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Fuzzy Intelligent Controller for the MPPT of a Photovoltaic Module in comparison with Perturb and Observe algorithm

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Abstract

Solar energy is one of renewable energy source which produces electricity by photo electric effect. To increase efficiency of photovoltaic system, a Maximum Power Point Tracking system (MPPT) is employed ,which continuously extracts the maximum possible power from solar panel and deliver it to the load. This paper proposes an intelligent control method for the maximum power point tracking (MPPT) of a photovoltaic system under variable temperature and insulation conditions performance analysis in comparison with perturb and observe method .

Keywords: MPPT, FLC, P&O .

INTRODUCTION

In recent years Traditional fossil fuels are expected to run out in the near future, the world already started to rely on renewable energy as a cheap, clean and permanent substitute One Of such renewable energy system is solar energy which uses maximum power point tracking method. Tracking the Maximum Power Point (MPP) of a PV array is important criteria of a PV system, where many algorithms are applied to track the MPP. Basic methods such as Perturb & Observe (PO) , fails to have good accuracy and response time as oscillation occurs around the optimum in steady state. To overcome this drawback, several intelligent and complex control methods are being developed. A new technique in development of MPP tracking is to use artificial intelligent control algorithms such as fuzzy logic. The comparison between conventional P&O and new intelligent algorithms fuzzy logic controller proves a improvement in overall performance of system in terms of parameters settling time ,peak overshoot .

MODELLING OF PV SYSTEM

The module of Photovoltaic (PV) consists arrangement of Photo voltaic cells which are photo-active semiconductor PN junction diodes. The cells of Photovoltaic observe solar type of energy from solar light and transform it into electrical energy. The entire solar photovoltaic is power electronic transformation systems in a type of circuit rely on the simulation design to simulate the behavior of electrical PV systems. The usage of electric equivalent circuits and numerical equations make it possible the model of the limitations of a Photo voltaic cell and then simulate it. A generalized PV model has hence been created utilizing MATLAB/Simulink to feature and verifies the nonlinear I-V and P-V characteristics of output Photovoltaic module. In order to prepare the generalized model easy to distinguish and recognize, a veiled model is intended to have a dialog box, in which the parameters of module of PV can configure in the similarly as the generalized Simulink blocks libraries. A general numerical model of I-V output characteristics for a cell of PV has studied, and the solar type cell shown by the electrical model as shown in fig 1.

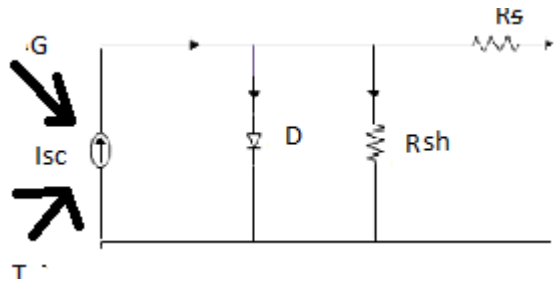


Figure 1. Equivalent Circuit for Single Diode modeling photovoltaic Cell

DC-DC CONVERTER

The switch mode of a chopper acts as the crucial control part of a MPPT system. These are mostly used to transform unregulated DC inputs to a controlled DC output at a converted current level and voltage level in DC type power level supply and DC motor drives. Such converter is utilized for a MPPT to give load matching for the extreme power transfer by controlling the voltage level at the input side of the array of PV system by controlling the duty cycle ratio (D). Therefore, there is a singular dot where the both curves intersect each other, exactly at a MPP. The generation curve nonlinearly transform with the rework of the radiation (G) and temperature (T), while the load curve has a different characteristic flowingly to the sort of load is associated to the PV module.

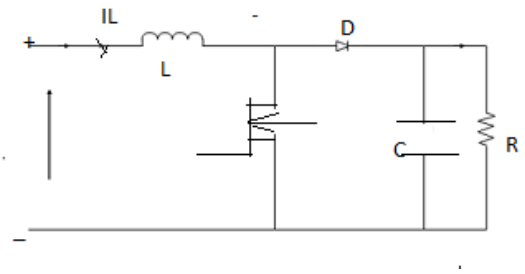


Figure 2: Ciruit of DC-DC Boost converter

If the resistance is lower or higher than this value, the power drawn will be not more than the extreme available, and hence the cell won't be utilized as efficiently. The greater part of the Maximum power point trackers (MPPT) use different sorts of logic or control circuit to look for this point and hence to permit the converter circuit to get the extreme power accessible from a cell.

