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DESIGN AND OPERATION FUZZY LOGIC BASED MPPT CONTROLLER UNDER AMBITIOUS CONDITION

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ABSTRACT

PV systems must use the Maximum Power Point Tracking System (MPPT) to maximise the efficiency of solar cells. There are numerous strategies that have been suggested to get the most voltage possible out of PV modules in a variety of climates. The P & O algorithm was suggested as a clever technique in this research for maximum power point tracking. A PV module coupled to a DC-to-DC boost converter is part of the model. The PV system is tested using sun radiation and temperature fluctuations. The simulation results demonstrate that the maximum power tracker could successfully and accurately track the maximum power under all test scenarios. The P&O Method can be used to measure the voltage, current, and power of the Module. This approach to raising the voltage Pv module proposes a fuzzy logic-based Mppt controller. When there is a change in the voltage and current across the PV panel, the proposed technique uses fuzzy logic-based controlled (FLC) to start the control command to the output buck-boost converter. With the aid of MATLAB/SIMULINK, the FLC-based MPPT controller is modelled for the PV module.

1. INTRODUCTION

Not only does energy impact our daily lives, but it also has a significant impact on the national economy. Because of the industrial revolution, our everyday needs for energy are growing. The majority of energy generation in a growing nation like India relies primarily on non-renewable energy sources. The progressive depletion of natural resources, including fossil fuels, oils, and other energy sources, is causing civilisation in developing nations to become unsustainable. Moreover, the production of energy from conventional sources contributes to greenhouse gas emissions. To assure reliable, affordable, and clean energy, it has become a global issue to minimise the emission of greenhouse gases like CO2 and CO3. In contrast, renewable energy sources are the best way to produce clean and sustainable energy [3]. Solar, wind, hydro, and other renewable energy sources are only a few examples. The most effective renewable energy source that has drawn the attention of researchers is the photovoltaic (PV) system. Because there are no moving parts, solar energy produces no noise and is clean, pollution-free, maintenance-free, and noiseless [1, 3]. However, the use of solar energy is constrained by two significant considerations. installation costs and insufficient energy conversion efficiency. The maximum power point tracking system (MPPT) of photovoltaic modules is one of the most efficient ways to boost the efficiency of the photovoltaic power system and gain control over these parameters, which include the cost of solar system installation. To boost the PV module's efficiency, MPPT is utilised to extract the most power from it and deliver it to the load [1, 2, and 5]. The output power of PV modules can be increased using a variety of methods. Constant voltage tracking is one of the techniques. This approach continually adjusts the duty cycle of the DC-DC converter to run the PV module at the predefined point near to the MPPT by comparing the measured PV module voltage with a reference voltage.

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The CVT (Constant Voltage Tracking) Technique is quite straightforward. It can keep track of the maximum power point even in a hazy situation. The P&O (Perturbation and Observation) Method is an alternative technique for determining the PV module's maximum power point. The P&O Method can be used to measure the voltage, current, and power of the Module. The voltage is then jerked in order to shift towards the maximum voltage. This approach exhibits strong oscillations around the MPPT as well as a slow tracking speed [2, 4, and 6]. In order to achieve maximum power point tracking, a new method-based MPPT controller is presented in this study.

2. CHARACTERISTICS OF SOLAR MODULE

It is necessary to comprehend the properties of a solar module in order to develop a PV panel. The model characteristic of the module is described by an electrical equivalent circuit. There are two forms of resistance in the solar cell. The first is parallel resistance, while the second is series resistance [7, 8]. The losses in the current path caused by the metal grid and current connecting bus are linked to the resistance in series. The second resistance, or parallel resistance, is used to reflect the slight current leakage across the p-n junction caused by the resistive route. The equivalent circuit flow of a PV cell is depicted in Fig. 1.

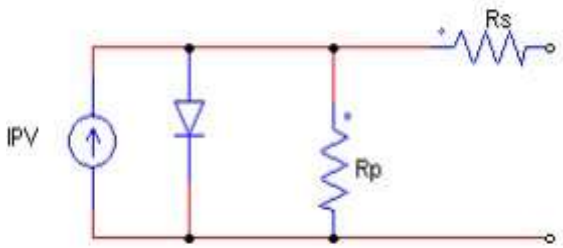

Fig. 1 Equivalent Circuit of PV Cell.

