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Modeling and Performance Analysis of Fuzzy-Pi Based Solar System

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ABSTRACT: This research paper discuss about the modeling and performance analysis of Fuzzy-PI based PV system are implemented. The duty cycle of DC-DC Boost converter is controlled by the proposed Fuzzy-PI based maximum power point technique (MPPT) control and hence Maximum power is acquire from solar system. MATLAB/Simulink was carried out and the proposed model is tested under various environmental conditions. The proposed technique is effectively analysis the maximum power for all weather conditions. The output power, voltage, current of the DC-DC boost converter is varying with respect to Maximum Power. The result of the fuzzy logic-PI controller shows high output power and efficiency . Thus the intelligent control systems of fuzzy-PI controller was used in a more effective and efficient manner of Solar system.

KEYWORDS: Maximum power point tracking(MPPT),PI control, Fuzzy logic control, DC converter, Photovoltaic.

I. INTRODUCTION

Now a days energy dangerous and environmental issue of pollution and global warming effects are more, but PV system becomes very attractive solution to improve the efficiency rather than actual system[1],[2]. This proposed system Fuzzy based MPPT controller is used to increase the system power and efficiency value. In olden days several MPPT techniques are available[3], Now Intelligent control based MPPT has been developed. Solar power concepts are essential to extract the more power as possible from sun radiations, this energy systems are being expanded studies and benefits of environmental aspects. In our government has introduced the Jawaharlal Nehru National Solar mission (JNNS), which target to 30GW of grid connected solar power generation by the year of 2022. This method many researches such as new materials strange of MPPT technique and voltage source converter design etc[4],[5]. The above researches MPPT technique is a important part to produce the maximum power from a solar radiation under the variation of environmental aspects. Maximum Power Point Tracking(MPPT) has a Non-Linear locus where it is various according to solar irradiation and PV cell temperature[9]. By increasing the efficiency of solar system the maximum power point has to be tracked and followed by adjusting the solar panel to operate in MPPT operating power, thus optimizing the production of electric power[8], [10].

There are several MPPT techniques are available and depends various components. In a conventional buck, boost converters input voltages are step down and step up and it can transfer the energy for all level of irradiation. This paper presents measured output voltage(current) of conventional and Fuzzy based DC-DC converter and operates the PV module at a predetermined value of MPPT. The conventional control of PID controllers are well known because of sensitive to parameter variation and other conditions[7]. If weather conditions change that can be reflected by solar arrays and addressed accurately using of Fuzzy logic control (FLC) . The main advantage of proposed control systems can be provide maximum power transfer from solar cell to boost converter of all weather conditions.

II. SYSTEM DESCRIPTION

The below figure 1, represents the proposed model of Fuzzy-PI control based MPPT operation of Boost converter for PV converter applications. This system always to transfer maximum power from PV cell to converter side. If only PI controller is used means to issue the maximum steady state error and overshoot.

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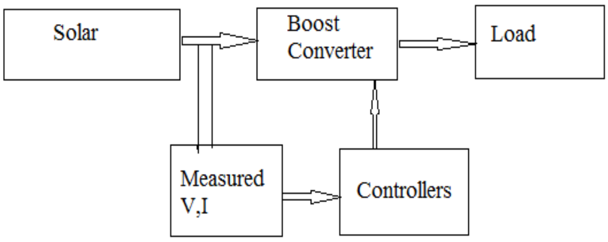

Fig 1: Proposed model

A. PV MODULE

Photovoltaic (PV) mean by converting solar energy(sun radiation) into direct current electricity using semiconducting materials that reveal of photovoltaic effect. This system employs solar panels composed a number of solar cells to supply the useful solar power. The amount of power generated by a solar cells to determined the light falling, which is turn to determined by the weather and time of day. PV panels is used to photovoltaic effect, a solar thermal collector supplies heat by absorbing sunlight, for the purpose of either direct heating or indirect electrical power generation from heat[14],[15].

