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A Modified MPPT Algorithm for PV Systems with Climatic Parameters Estimation

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Abstract: ***The power and voltage characteristics of photovoltaic arrays (PV) displays multiple local maximum power points. When all the modules do not receive same solar radiation that is when under partial shading conditions. Traditional MPPT methods likes P&O, Incremental conductance, Constant voltage method, etc., are failed to track the MPP(maximum power point) under partial shading conditions. For that purpose here introduce a new method this is a combination of conventional Hill climbing MPPT technique and an ANFIS(adaptive neuro fuzzy interface system)based MPPT is presented. For the conventional MPPT searches maximum power point only under some particular region. The simulation results are clarify the conventional MPPT algorithm and estimate the capable of climatic parameters. The simulation results are evaluated under MATLAB/Simulink and shows the comparison of HC MPPT with ANFIS MPPT under different climatic parameters.***
Keywords: MPPT, PV system, HC MPPT, ANFIS

I. INTRODUCTION

Maximum power point tracking (MPPT) is an important concern in the operation of photovoltaic(PV) systems. Each PV cell have some particular efficiency at converting the energy in solar energy into electrical energy. Moreover the PV cell exhibits non linear power-voltage and non linear current-voltage that means there is a single operating point which corresponds to maximum power and efficiency. When number of cells are connected in series and parallel arrangements the characteristics of a I-V and P-V becomes more difficult and exists more local maxima. A PV source has the advantage of low maintenance cost and absence of extra rotating parts.

However the major drawback of the PV system is its ineffectiveness during the night times or low insolation periods or partially shading conditions. Tracking the global peak of a PV array in all conditions is important to achieve the maximum available power. Many MPPT methods are proposed in this literature [1]-[3].

Popular MPPT methods like P&O, Incremental conductance, Constant voltage-power method are shown effective under uniform shading conditions. They may fail to track the global maximum available power from the PV cell when under partial shading conditions. These methods can be classified into two groups hardware and software based methods [4].

Perturb and observe algorithms [5] is particularly popular approach because it is simple to implement [6]. The matter is further complicated due to the dependence of these characteristics on solar insolation and temperature. As these parameters vary continuously, MPP also varies. Considering the high initial capital cost of a PV source and its low energy conversion efficiency, it is imperative to operate the PV source at MPP so that maximum power can be extracted.

In generally, a PV source is operated in conjunction with dc-dc power converter whose duty cycle is varied in order to track the instantaneous MPP of PV source. In [7]-[8] a controller is assigned for each module. These hardware method problem can resolve the problem, since P-V characteristics of a module has always a single peak. These methods are not cost effective and requires more devices when compare to software based methods.

In [9] HC method has been improved. It can effectively detect the shading condition. While by measuring the power in suitable points it chooses the highest one and then perform HC around it. However it does not have acceptable accuracy for tracking the GP, since it compares the power points near the local points instead of local points themselves.

Authors of [10] have proposed an effective MPPT method for PV systems based on particle swamp optimization (PSO) algorithm. This method is too complex to be applied to the commercial appliances, since some parameters have set by the user. In [11] artificial neural network (ANN) has been opted. The main problem of ANN-based methods is that the ANN's accuracy under different conditions is highly dependent to the amount of available training data. This paper provides an ANFIS based MPPT method with reduced components. It find out the instantaneous and junction array's conductance's. Hence the proposed ANFIS based MPPT is analytical. The simulation results are provided to validate the proposed ANFIS based MPPT scheme capabilities.

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II. PV MODULE CHARACTERISTICS AND MPPT

A. Uniform Irradiance Condition

In the literature, different models are presented for solar cells. Among these models, single-diode model that is shown in Fig. 1 is used in this paper. Based on this model, relation between voltage (V) and current (I) of a PV module is expressed as follows:

$$I = I_{pv} - I_0\left[\exp\left[\frac{V+R_sI}{AV_T}\right] - 1 - \frac{V+R_sI}{R_{sh}}\right] \quad (1)$$

Where Ipv is the equivalent photocurrent of module, Io is the reverse saturation current of the equivalent diode. A is the ideal factor and Vt is the thermal voltage. Rs and Rsh are the equivalent series and shunt resistances.