Maximum Power(Pmax)	175.42W
The voltage at Pmax (Vmp)	35.8V
Current at Pmax (Imp)	4.9A
Open Circuit Voltage (Voc)	44.2V
Short Circuit Current (ISC)	5.4A
Temperature coefficient of Isc	-0.398 ± 0.113 %

Table.1. PV module parameters

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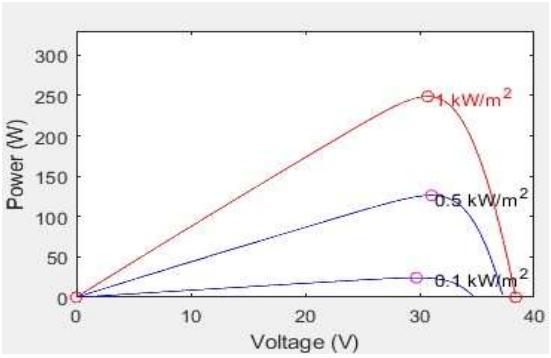

Fig. 2. P-V Curves under changing in Solar Radiations

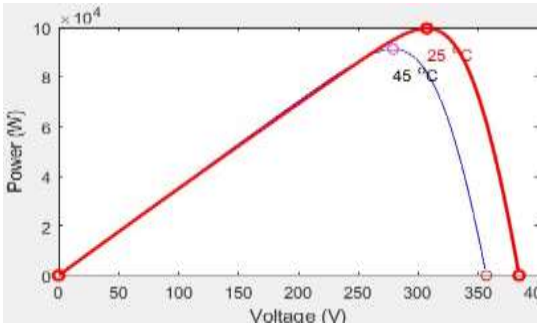

Fig.3 P-V curves under changes in Temperature.

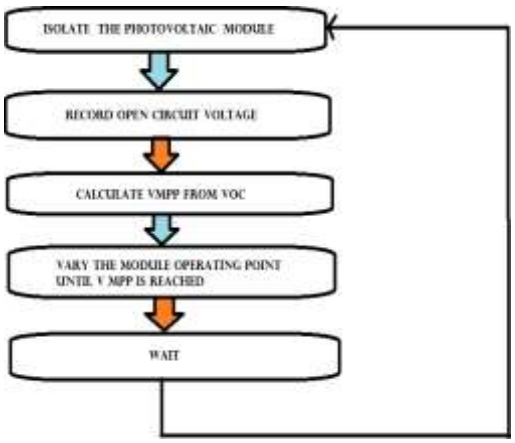

Fig.4. Open circuit voltage algorithm flowchart

3 DC TO DC BUCK -BOOST CONVERTER

Using DC to DC An electrical circuit called a buck-boost converter is used to convert one level of DC to another level. Several types of DC-to-DC converter exist. The most widely employed DC to DC converter is the Buck-Boost model. By adjusting the switch duty ratios, it is possible to step up or step down the DC-to-DC voltage.

the buck-boost converter's performance while operating in SMPS (Switching Mode Power Supply) Mode. When the duty ratio is less than 50%, the output voltage and vice versa are less than the input voltage.

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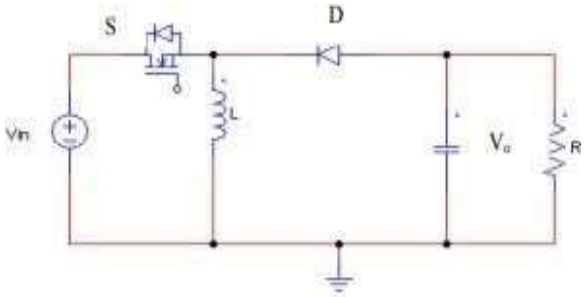

Fig.5 The Buck-Boost Converter.

3.1 OPERATION OF DC-TO-DC BUCK BOOST CONVERTER

The DC to DC Buck-Boost converter functions as follows: During the ON state of the T1 transistor. The diode is then in a non-conducting state due to reverse bias. During the 0 t DTS interval, the transistor T1's activation is investigated. The diode is in the conducting mode when the T1 transistor is switched off. It is renowned for operating in steady state. For a single switching cycle, the net charge in the current inductor should be zero. The transistor T1 is then checked during the DTS-tTS period when it is turned on [1].