THE PERTURB AND OBSERVE METHOD

The Perturb and Observe method (P&O), also called Hill climbing method, is the most famous MPPT technique. P&O is widely used as it is the simplest method among all MPPT ones. P&O is simply measuring the PV's terminal voltage and output current, from which the actual Power can be calculated and varying the duty cycle of the DC-DC converter is done till the extreme power point is achieved. As the name of the P&O method states, the process starts by operating the DC-DC converter with the initial set duty cycle, and then starts increasing the duty cycle with a certain step width (user defined), and the Power is observed with the addition of each step. If at a certain point the Power gets less than its previous value that means that the duty cycle should get one step in the opposite direction i.e. getting to the MPP again and so on the process continuous. But the

The P&O method have the drawback of slower response that the settling time is more. To over come this problem in this paper a new Fuzzy logic controller approach is implemented.

FLC MPPT

Very Recently fuzzy type logic controllers (FLC) have been introduced in the tracking method of the MPP in Photovoltaic (PV) systems. They have the lot of merits to be robust and relatively easy to design. Since they won't required the knowledge of an accurate plant model. On the next hand, the designer needs expert matter of the PV devices working. The proposed FLC is designed figure comprises of paired inputs and one sided output.

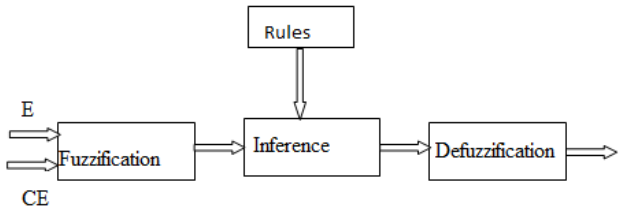


Figure 3: Fuzzy MPPT inputs and output variables

The both FLC input sided blocks are E, CE output sided (U) is interconnected with their saw tooth waveform to produce a pulse width modulation signal for a D of boost converter

Where the inputs of FLC can be expressed by equation

$$E=(K)-P(K-1)V(K)-V(K-1) \quad (1)$$

$$CE=(K)-E(K-1) \quad (2)$$

Where P, V are the PV power and voltage level respectively at the instant k. E is very equal to the zero at MPP, so E shows load operating method point at instance k if it is situated at left or right or at MPP on P-V characteristic cure of PV, on other hand changing of errors is used to explain the moving direction of this point.

A. Fuzzification of MPPT

The Fuzzification process changes the device present inputs values CE and E into linguistic fuzzy type sorts utilizing fuzzy triangular and trapezoidal functions of membership as designed in figure 4. These linguistic variable has considered in terms of five number linguistic variables.

Positive Big-PB. . . Negative Big-NB.

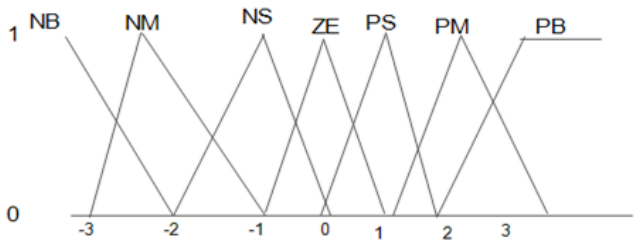


Figure 4: Membership function (MF) of E, CE

B. Knowledge Base to MPPT

Fuzzy base rule is a collecting of if-then ruling of that contain all the informating for the controlling parameters. It is set of according to professional experience and the operation of the device control. The fuzzy rule algorithm includes some of the following fuzzy control rules listed below in table 1

Table 1: fuzzy control rules

CE / E	NB	ZE	PS	PM	PB
NB	ZE	NB	NB	NB	NM
ZE	NM	ZE	ZE	PS	PM
PM	PM	ZE	ZE	ZE	ZE

In this, Mamdani's fuzzy inference method, with operation of Max-Min fuzzy collaboration has been utilized.

C. Defuzzification to MPPT

Defuzzification of the engine inference, which evaluates the based rule on a sorts of controlling activities for a sended sources of fuzzy inputs. This operation transforms the inferred fuzzy type controlling activity into a numerical values at the outputsided by forming the group of the outputsided obtained from every rule. The center of that area algorithm is utilized for defuzzification. Figure (5) shows member ship of output U.