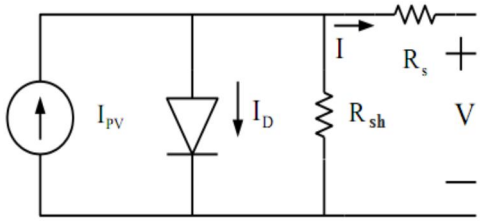


Fig1: Single diode model of a PV module

$$I = N_pI_{pv} - N_pI_0\left[exp\left[\frac{V+\frac{N_s}{N_p}R_sI}{AN_sV_t}\right] - 1\right] + \frac{V+\frac{N_s}{N_p}R_sI}{\frac{N_s}{N_p}R_{sh}}$$

…..(2)

Np= no of parallel connected modules,

Ns = no of series connected modules

The solar PV module operation depends on the load resistance and is mainly influenced by solar irradiance and temperature. The term solar irradiance means the amount of energy received by the sun with respect to the time.

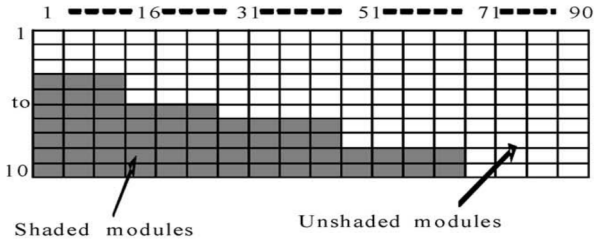


Fig2: Sample PV array with insolation of 1000W/m2

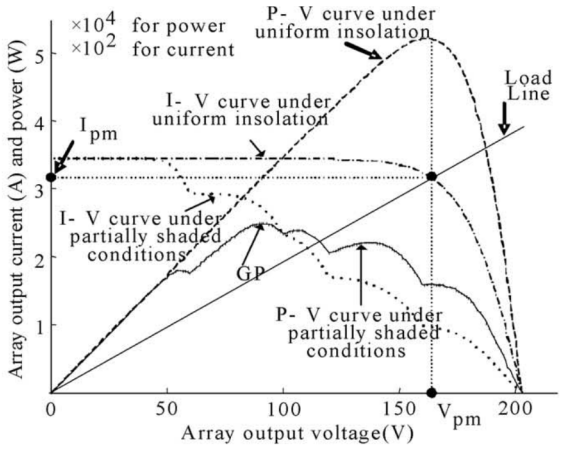


Fig3: Shaded modules with 300W/m2

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Above figure represents the relation between solar irradiance and temperature demonstrate that solar irradiance increase then the power of PV cell decrease otherwise if the solar irradiance decrease the power will increase.

In case of the maximum power point tracking mechanism makes use of an algorithm and electronic circuitry. The mechanism is based on the principle of impedance matching between load and pv module, which is necessary for maximum power transfer. This impedance matching is done by using a DC-DC converter using DC-DC converter the impedance is matched by changing the duty cycle of the switch.

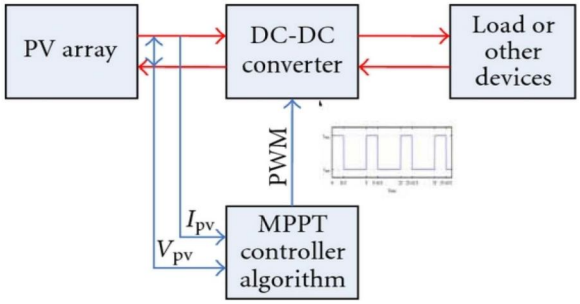


Fig4: A MPPT controller in a PV system

The method is most popular algorithm is hill climbing method. It is applied by the perturbing duty cycle d at regular intervals and by recording the resulting array current and voltage values, there by obtaining the power. Once the power is known, a check for the slope of the PV curve or the operating region (current source or voltage source region) is carried out and then the change in d is effected in a direction so that the operating point approaches MPP on the power-voltage characteristics.