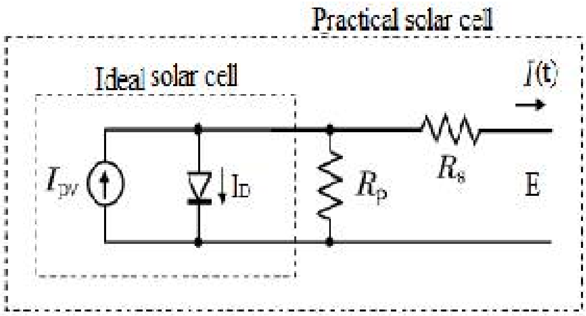

Fig 2: Solar cell model

B. DC-DC CONVERTER

A boost converter (DC-DC converter) means output voltage is greater than the input voltage. It is a classes of switched-mode power supply (SMPS) containing two semiconductor switches (diode and MOSFET switches) and one energy storage element likes capacitor and inductor[12]. Inductor and Capacitor (LC) filter is added to the output side to reduce the ripple voltage. The step-up (boost) converter is used to regulate the chosen level of solar output voltage and to keep the maximum output power from solar panels at all conditions.

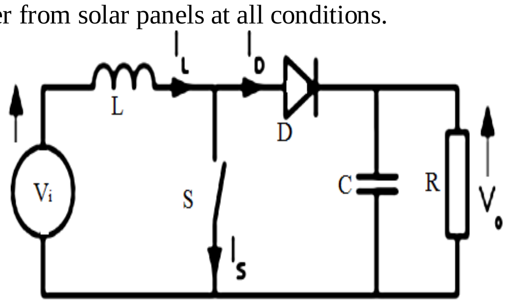

Fig 3: Boost Converter

C. MAXIMUM POWER POINT TRACKING:

It is a fully electronic modules that operates the solar system, it varies the electrical operating point of module to produced maximum available power. This proposed model of MPPT system operates at 17V to extract the full power 75W, to observe the present battery voltage. The maximum efficiency of DC-to-DC (step-up) converter converts the 17V PV module voltage at the controller battery voltage of output. Perturbation and Observation Method(P&O) method

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is most efficient algorithm to track the maximum power due to simple operation and less required parameter, it is used for PV modules by means of repeated process for perturbing, observing and comparing the generated power[13].

III. FUZZY CONTROLLER

This proposed control is a new method of control theory, its design philosophy of deviates from all earlier methods by accommodating best way of controller design. Fuzzy is one of the most applications of set theory. Its major features are the use of linguistic variables rather than numerical variables. Linguistic variables means variable whose values are sentences in real language may be represented by fuzzy sets. It has an attractive choice when exact mathematical formulations are not possible[11]. The below figure shows the general structure of fuzzy logic controller and comprises the four components.

The input and output variables are processed by an inference engine which executes 25 rules. There are two inputs which are used in Fuzzy logic like error *(E)* and change in error *(CE)* for linguistic variables and produce the control rules. Control variable is applied to produce angular value (α) of the system, which determines output cycle. This design of fuzzy rule is used to obtain the control performance for the membership function plot operation . Classical analysis and control strategy are incorporated in the rule base. Each rules describes If (e (t) is NB) and (Δe (t) is NB) then (output is NB). The rule base is used for different optimization techniques like GA, PSO and Intelligent controllers. The universe of input and output variables are divided into five fuzzy sets like: NB, NS, Z, PS, PB. Each variables are member of subsets with degree of -10 and +10. The representation of membership functions of input (E and CE) and output variables are described in Figure 5, 6 and Fig 7.

