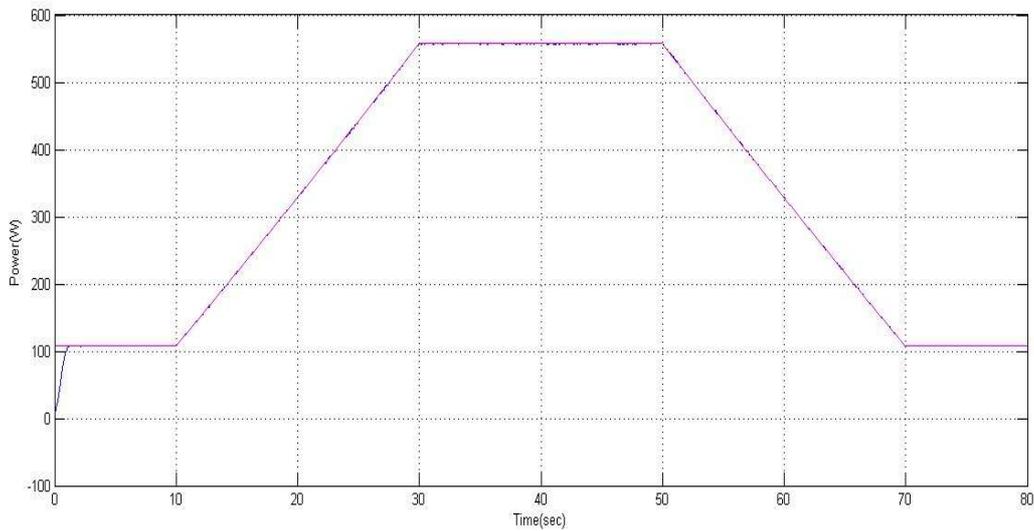


Fig 15: PV array power with Fuzzy MPPT and IC MPPT

Figure. (15) Shows the performance of power with Fuzzy and IC MPPT. Fuzzy is the better then the IC method the power is varying with Fuzzy and IC Fuzzy is the better stedy state response and fast dynamics

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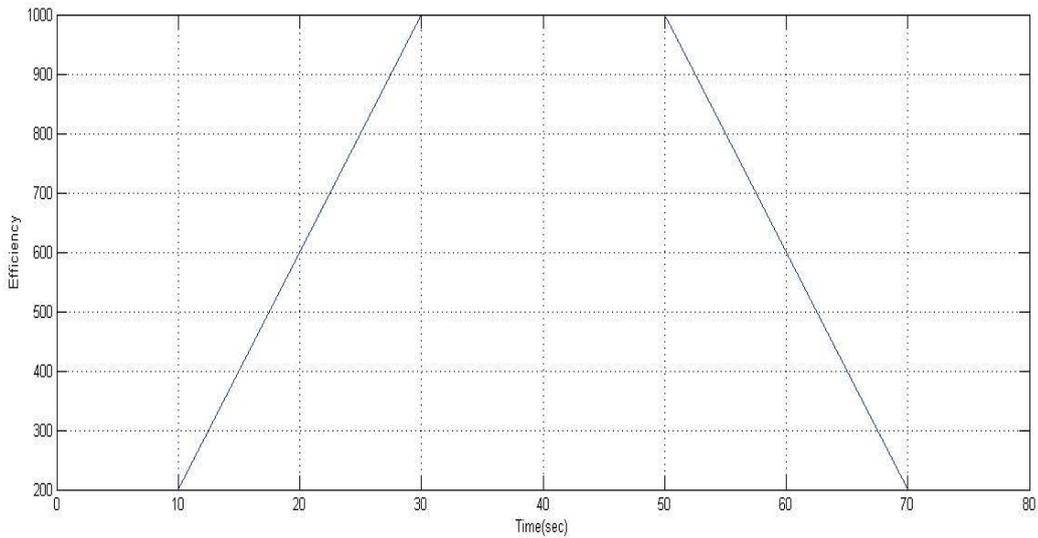


