

Maximum Power Point Technique by Fuzzy Logic Based Boost Converter

Tanmay Prassanno¹, Dr. Surekha Bhusnur², Dr. Heena Mishra³

M. Tech Scholar, Department of Electrical Power & Energy System, BIT, Durg, C.G, India¹

Professor, Department of Electrical & Electronics Engineering, BIT, Durg, C.G India²

Assistant Professor, Department of Electrical & Electronics Engineering, BIT, Durg, C.G India³

ABSTRACT: Loads on the grid increasing continuously due to expansion in industries and urban areas . solution to be find out for this grid load and can be distribute by use of renewables. Solar PV systems applications increasing day by day and the generation plants capacity will also increase. In whole generation system the control system is one of the most important factor. Various control theories have been implemented in the systems. The conventional methods are perturbation and observation and incremental conductance method. Now a days artificial neural network and fuzzy logic control systems are popular. In this work a fuzzy logic controller has been designed and connected in the system. a MATLAB-based model of a grid-connected solar PV system integrated with MPPT control strategies has been developed to analyse system performance under varying environmental conditions.

KEYWORDS: Maximum Power Point Tracking MPPT, Perturbation & Observation P&O, Fuzzy Logic Control, Artificial Neural Networks (ANN).

I. INTRODUCTION

With more demand for electricity, continuously raising fuel costs and more concerns of global climate change have leads to more and more use of renewable energy sources. These energy resources have got more fame due to the depletion of non-renewable energy sources and their adverse impact on the environment. The energy extracted from Solar is one of the alternative renewable energy sources. In case of solar PV, the energy is collected as dc which, further can be converted into ac by the use of inverter and then subsequently fed to utility grid or it may be used in isolated load. The inverter output can be fed to the grid as well as standalone system. The main objective of Grid connected SPV system is to supply the local loads and any surplus power generation have to be injected into the grid [1].The MPPT working principle is based on the maximum power transfer theory. The power delivered from the source to the load is maximized when the input resistance seen by the source matches the source resistance. Therefore, in order to transfer maximum power from the panel to the load the internal resistance of the panel has to match the resistance seen by the PV panel. For a fixed load, the equivalent resistance seen by the panel can be adjusted by changing the power converter duty cycle [2]. The warming of global surface is increasing 0.6 degree Celsius per century. This warming caused by huge release of carbon dioxide and carbon monoxide. This causes acid rain, depletion of ozone layer and radioactive emission these effects can be minimized by searching some effective solution, this solution also include energy conservation with improved energy efficiency.