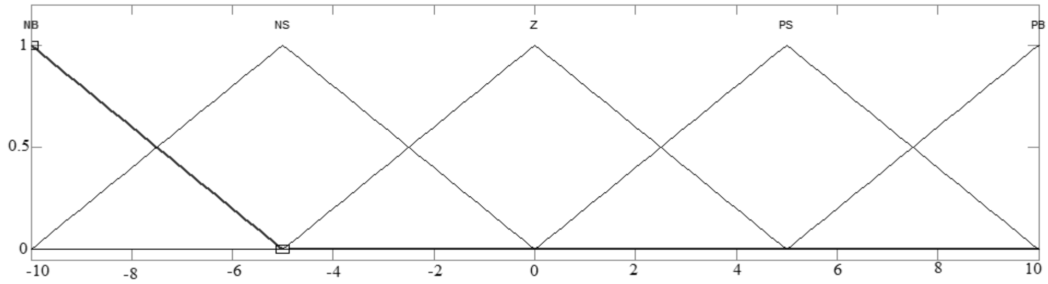

Fig.5 Input membership function error

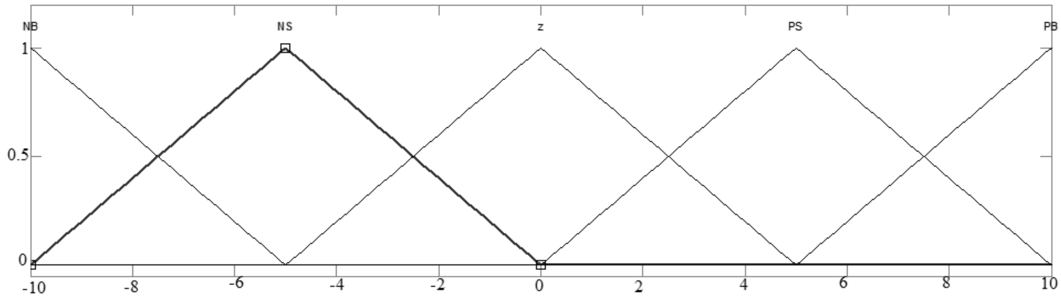

Fig.6 Input membership function of change in error

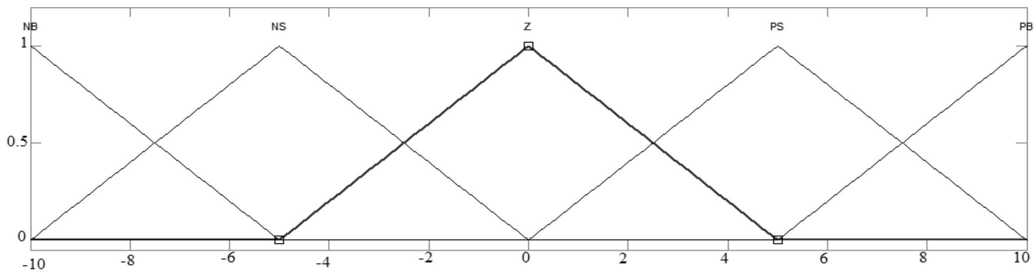

Fig.7 Output membership function

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The first step of the fuzzification processes is to create the member ship function for input . Five fuzzy sets are chosen and defined by following library of fuzzy sets value for the Error(E) and Change in Error(CE) as stored in rules table. The number of fuzzy levels is not fixed and depends on input resolution and needed in a application. If the fuzzy levels is large to produced high input resolution. The fuzzy controller utilizes centroid functions on controller input. Inference Mechanism: Result of inference mechanism is including the weight factor W_i and Change in duty cycle (C_i) of the particular rules. The weight factor (W_i) is obtained by using mamtani minimum fuzzy implication.

De-fuzzification: The product of centroid de-fuzzification method and weighing factor (W_i) gives the contribution of inference result of crisp value of the change in duty cycle. The fuzzy control rules are indicated in Table 1 with Error (e) and Change in Error (ce) as inputs and Duty cycle(D) as a output.

Table-1 If-Then Rule base of FLC

Duty		**Δe(t)**				
		NB	**NS**	**Z**	**PS**	**PB**
e(t)	**NB**	Z	Z	PB	PB	PB
	NS	Z	Z	PS	PS	PS
	Z	PS	Z	Z	Z	NS
	PS	NS	Z	Z	Z	NB
	PB	NB	NB	Z	Z	Z

IV. SIMULATION MODEL AND RESULTS

We can analysis the simulation and test the output of Fuzzy based PI controller (F-PI) to give better result .The designed of control system has been simulated via MATLAB Simulink software rather than other methods. Simulink setup has been done with the schematic diagram shown in fig 8 .