4 MPPT [MAXIMUM POWER POINT TRACKING SYSTEM]

It is a method for increasing energy extraction when conditions change when utilised with variable power sources. The method can be utilised with a variety of energy sources, but is most used with photovoltaic (PV) solar systems. Different inverter systems, external grids, battery banks, and other electrical The main issue that MPPT attempts to solve is the fact that the efficiency of power generated by solar cells varies on the amount of sunlight, the amount of shade, the temperature of the solar panel, and the electrical characteristics of the load. The load characteristic that provides the maximum power transfer varies as these variables change. To maintain the best efficiency of power transfer as the load characteristic changes, the system is optimised.

4.1TYPES OF MPPT TECHNIQUES:

P & O (PERTURB AND OBSERVE) METHOD

Due to the fluctuation in PV module power, P&O is utilised to track the Maximum Power Point (MPP) of a PV system in mirror scale. The output power can be Compared to the prior output power while measuring it, and it is periodically measured. The same procedure is sometimes continued as power levels rise in order to prevent the P&O from going backwards.

The power of a PV module depends on the voltage and current; as they rise or fall, so does the power.

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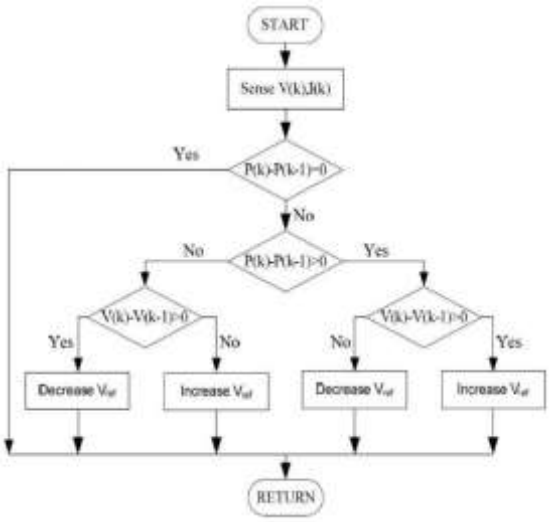

Fig.6. Flow chart of P&O method

4.2 FUZZY LOGIC CONTROLLER

Renewable energy resources have a wide range of applications for the Fuzzy Logic controllers (FLC). From the last decade, the requirement of FLC has been increased due to simplicity. FLC also deals with the imprecise input, which does not need any accurate mathematical model for the controller. FLC can easily handle nonlinearity conditions for obtaining the maximum power from PV Modules. It is capable of performing in any weather condition or any change in the temperature or irradiance level [8].

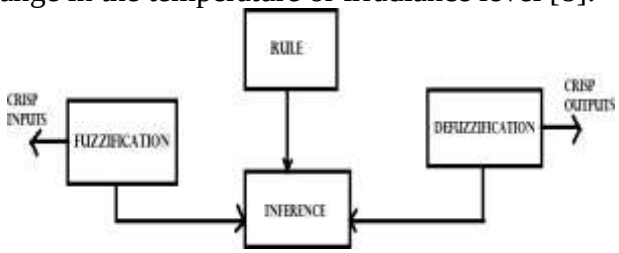

Fig.7. The Stages of Fuzzy Logic controller

Fuzzy logic controller process can be assorted into three categories: -
Fuzzification
Rule evaluation
Defuzzification

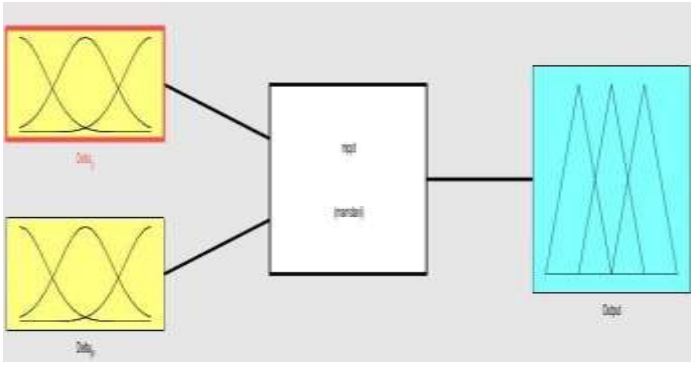

Fig.8. The FLC

FUZZIFICATION

The procedure of transforming a crisp input value into a fuzzy value using knowledge from the knowledge base.

