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# Design of MPPT Fuzzy logic control for solar system and PI control as a charge controller

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**ABSTRACT**

**This paper presents the Fuzzy logic MPPT (maximum power point tracking) method used in photovoltaic panel using buck, boost converter for charging the battery load. Using variable temperature (20-60`C) and irradiance level (600-1000 $W/m^{2)}$ then PI control was applied in buck converter to use as a charge controller. The temperature and irradiance level effect the voltage and current of PV panels. They are nonlinear to each other. By changing these two factors effect the voltage, current and also effect to change maximal available power of PV panels. Under any changing environment condition there is single MPP. There are many MPPT methods find out in literature. To operate PV panels at that single MPP point. Resone behind using FLC MPPT method in this study because quick response to varying environmental conditions. There are two traditional methods used for charge the battery load. Which are constant voltage and constant current methods. In this study PI controller gives constant which was used in controller action. PI controller is a simple method also its provide accurate results. The main aim of this study is to operate the PV panel at maximum power point under changing environmental conditions to more efficiency and less cost and also provide constant voltage and current for charging battery quickly. This model was established and analyzed in MATLAB /Simulink.**

**Keywords: FLC (Fuzzy Logic Controller), CV, CC, Simulink, MPPT**

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## I. Introduction

In previous year, fewer sources of coal, more energy needs and increasing pollution attracted the research world to study on non-conventional energy sources. In non-conventional energy sources solar systems have more importance. Because it's clean energy, less pollution. The solar system has producing electrical energy anywhere there is sunlight available. But some disadvantage of solar system like, efficiency of solar panel less (10-20%), also temperature and irradiation level effect the current and voltage of solar panels. Because of changing this factors effect on change current, voltage, maximum power point of PV panels. Using MPPT methods we increase the efficiency of solar system and also reduce the cost of solar system. In recent year many MPPT methods are developed in literature such as Perturb & Observe, Inc. Conductance, Fuzzy logic and etc. The FLC MPPT method have many advantages like quickly response to changing environmental conditions and also no need of any information about system parameters. Solar system consists of solar panels and DC-DC converters (choppers) such as boost converter, buck converter. MPPT methods find voltage and current of solar panels and then adjust the duty cycle of PWM which gives the switch (IGBT, MOSFET) to vary the voltage and current of converter. After boost converter buck converter are used for charging the battery load. But output of boost converter changes due to change in environmental conditions. There are some methods to charge a battery such as constant voltage and constant current method. For charging battery in less time and less losses its need constant current and constant voltage. Getting constant voltage and constant current for battery PI controller used in buck converter. It is simple controller and easy to implemented also gives accurate results for this study

## II. Fuzzy logic controller MPPT method

Fuzzy logic controller simple to design as they do not require knowledge about model of the system. They require complete knowledge of the operation of the solar system.

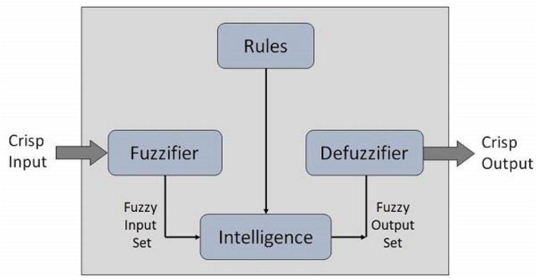


**Fig.2.1.** Diagram of the fuzzy controller

In fig. 2.1. shown FL MPPT has two input and one output. The input is the error E and change of error CE at sampled time k given by

$$E(k) = \frac{P1(k) - P1(k-1)}{V1(k) - V1(k-1)} \quad (1)$$

$$CE(k) = E1(k) - E1(k-1) \quad (2)$$

Where P1(k) is power and V1(k) is the voltage of solar panels and P1(k-1), V1(k-1) are the previous power and voltage of solar panels. By using madan's method the fuzzy inference is done. Center of gravity used for defuzzification process to calculet the output of this FLC which the duty cycle D.

**Table 1**.

shows the rule table of fuzzy logic controller

| E/CE | NB | NS | ZE | PS | PB |
|---|---|---|---|---|---|
| NB | ZE | ZE | NB | NB | NB |
| NS | ZE | ZE | NS | NS | NS |
| ZE | NS | ZE | ZE | ZE | PS |
| PS | PS | PS | PS | ZE | ZE |
| PB | PB | PB | PB | ZE | ZE |