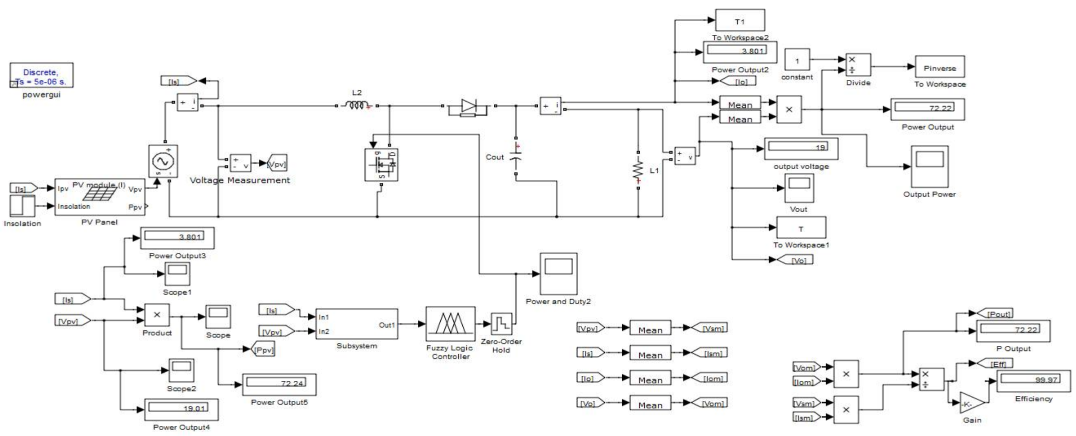

Fig 8 Simulink of PV based DC-DC converter with F-PI controller

The graph plotted in Fig 9. shows the DC-DC converter output voltage of Fuzzy- PI controller with time plotted in msec in x-axis and output voltage in volts in y-axis. Initially the output voltage starts increasing normally and measure the study state period and evaluated with the study state DC voltage of 19 Volt.

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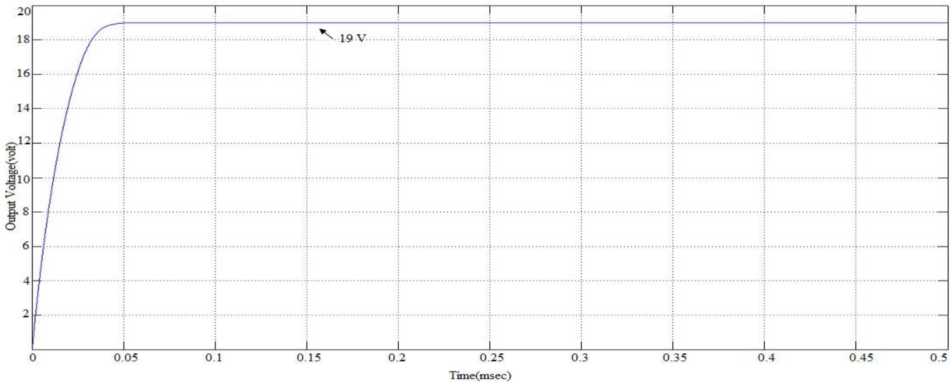

Fig 9 Output voltage of PV based F-PI controller

The graph plotted in Fig 10. shows the DC-DC converter output current of proposed controller with time plotted in msec in x-axis and output current in ampere in y-axis. Initially the output current starts increasing normally and measure the study state period and evaluated with the study state DC current of 3.81 Amps.