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RULE EVALUATION

The input variable and output variable have been separated into several levels by the rule given to the MPPT block in FLC design: NB (Negative big), NS (Negative small), ZE (Zero), PB (Positive big), and PS (Positive small). With respect to sample time, the variables are provided to the sampling sequence. The Fuzzification method converts numerical input to a linguistic variable based on a membership function as it runs. When constructing the MPPT regulations, consideration is given to the fact that a change in voltage results in an increase in power. When there is an increase, the change is always moved in that direction; if there is a decline, the change is moved in the opposite direction. The membership function and rules were altered with the errors following the theoretical design in order to achieve the best performance.

ΔV \ ΔP	NB	NS	Z	PS	PB
NB	PB	PS	NB	NS	NS
NS	PS	PS	NB	NS	NS
Z	NS	NS	NS	PB	PB
PS	NS	PB	PS	NB	PB
PB	NB	NB	PB	PS	PB

Table.3. Rule-Based used in FLC

DEFUZZIFICATION:

The method of getting one number out of the output of the combined fuzzy set. It is used to convert the findings of fuzzy inference into a clear output. In other words, a decision-making algorithm that chooses the optimal crisp value based on a fuzzy set achieves defuzzification. The most straightforward but least effective defuzzification technique is to pick the set with the highest membership—in this case, "Add Pressure" because it has a 72% membership—ignore the others, and convert this 72% to some other value. This method has the drawback of information loss. In this instance, the rules that called for lowering or maintaining pressure might as well not have existed. Center of gravity defuzzification is a popular and practical method. The most straightforward but least effective defuzzification technique is to pick the set with the highest membership—in this case, "Add Pressure" because it has a 72% membership—ignore the others, and convert this 72% to some other value. This method has the drawback of information loss. In this instance, the rules that called for lowering or maintaining pressure might as well not have existed. Centre of gravity defuzzification is a popular and practical method. The outcomes of the rules must first be combined in some way.

5 MEMBERSHIP FUNCTION PLOTS

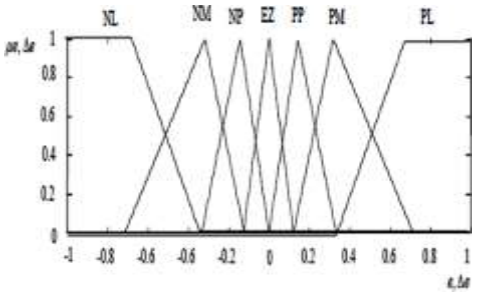

Fig.12. Membership functions for Input, Change in input, Output.

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CASE-1:

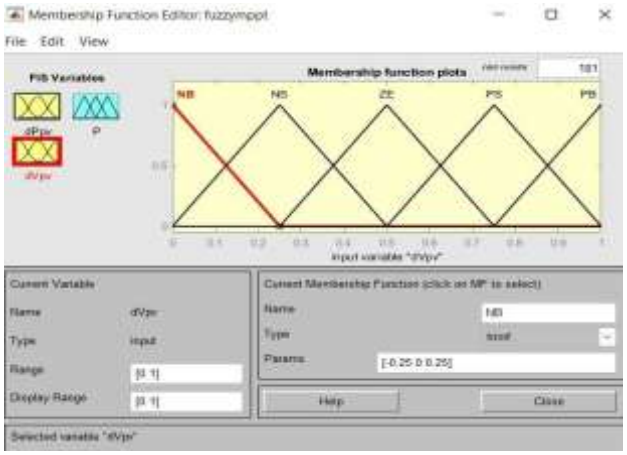

Fig:12.1- Input 1 [Change In Voltage-Membership Function Plots]

CASE -2:

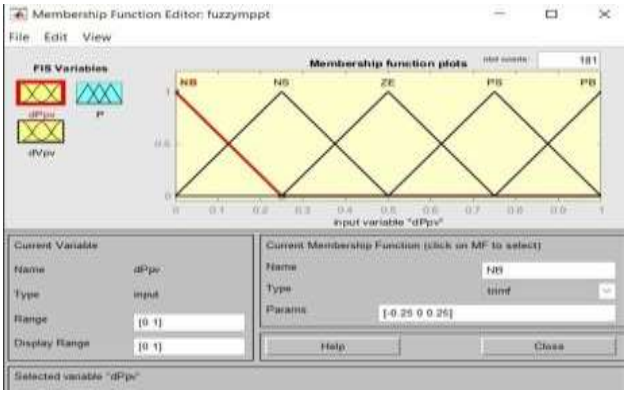

Fig:12.2.-Input 2 [Change InPower-Membership Function Plots]

CASE-OUTPUT:

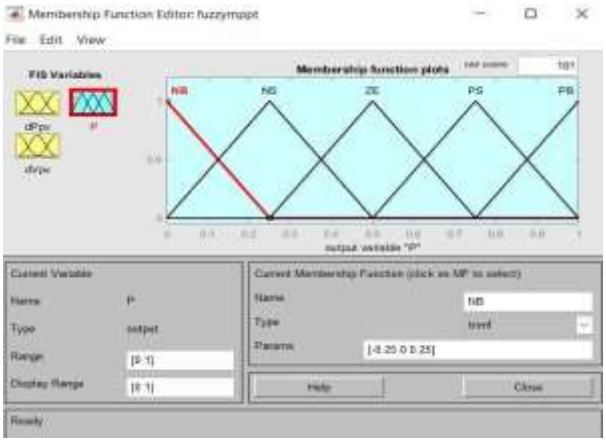

Fig:12.3.-Output-Membership Function Plots]

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6.SIMULATION RESULTS

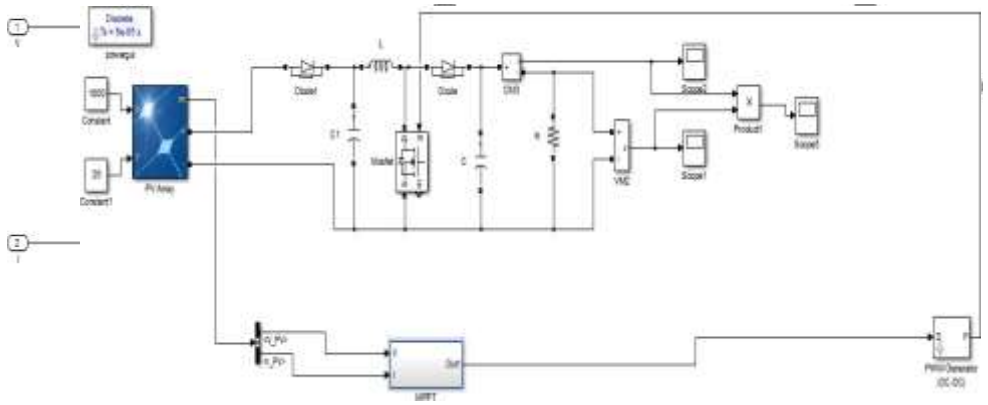

Fig.13. simulation circuit

OUTPUTS: POWER AND VOLTAGE

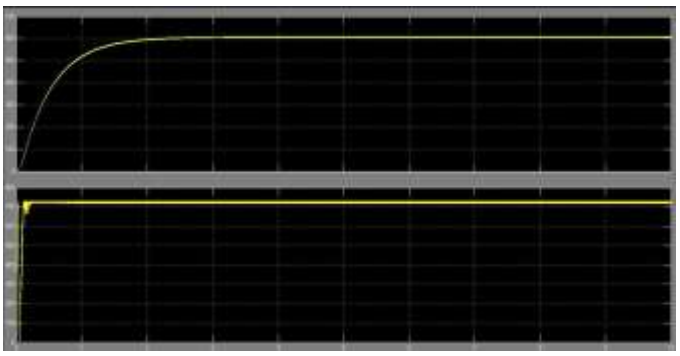

Fig.13.1: Power and Voltage Outputs

6.1 MPPT

Fig.14. maximum Power Point Tracking

The output of the Mppt controller is provided to the gate duty of the DC-to-DC buck-boost converter in this instance since it is based on the Simple P&O algorithm. giving the PV Module the input uncertainty signal. The model of the P&O technique is depicted in figure.15, which demonstrates that voltage and current serve as the method's inputs. The buck-boost converter's gate circuit is then supplied with the model's output. As can be observed, the output voltage and current of the solar module are 356 volts and 3.56 amps, respectively. This depends on the maximum uncertainty signal; the voltage and current are not set values but rather change based on the input to the PV Module. The DC-DC Buck-Boost converter, which houses the electric drive, is connected to the output of the PV module. Fuzzy Logic Based Mppt Controller provides the gate signal pulse to MOSFET. Under ambiguous circumstances, the controller is built to monitor the maximum power output from the PV Module. The temperature and irradiance level changes may be the uncertain situations. As the numerous

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input signals to the PV Module are contained in a signal block, which also provides the uncertainty. For easier comparison, the level of uncertainty for both methods is comparable.