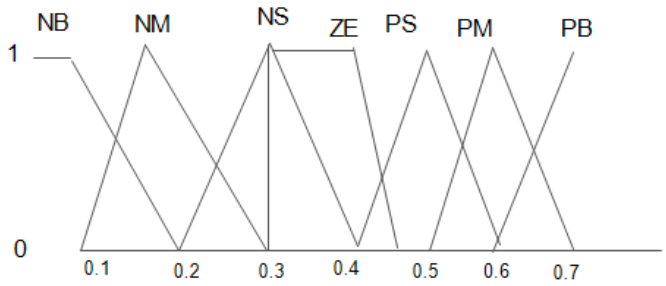
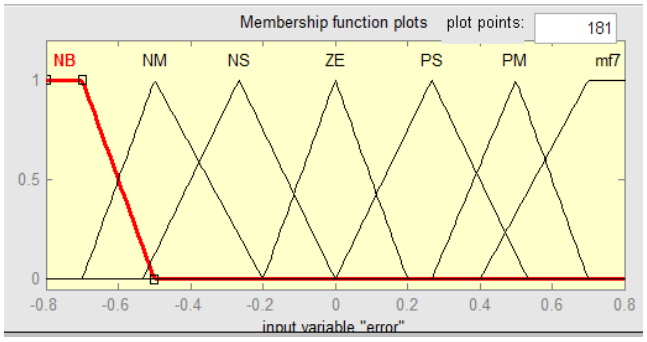


Figure 5: Membership function (MF) U

If E is NB and CE is ZE then crisp U is NB, it means that if the working point is away from the MPP by the right side, and the difference of the slope of the curve reaches to Zero; then increment the duty cycle.

D. Fuzzy Input to MPPT

The Fuzzy Logic control (FLC) system are represented in the MATLAB/Simulink software. In the MATLAB/Simulink write the "fuzzy" in the command window and the fuzzy system window will be appear in which there is a Mamdani-type system with two inputs and single output has been established. The figure contains of two inputs. The input E represents the power and the input CE represents the change in voltage of the PV generator and output D represents the duty cycle which will generate the control signal to the converter of the Photovoltaic (PV) generator.



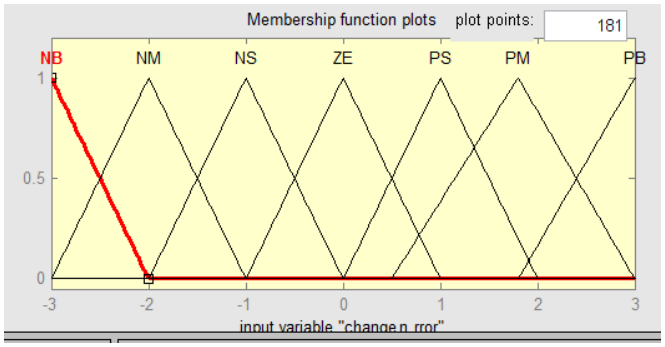


Figure 6: Membership function (MF) of E, CE

E.Rule base for MPPT

Rule base is the centre of the FLC, which is a arrangement of rules in the form of IF-THEN statement that explains the state and the behavior of the controlling system. The knowledge base defining the principles for the desired relation between the input and output variables regarding the membership functions (MF) showed in Table

Table 2: Membership functions

NB	Negative Big
NM	Negative medium
NS	Negative Small
ZE	Zero
PS	Positive small
PM	Positive medium
PB	Positive Big

Selection of Fuzzy rules and surface of the base rules are displayed in the figure7 and figure 8

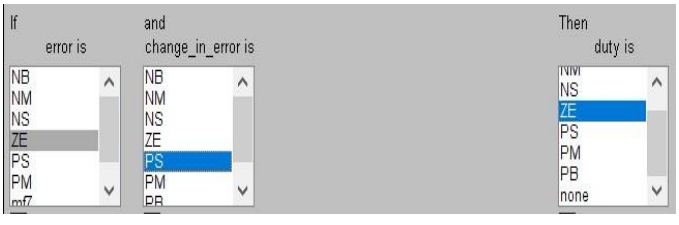


Figure 7: Selection of Fuzzy rules

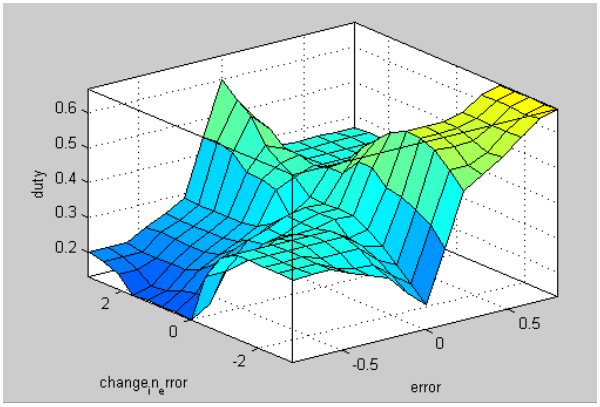


Figure 8: Surface of Fuzzy Control

F. Defuzzification for MPPT

This operation changes the inferred fuzzy control activity into a numerical value at the output by generating the combination of the outputs resulting from each rule. The centroid method is utilized for defuzzification. Figure 9 shows member ship of output U.