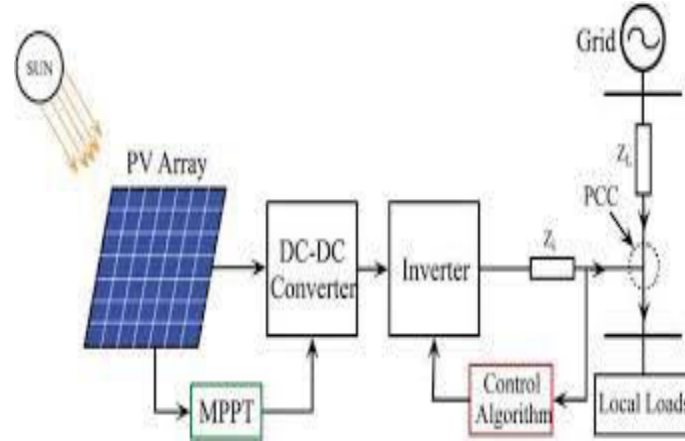


Fig -1: Solar PV connected to grid

II. MODELLING OF PV ARRAY

Proposed Model

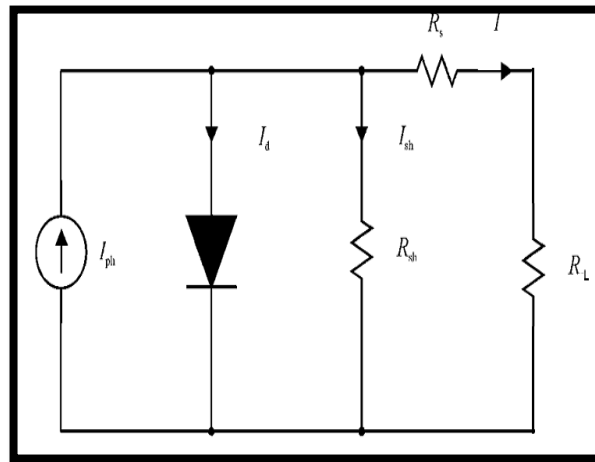


Fig -2: PV Cell Model

Implements a PV array built of strings of PV modules connected in parallel. Each strings consists of strings connected in series. Parallel strings 40 and series connected modules per strings 10. With open circuit voltage 37.14V and short circuit current 8A.

The mathematical model of PV cell is represented by a current source with a diode connected in parallel as shown in figure The intrinsic series resistance whose value is very small. The equivalent shunt resistance whose value is very high, applying Kirchoff's law to the node where I_{ph}, diode, R_p and R_s meet. [2]

$$I = I_D - I_{RP} - I_{ph} \dots\dots\dots (1)$$

$$I = I_{ph} - I_0 - \left[\exp \left(\frac{V+IR_s}{V_T} \right) - 1 \right] - \left[\left(\frac{V+IR_s}{R_p} \right) \right] \dots\dots\dots (2)$$

$$I = n_p I_{ph} - n_p I_{rs} - \left[\exp \left(\frac{q}{KTA} * \frac{V}{n_s} \right) - 1 \right] \dots\dots\dots (3)$$

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$$I_{rs} = I_{rr} \left[\frac{T}{T_r} \right]^3 \exp \left(\frac{qE_G}{KA} \left[\frac{1}{T_r} - \frac{1}{T} \right] \right) \dots \dots \dots (4)$$

$$E_G = E_G(0) \frac{\alpha T^2}{T + \beta} \dots \dots \dots (5)$$

$$I_{ph} = [I_{scr} + K_1(T - T_r)] \frac{s}{1000} \dots \dots \dots (6)$$

Where, I_{ph} is the Insolation current, I is the Cell current, I_0 is the Reverse saturation current, V is the Cell voltage, R_s is the Series resistance, R_p is the Parallel resistance, V_T is the Thermal voltage (KT/q), K is the Boltzmann constant, T is the Temperature in Kelvin, and q is the Charge of an electron. [3]

In this paper a review of major MPPT techniques used in major PV standalone system are presented and gives a detailed review on various MPPT techniques used in this work. The P-V characteristics with different irradiation and temperature variation are shown in figure below.

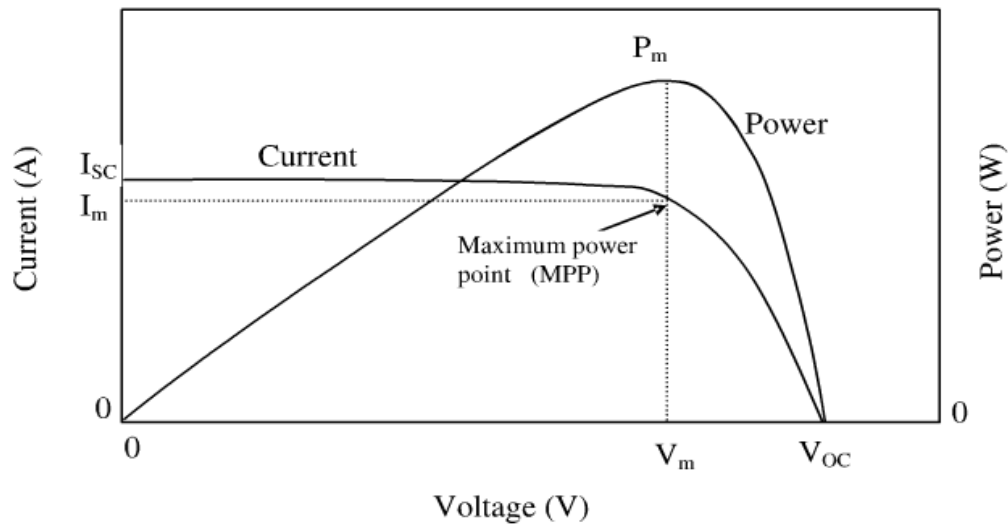


Fig. 3 PV Characteristics of Solar PV

III. MAXIMUM POWER POINT TRACKING

Maximum Power Point Tracking (MPPT) is a technique used in solar photovoltaic (PV) systems to extract the maximum possible power from solar panels under varying environmental conditions such as irradiance and temperature. The output characteristics of a PV panel are non-linear, meaning there is a unique operating point on the voltage-current ($V-I$) curve where the product of voltage and current (power) is maximum. This point is called the Maximum Power Point (MPP).