III. PROPOSED METHOD FOR MPPT

The combination of NN (neural network) and fuzzy refers to the neuro fuzzy technique in which the number of various methods in neural networks can be applied into FIS(fuzzy interface systems). One representative intelligent system which combines NN and fuzzy logic is ANFIS(adaptive neuro fuzzy interface system). General structure of the adaptive network is with first order Sugeno fuzzy interface system. In order to find out the network parameters and evaluate the sugeno first order system the learning method of ANFIS represents the back propagation, gradient descent in one side and least square algorithm [11].

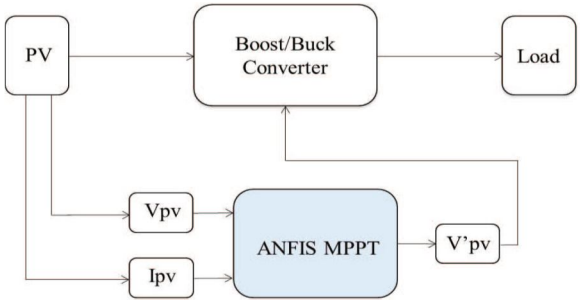


Fig5: Block diagram of a ANFIS based MPPT

The architecture of a typical an ANFIS is shown in below figure in which circle shows a constant point and square represents adaptive point. While for our convenience we have taken two input points x,y and one output point z. For many ANN networks we choose sugeno because its consists high efficiency, less complexity, optimal adaptive techniques.

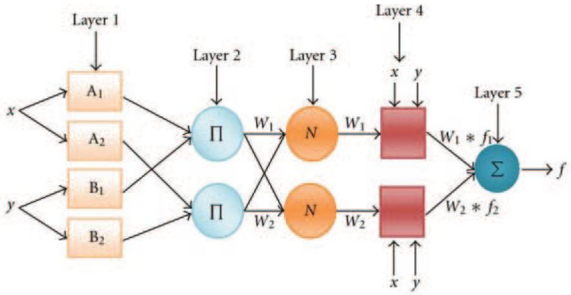


Fig6: The structure of an ANFIS

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The ANFIS structure have two rule as shown in the above figure from above scenario network has five layers each layer and every point contains same function and final output is in the form of linear combinations for all given inputs.
The rules are shown below:
Rule1 If x is A1 and y is B1 then f1=p1x+q1y+r1
Rule2 If x is A2 and y is B2 then f2=p2x+q2y+r2
A1,A2 fuzzy sets
P,q and r constant parameters

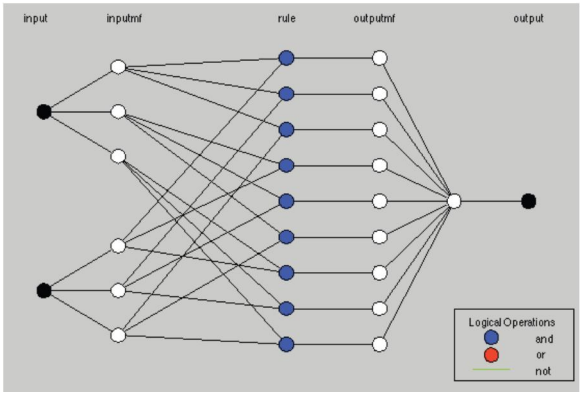


Fig7: An ANFIS based control structure

IV. SIMULATION RESULTS

To evaluate the performance of the ANFIS based MPPT a PV module is characterized by a rated current 4.15A. The output voltage of the PV module is 25V to 30V and output current is 1.4A to 8A. Total output power is 270W.