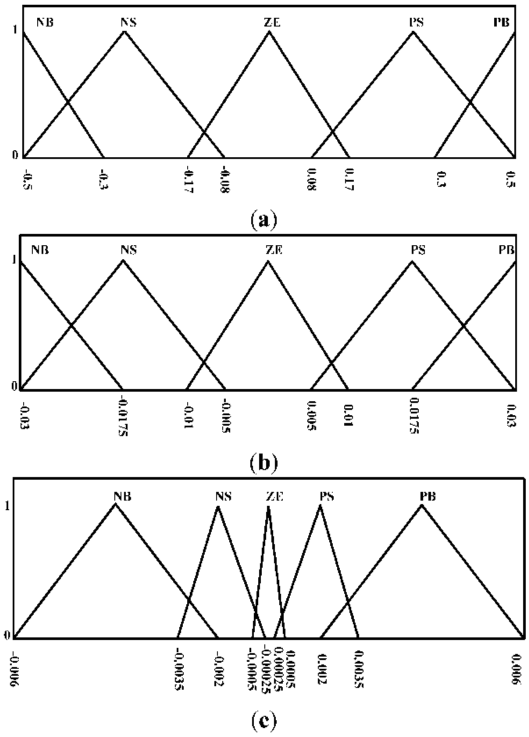


**Fig.2.2.**(a) The input of fuzzy logic controller error E(k), (b) The input of fuzzy logic controller CE(k), the output of fuzzy logic controller duty (D).

## III. Design of the DC-DC converters

DC-DC converters are the electromechanical device that converts a direct current from one voltage level to another. It is include in electrical power converter. In this system step up converter is used as MPPT circuit to operate solar panel at maximum power point. Fuzzy logic control method is used to switch (MOSFET) of step up converter to change duty cycle of PWM.

3.1. Operation of step up converter

MOSFET is used for switching purpose, it is on or off state, where D is the duty cycle. When the switch is closed (MOSFET is on state) current flows through inductor in clockwise direction during $0 < t < DT$ the diode is reverse biased. The voltage across inductor is input voltage Vin. When the switch is opened, (MOSFET is in off state) during $DT < t < T$, diode become forward bias, current will be reduced. The voltage across inductor Vl = Vin – Vout. In the steady state, the DC (average) voltage across the inductor must be zero so that after each cycle the inductor returns the same state,

$$Vin = V0\ (1 - D) \quad (3)$$

 

$$\frac{V0}{Vin} = \frac{1}{1-D} \quad (4)$$

To find capacitor and inductor of step up converter the following equations are used

$$L = \frac{Vin(V0-Vin)}{\Delta Il\, fsVo} \quad (5)$$

$$C = \frac{I0\, D}{fs\, \Delta Vo} \quad (6)$$

Vin=input voltage, Vo=output voltage, $\Delta$Il = inductor ripple current, fs=switching frequency, $\Delta$Vo =output ripple voltage, D=duty cycle

3.2. Operation of step-down converter

Step down converter as buck converter is used to reduce the input voltage level at the output side. MOSFET is on state during time interval 0 < t < DT and reverse biased the diode. If MOSFET is in off state (DT < t < T) then voltage across the inductor Vl = -Vout. The total change in current in the inductor must be zero in the steady state condition.

$$Vo = D\ vin \quad (7)$$

To calculate the inductor of step-down converter

$$Il = \frac{Vo\ (Vo-Vin)}{fs\ L\ Vin} \quad (8)$$

To calculate capacitor of step-down converter

$$\Delta\ Vr = \frac{D\ Il}{8\ Fs\ C} \quad (9)$$

$\Delta$Il=inductor ripple current, Vin = input voltage, Vo=output voltage, Fs=switching frequency, L=inductor, D=duty cycle, $\Delta$Vr = ripple voltage, C= capacitor.

### IV. Design of PI control for step down converter

For constant output voltage and power of step-down converter to charge battery quickly PI control is used. This is shown in fig. integral gain and proportional gain are the parts of PI control. To find the integral gain ki and proportional gain kp. Ziegler-Nichols method is used the integral controller ki, is used to eliminate steady state error. To reduce the step-up time proportional gain kp is used.

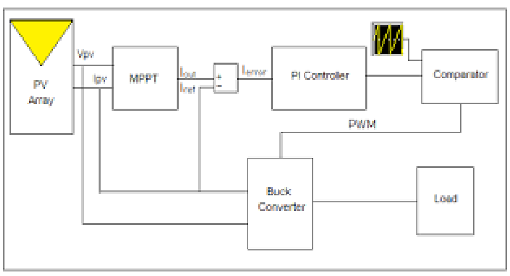


**Fig. 4.1.** PI control applied buck converter

### V. PROPOSED SYSTEM

Solar system consists of solar panels and step up, step down converters. Solar panel give voltage and current to MPPT algorithm. In MPPT algorithm adjust the duty cycle of PWM (pulse width modulation) which gives the switch (MOSFET) of step-down converter to adjust the voltage and current of converter. The system shown in fig. 5.1. below