If E is taken as NS and NM as ZE then crisp U is PB, which says that if the working point is far away from the Maximum Power Point (MPP) to the right side, and the change of the slope of the curve is almost Zero; then it rises the duty cycle.

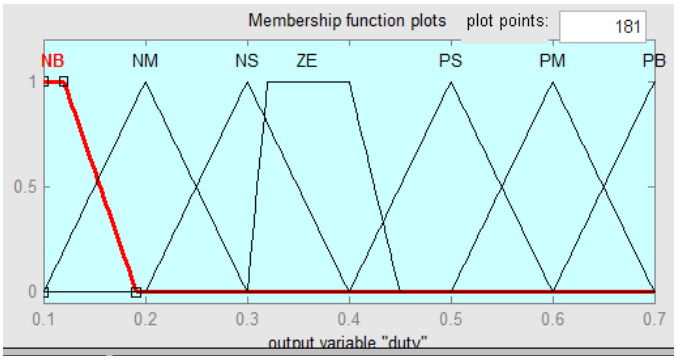


Figure 9: Membership function (MF) U

COMPARISON OF P AND O WITH FUZZY LOGIC ALGORITHMS:

Figure 10 and Figure 11 shows the Voltage, Power comparison of Photovoltaic(PV) panel using P&O with Fuzzy Logic algorithms. Figure 12, shows Boost converter voltage and power comparison of Photovoltaic (PV) panel using P&O with Fuzzy Logic algorithms.

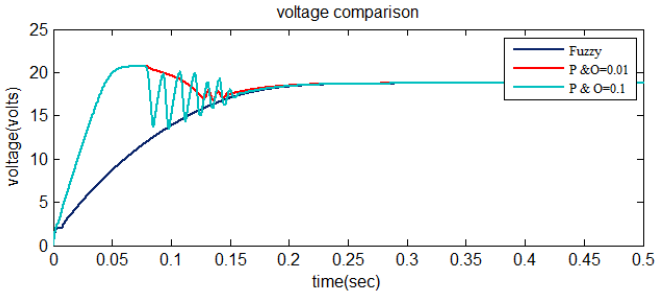


Figure 10: Voltage comparison of PV panel using P and O with Fuzzy Logic algorithms

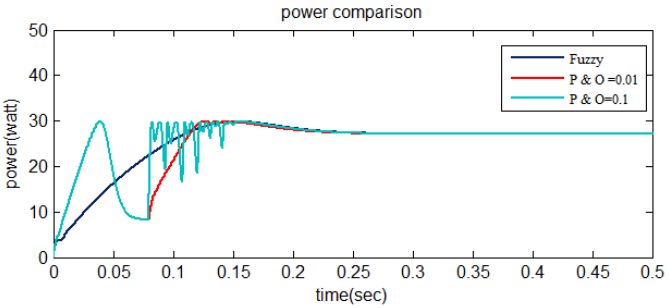


Figure 11: Power comparison of PV panel using P and O with Fuzzy Logic algorithms

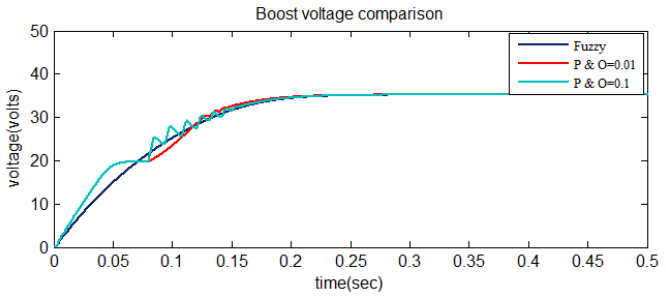


Figure 12: Power comparison of PV panel using P and O with Fuzzy Logic algorithms

Table 3: Performance comparison between P&O with Fuzzy Controller of PV system

MPPT METHOD	Settling Time (Sec)	Peak Over shoot
P & O=0.1	0.3	4
P & O =0.01	0.28	3
FUZZY	0.24	1

CONCLUSION

The Maximum Power Point Techniques (MPPT) are utilized to deliver most extreme possible Power from solar array. Here, an accurate Photovoltaic (PV) module is implemented using two techniques namely, Perturb and Observe (P&O)

algorithm and the Fuzzy Logic Control (FLC) method and to control the output voltage of DC-DC converter. The IV characteristic and PV characteristic of the Photovoltaic module is obtained with the change in irradiance and temperature. Based on the simulation parameters, results may be concluded as Fuzzy controller shows better performance regarding efficiency compared to the P&O algorithm. It also shows fast power tracking; less oscillation and good stable operation. Even a small improvement of efficiency could bring substantial savings if the system is large

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