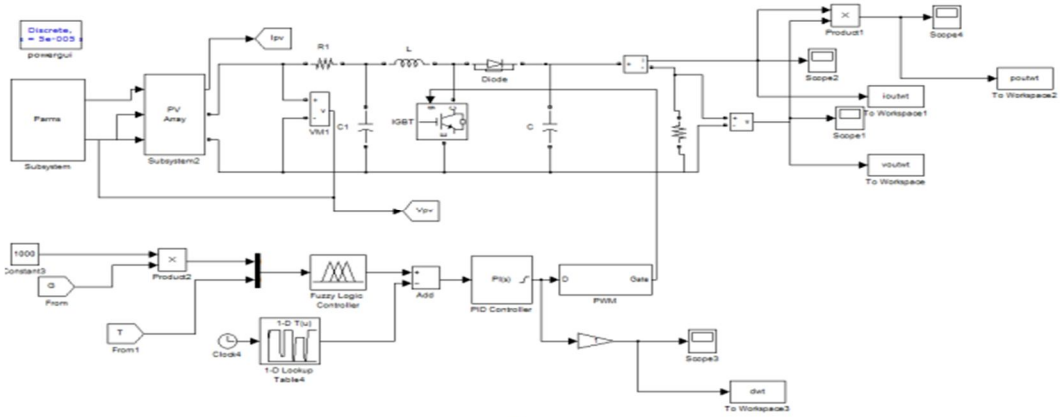


Fig8: Complete MATLAB/simulink model of the proposed ANFIS based MPPT system.

MATLAB/Simulink representation of the ANFIS based MPPT is shown in fig8. All the simulations are done in the widely used MATLAB/Simulink environment. Simulation results of ANFIS algorithm as MPPT on PV system is done by providing interface in the form of solar irradiance and temperature changes because these two variables affect PV output voltage and current.

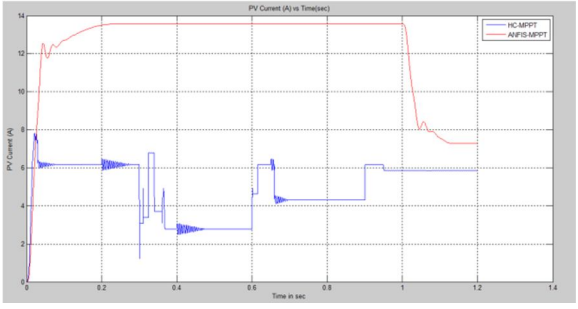


Fig9: Output current and time waveform of ANFIS based MPPT

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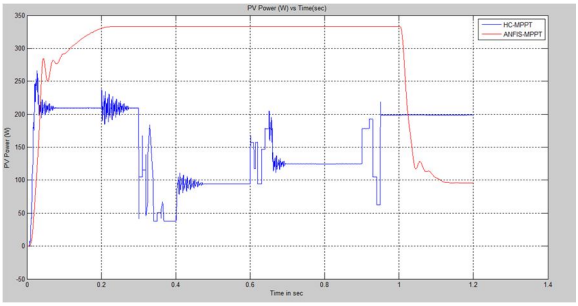


Fig10: Output power and time waveform of ANFIS based MPP

S.no	System	Voltage	Current	Power
1.	HC MPPT method	25V	8.25A	208W
2.	ANFIS based MPPT	30V	12.5A	270W

Fig11: Comparison table of HC MPPT with ANFIS based MPPT.

V. CONCLUSIONS

Detailed implementation of the proposed ANFIS based MPPT algorithm has been presented and its flexibility and effectiveness has been demonstrated on under various irradiance and power reference profiles. This paper proposes an ANFIS based MPPT algorithm for control scheme in the solar PV module. The operative implementation of ANFIS based MPPT algorithm can effectively track the global maximum power point under irrespective of climatic parameter. Beside the comparison of HC MPPT with ANFIS also presented. The experimental results can show the feasibility of ANFIS based algorithm tracking and extracting the maximum available power from the PV module.