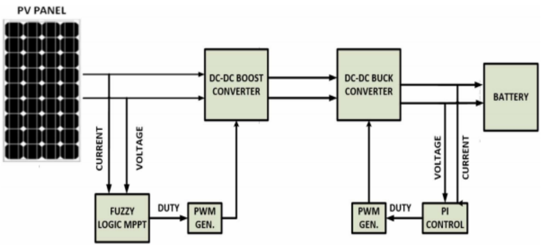


**Fig. 5.1**Solarsystem MPPT algorithm and PI control charge circuit.

After step up converter, step down converter used with PI controller because changing environmental condition voltage and current of solar panel changes constantly. For charging battery constant current and appropriate voltage required. PI controller gives the constant current and appropriate voltage to the battery load by regulating the step-down converter. PI controller easy to implemented and gives accurate results for this system.

### VI. Simulation results.

The simulation results are presented in this section the system was operated for four levels

Level 1: 1000 w/m2 and 20` C.
Level 2: 750 w/m2 and 20` C.
Level 3: 1000 w/m2 and 50`C.
Level 4: 750 w/m2 and 50`C.
The P-V curves of solar panel and maximum power point under variable temperature and irradiance are shown in fig.

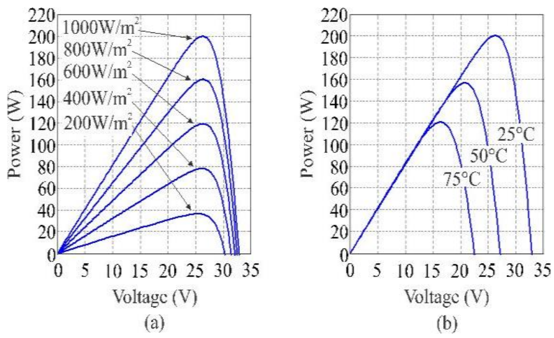


**Fig. 6.1.** (a) P-V characteristic variable irradiance (b) P-V characteristic variable temperature.

**Table 2**

voltage of buck converter, power of PV and current the power of MPP, accuracy of MPPT

| Levels | Vbuck | Ibuck | Pmpp | P(pv) | Accuracy |
|---|---|---|---|---|---|
| Level 1 | 15.12 | 2.940 | 85 W | 80.1 | 95.1% |
| Level 2 | 15.12 | 2.938 | 65W | 64.1 | 98.1% |
| Level 3 | 15.12 | 2.940 | 72.1 | 66.1 | 92.6% |
| Level 4 | 15.11 | 2.940 | 52.1 | 52.1 | 99.1% |

The proposed system constructed in MATLAB /Simulink is shown in fig. 6.2.

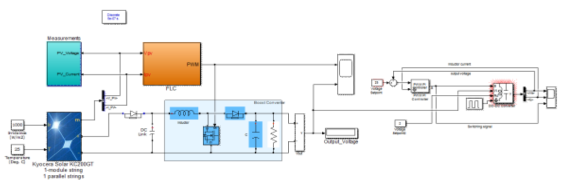

**Fig.6.2.**simulation diagram.

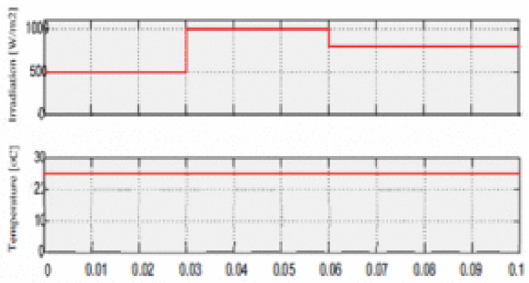

**Fig. 6.3.**Changing the solar irradiation and temperature.

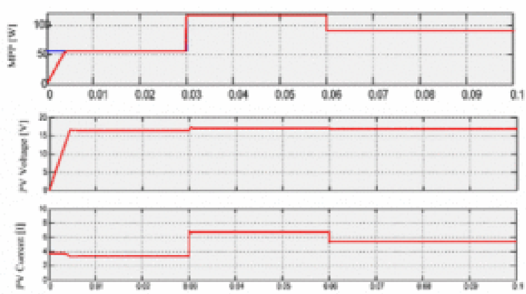

**Fig. 6.4.** Performance of fuzzy logic method.

## VII.CONCLUSION

The system is study under four different levels. By changing radiation and temperature responses of system observe. The efficiency of solar panel increases more effectively than previous one. The load voltage and current of step-down converter not change until end time of system (2.940A, 15.12V). PI controller more effectively regulate the output voltage and current of step-down converter. This system getting maximum efficiency from the solar panel, to reduce the cost and to charge the battery with constant current and correct voltage level to reduce losses, fast charge, and increase the life cycle of battery. This system used in real life application to increase the efficiency of solar panels and charging the battery load in less time.

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