Fig 16: The instantaneous efficiency with Fuzzy

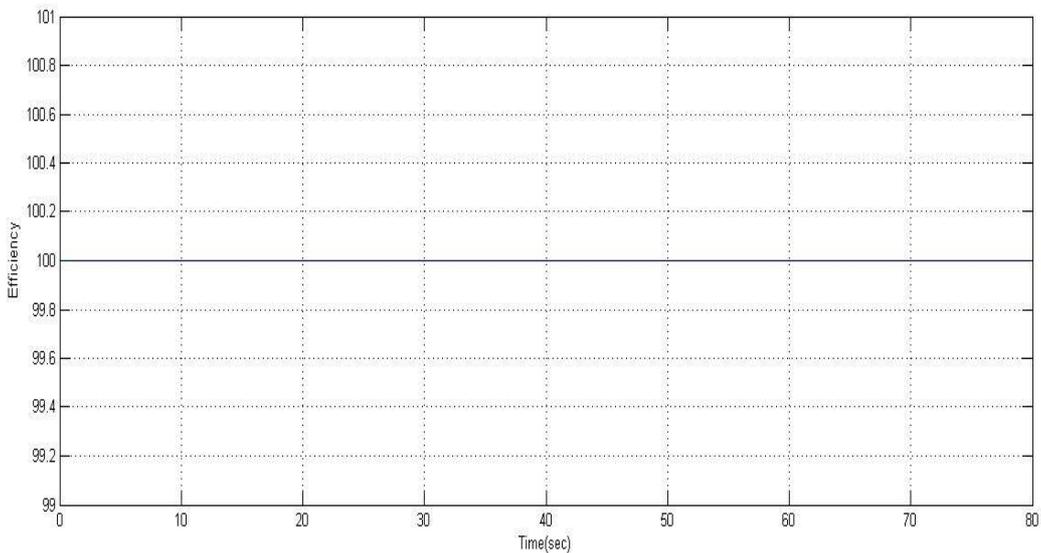


Fig 17: The instantaneous Efficiency with IC

Figure (16) and (17) shows PV Efficiency under changing irradiance, it can be observed that using MPPT algorithms succeed to track MPP of PV model. It can be seen also fuzzy algorithm is smoother than IC algorithm. It is cleared that using MPPT increase output power of the PV especially at high irradiance levels. In the IC algorithm irradiance is constant so better irradiance is Fuzzy algorithm.

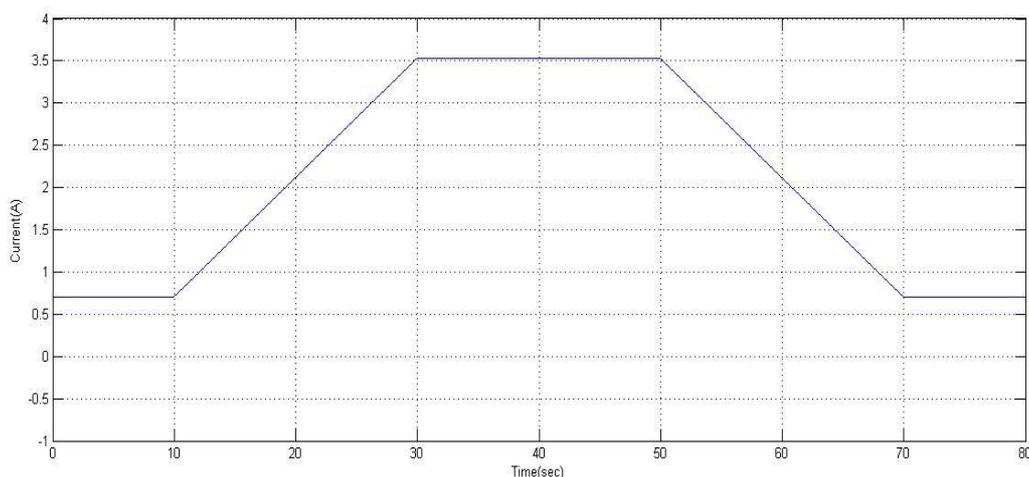


Fig 18: PV Current

Figure (16) and (17) shows PV current under changing irradiance, it can be observed that using MPPT algorithms succeed to track MPP of PV model. It can be seen also fuzzy algorithm is smoother than IC algorithm. It is cleared

VIII. CONCLUSION

This paper presents an intelligent control strategy of MPPT for the PV system using the FLC. Simulation results Show that the proposed MPPT can track the MPP faster when compared to the conventional IC method. In order to avoid possible mistakes of the incremental conductance algorithm due to the fast-changing irradiation, in the simulation results, the robust tracking capability under rapidly increasing and decreasing irradiance has been proved. Furthermore, one can see that the control algorithm is simple and easy to implement in real time. This paper presents an intelligent control strategy of MPPT for the PV system using the FLC. Simulation results that show the proposed MPPT can track the MPP faster when compared to the conventional IC method. In conclusion, the proposed MPPT using fuzzy logic can improve the performance of the system.

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