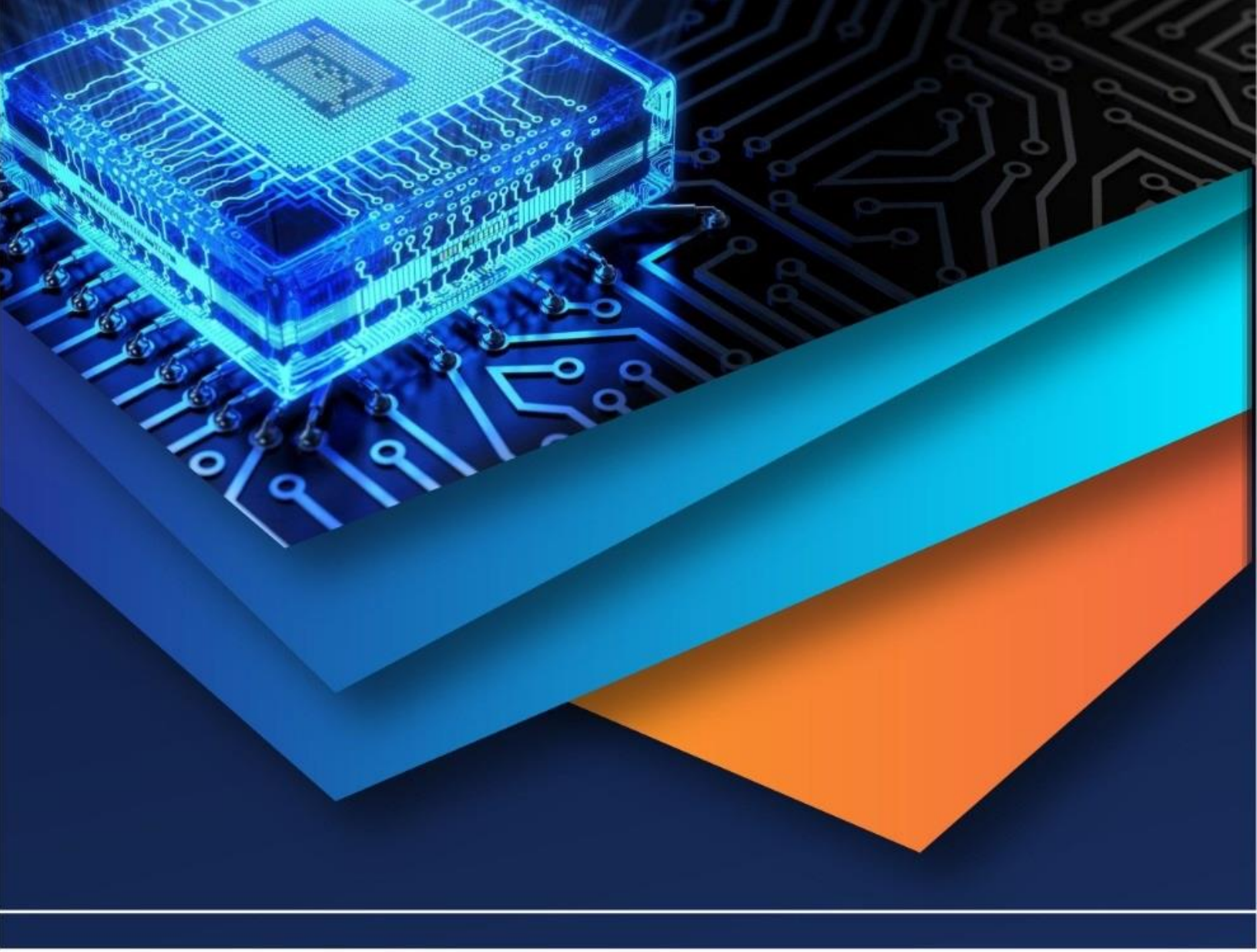
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