SIMULATION OUTPUTS

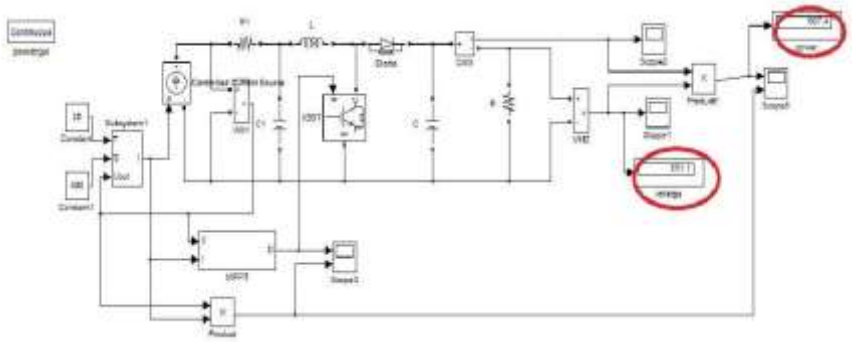

Fig.14.1. simulation output

Maximum power point tracking (MPPT) is an algorithm used in photovoltaic (PV) inverters to continuously adjust the impedance seen by the solar array in order to maintain the PV system's performance at, or relatively close to, the peak power point of the PV panels under varying conditions, such as changing solar irradiance, temperature, and load.

To maximise the electricity provided by PV systems, engineers who create solar inverters use MPPT algorithms. In order for the system to function at the "maximum power point" (or peak voltage) on the power voltage curve, as shown below, the algorithms control the voltage.

6.2 FUZZY LOGIC BASED MPPT CONTROLLER

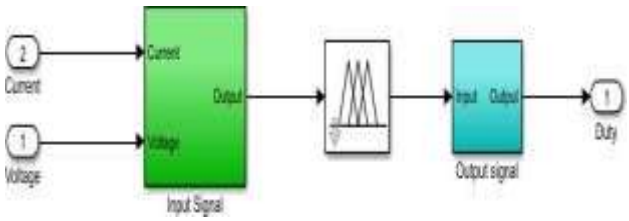

Fig.15. FLC based method

The recommended approach, the fuzzy logic-based Mppt Controller, is used in this instance. To achieve the best possible power point tracking in this scenario, the fuzzy logic controller is coupled to the Mppt controller's P&O algorithm. The membership file that is saved and the rules-based evaluation are both contained in the fuzzy logic controller. The DC-to-DC buck-boost converter receives the gate pulse from the output of the fuzzy logic Mppt controller. The output of the PV module in this instance is 356 volts and 3.56 amperes when the same PV module is utilised with the same uncertainty signal. this is depending on the Maximum uncertainty signal the voltage and current are not fixed it fluctuates with the input to the PV Module.

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6.3 SIMULATION CIRCUIT USING FUZZY LOGIC CONTROLLER

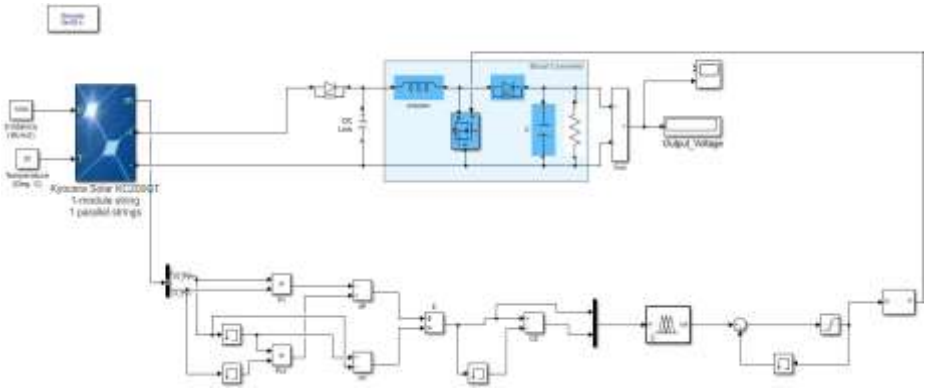

Fig.15.1. Fuzzy Logic Controller

Expert systems and process control employ fuzzy logic, a rule-based decision-making technique that simulates human rule-of-thumb reasoning. Fuzzy set theory, which was created by Lofty Zadeh in the 1960s, is the foundation of fuzzy logic.In contrast to conventional Boolean (or two-valued) set theory, fuzzy set theory permits partial membership in a set.