To continuously operate the PV system at this optimal point, MPPT algorithms are implemented using power electronic converters (usually DC-DC converters like boost converters). These controllers adjust the duty cycle of the converter so that the PV panel operates at the voltage corresponding to the maximum power point, even when environmental conditions change.

The most commonly used MPPT techniques include:

- Perturb and Observe (P&O): This method slightly perturbs the operating voltage and observes the change in power. If power increases, the system continues in that direction; otherwise, it reverses the direction. It is simple but may oscillate around the MPP.

- Incremental Conductance (INC): This method uses the condition that at MPP, the derivative of power with respect to voltage is zero. It compares incremental conductance with instantaneous conductance to accurately track the MPP, especially under rapidly changing conditions.
- Fuzzy Logic Control (FLC): An intelligent method that uses rule-based decision-making. It adapts better to varying climatic conditions and reduces oscillations but requires more computational effort.
- Artificial Neural Networks (ANN): These are advanced adaptive techniques that can predict the MPP based on trained data, offering high accuracy but increased complexity.

Overall, MPPT significantly improves the efficiency of solar PV systems, typically increasing energy extraction by 20–30% compared to systems without tracking. It is an essential component in modern solar power systems to ensure optimal performance and energy utilization.

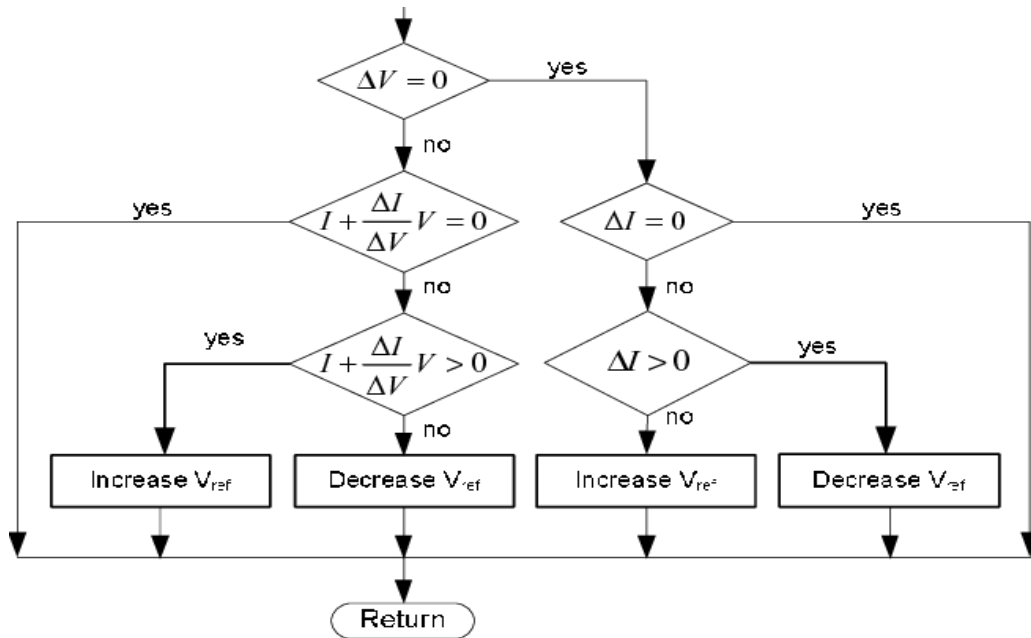


Fig. 4 Flowchart of INC MPPT Method

IV. FUZZY LOGIC CONTROL

Fuzzy Logic Control (FLC) system is an intelligent control technique that works in a way similar to human reasoning rather than depending entirely on precise mathematical models. It is particularly suitable for applications like solar PV systems, where conditions such as sunlight and temperature change continuously. In Maximum Power Point Tracking (MPPT), the fuzzy logic controller helps maintain the operating point of the PV panel at its maximum power level despite these variations. Instead of using exact numerical values, it interprets inputs in qualitative terms such as low, medium, or high. Typically, the controller takes two inputs: the error, which shows how far the system is from the maximum power point, and the change in error, which indicates whether the system is moving toward or away from it. These inputs are processed through membership functions to convert them into fuzzy values. Based on a set of IF–THEN rules, the controller decides the required action, and the output is then converted back into a precise signal to adjust the duty cycle of the DC–DC converter. This approach allows the system to react quickly to changing environmental conditions and minimizes fluctuations around the maximum power point. Although designing the rule base and membership functions requires effort and slightly more computation, fuzzy logic provides improved stability and accuracy compared to conventional MPPT methods