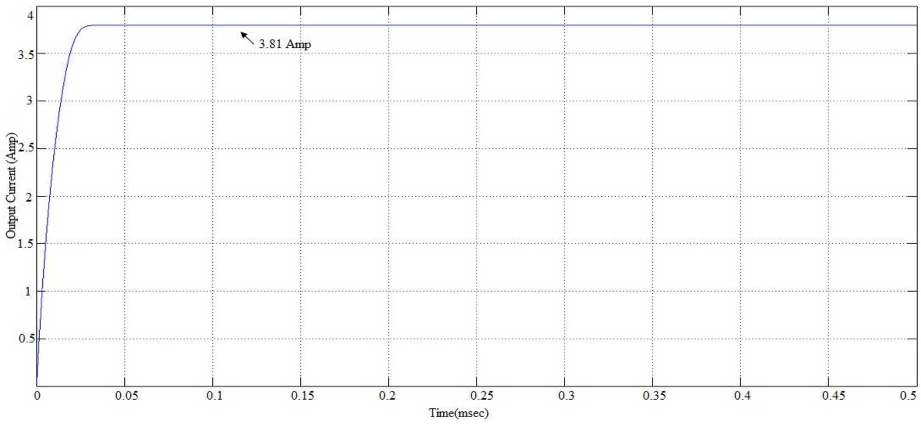

Fig 10 Output current of converter based solar system

The graph plotted in Fig 11. shows the DC-DC converter output power of proposed controller with time plotted in msec in x-axis and output power in Watts in y-axis. Initially the output current starts increasing normally and measure the study state period and evaluated with the study state DC power of 72.22 Watts.

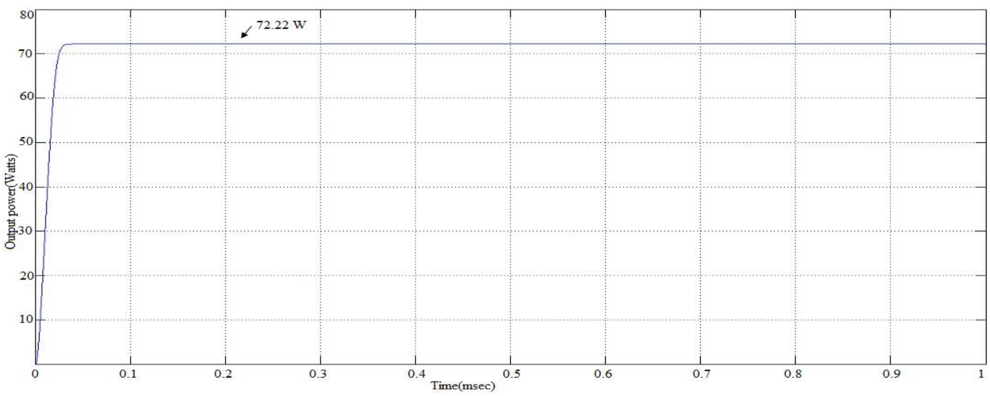

Fig 11 Output power of PV based F-PI controller

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A. RESULT AND DISCUSSION

Thus we verify the fuzzy-PI controller, with various parameters like converter output voltage, current, and power of F-PI controllers. In table 2 shows the various parameters which shows the fuzzy control has low settling time and overshoot. This proposed system is to produced 99.65% efficiency and better output power.

Table-2 System Performances

Output parameter	Result
Current(Amp)	3.81
Voltage(Volt)	19
Power(Watts)	72.22
Settling time(msec)	0.03
Overshoot(msec)	0.01

V. CONCLUSION

In this research fuzzy-PI based MPPT of DC-DC Converters has been implemented using MATLAB/Simulink software. To extract the large power from the solar module by using Fuzzy Logic Controller. For different operating conditions fuzzy algorithm has been verified and it's found that the error percentage lodge between 0.03 % to 0.2%. The fuzzy-PI controller is used in this paper for tracking of maximum power(MP) and energy flow is bidirectional with the help of a diode and a switch. This simulation shows the follow of irradiance and temperature changes, the output power varies fast and the regulation is strong disturbances. This solar system not only a boost up the voltage and also produces transient noise. The performance of closed loop system can be improved by using F-PI, this power can be utilized either remote places. It is used for consumer appliances and industrial applications with the help of duly designed converter. In order to produce a pure DC output with low harmonics an inductive capacitive (LC) filter is used. Finally simulation results are verify the operation and shows the output power.

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