SIMULATION OUTPUTS

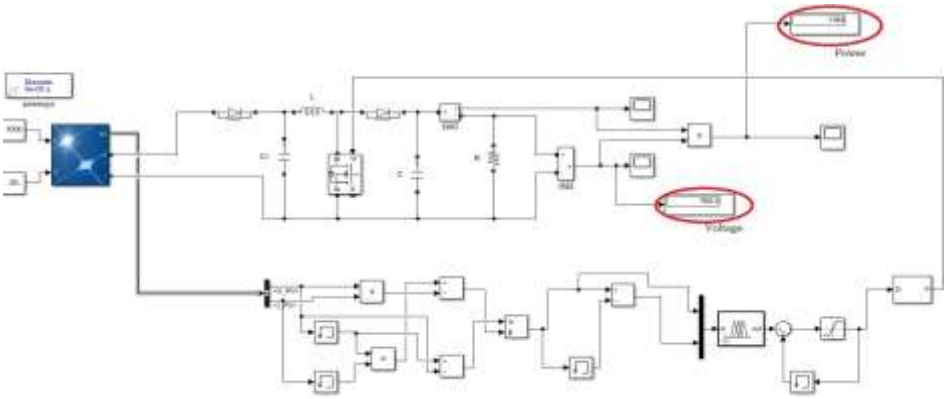

Fig.15.2. Simulation Outputs

6.4 SIMULATION CIRCUIT USING FUZZY LOGIC CONTROLLER

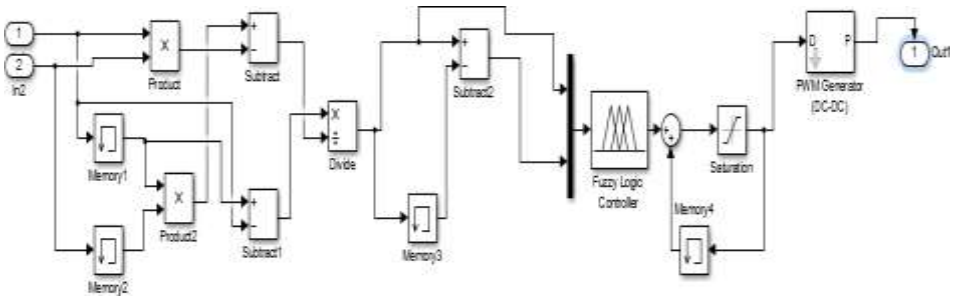

Fig.15.3. Simulation Circuit Using FLC

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VOLTAGE OUTPUT

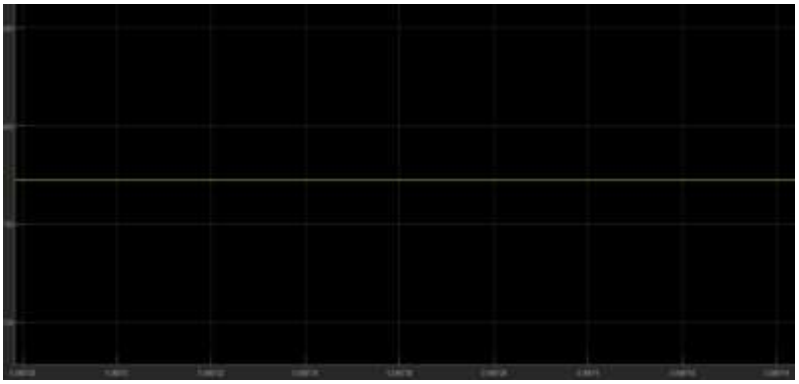

Fig15.4: Voltage output

POWER OUTPUT

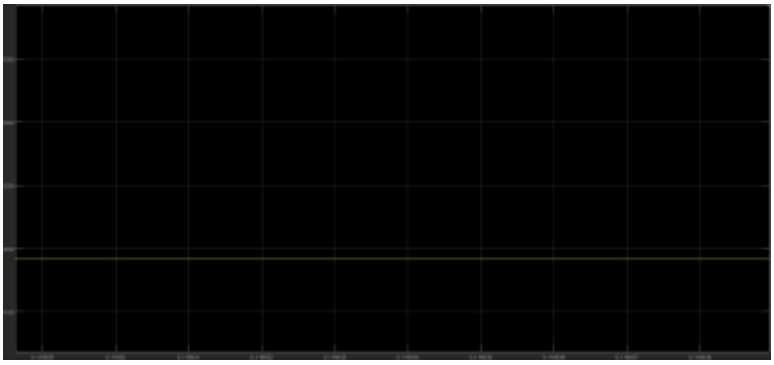

Fig15.5: Power output

7.CONCLUSION

This study has considered the design and use of a fuzzy logic-based MPPT controller in uncertain situations. Model development is carried out in MATLAB/SIMULINK. To control the output of the DC-DC boost converter, many researchers adopted the MPPT system based on the P&O algorithm. The FLC based MPPT system has been provided in this work, and the outcomes of the suggested model have then been compared to various traditional MPPT Methods.