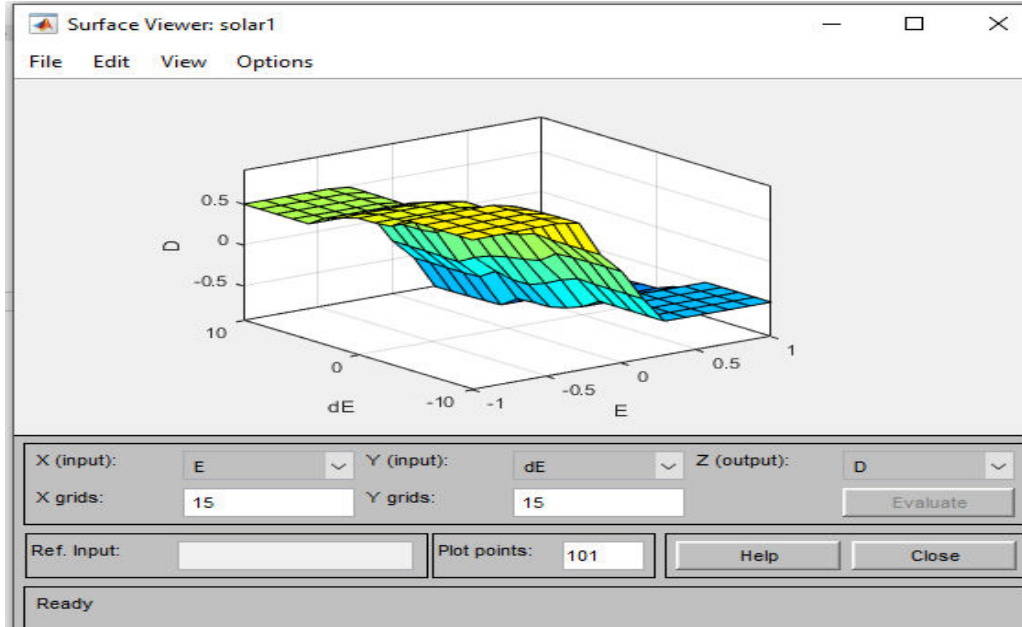


Fig. 5 Surface View

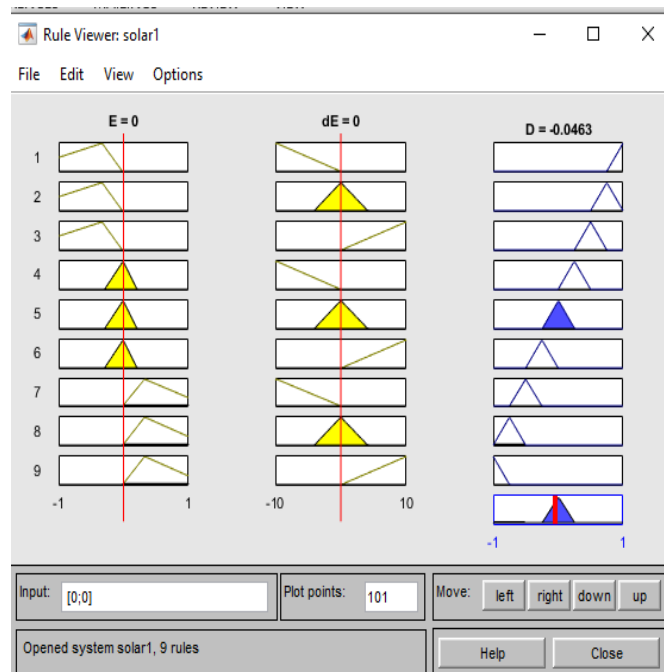


Fig. 6 Rule View

V. RESULT AND DISCUSSION

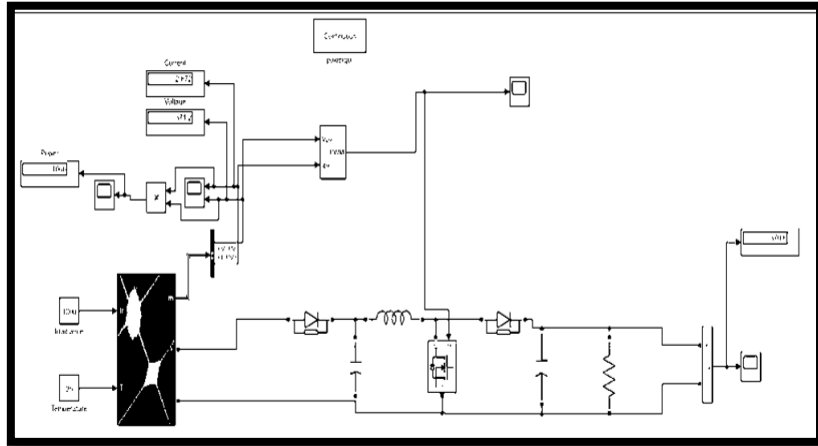


Fig. 7 Solar PV with Fuzzy

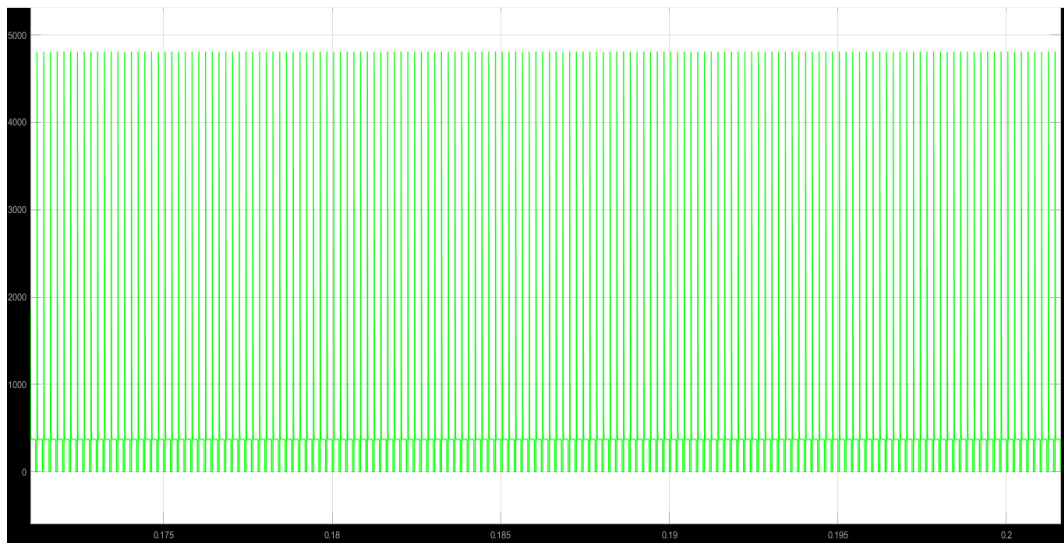


Fig. 8 Voltage output

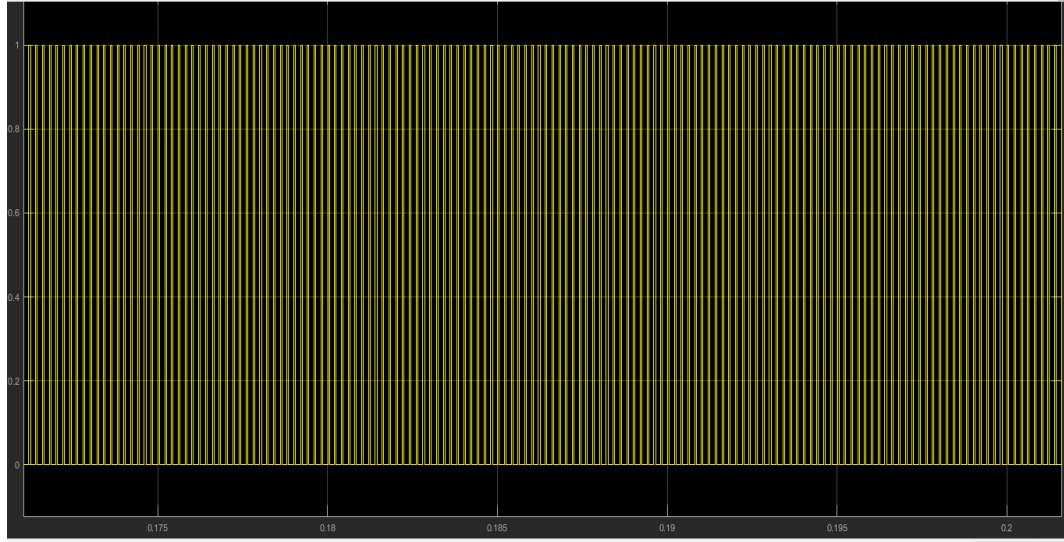


Fig. 9 PWM Pulses

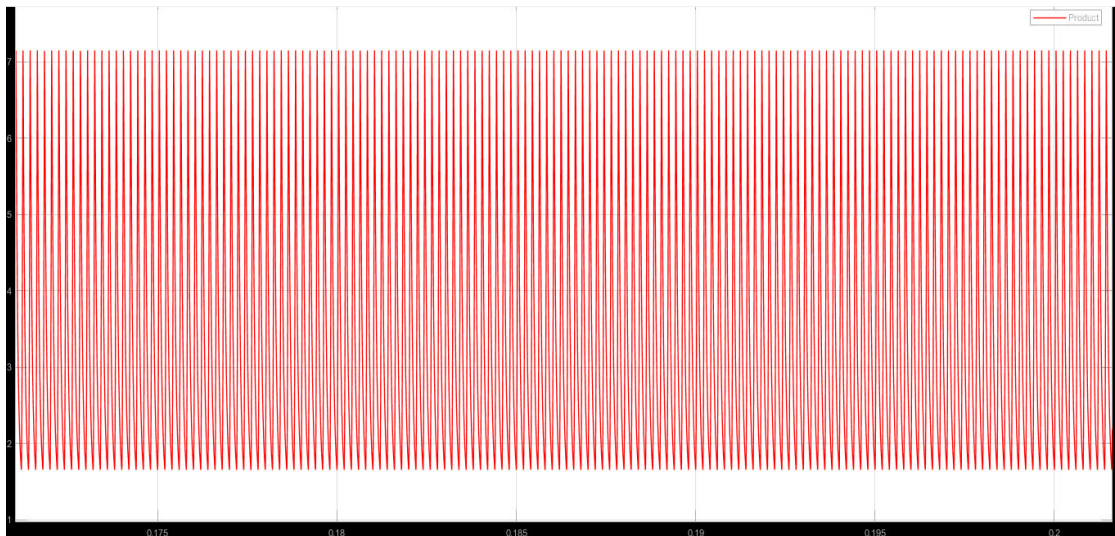


Fig. 10 Output Power

In this work analysis of various control techniques has been done from the previous research journals. The idea is to make the control system as per the condition of the generating plants. In fuzzy control system the input values and its limits can be set as per the historical data. The rules can also be defined in the rule set. After the installation the real time data can be feed in the control system and rules can be set as per the maximum output. The maximum power point extraction method can be done in many ways like perturbation and observation and incremental conductance method, particle swarm optimisation but after analysis the control system depends upon the site location. The variable weather conditions are favourable for the fuzzy based MPPT control system. The voltage can be boosted easily in the system and gate pulse generation done by our designed control system. The flexibility of the rules setting and input output range and variables are the main advantage of fuzzy control system.

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