The PV module is given the uncertain condition so that it can test the model in the uncertain conditions for both irradiance (solar radiation) and temperature. The output of the simulation demonstrates that, even in the face of uncertainty, the approach is still able to track the Highest power point. When compared to the traditional P&O Technique, it also offers a better responsiveness and less oscillation near the maximum power point. It was discovered that the proposed approach is more efficient than previous P&O-based MPPT Methods by comparing the effectiveness of tracking maximum power in PV Modules.

REFERENCES

[1] Ting-Chung Yu and Tang-Shiuan Chien, “Analysis and Simulation of Characteristics and Maximum Power Point Tracking for Photovoltaic Systems”, Proceedings of Power Electronics and Drive Systems Conference, pp. 1339 - 1344, Taipei, 2009.

[2] D. P. Hohm and M. E. Ropp, “Comparative Study of Maximum Power Point Tracking Algorithms using an experimental, programmable, maximum power point tracking testbed”, Proceedings of Photovoltaic Specialists Conference, pp. 1699 - 1702, USA,2000.

[3] Jancarle L. Dos Santos, Fernando L. M. Antunes, and Anis Chehab, "A Maximum Power Point Tracker for PV Systems Using a High-Performance Boost Converter", Solar Energy, Issue 7, Vol. 80, pp. 772- 778, 2005.
[4] Trishan Osram and Patrick L. Chapman, "Comparison of Photovoltaic Array Maximum Power Point Tracking Techniques", Energy Conversion, Issue 2, Vol. 22, pp. 439 - 449, May 2007.
[5] Roberto Faranda, Sonia Leva, "Energy Comparison of MPPT techniques for PV Systems", Wseas Transactions on Power System, Issue 6, Vol. 3, pp. 446- 455, June 2008.
[6] V. Salas, E. Olias, A. Barrado, A. Lazaro, "Review of The Maximum Power Point Tracking Algorithms for Stand-alone Photovoltaic Systems", Solar Energy Materials and Solar Cells, Issue 11, Vol. 90, pp. 1555- 1578, July 2008.
[7] Walker Geoff, " Evaluating MPPT Converter Topologies Using a Matlab PV Model ", Journal of Electrical & Electronics Engineering, Vol. 21, No. 1, pp. 49-55, 2011.
[8] C. Larbes, S.M. Aıt Cheikh*, T. Obeidi, A. Zerguerras, " Genetic algorithms optimized fuzzy logic control for the maximum power point tracking in the photovoltaic system", Renewable Energy, Vol. 34, Issue 19, pp. 2093-2100-55, 2009.
[9] Castañer, Luis & Santiago Silvestre "Modelling Photovoltaic Systems using PSpice", John Wiley & Sons Ltd, 2002.
[10] Tavares, Leite, Suemitsu, Bellar, " Performance evaluation of photovoltaic solar system with different MPPT methods", Proceedings of Industrial Electronics Conference, pp. 719-724, 2009.
[11] Mohan, Undeland and Robbins, "Power Electronics Converters, Applications and Design" Third Edition, 2003.
[12] Altin N, Ozdemir S. Three-phase three-level grid-interactive inverter with fuzzy logic based maximum power point tracking controller. Energy Convers Manag 2013;69:17e26.
[13] Ozdemir S, Altin N, Sefa I. Single-stage three-level grid-interactive MPPT inverter for PV systems. Energy Convers Manag 2014;80:561e72.
[14] Salas V, Olias E, Barrado A, Lazaro A. Review of the maximum power point tracking algorithms for stand-alone photovoltaic systems. Sol Energy Material Sol Cells 2006;90(11):1555e78.
[15] Osram T, Chapman PL. Comparison of photovoltaic array maximum power point tracking techniques. IEEE Transaction Energy Convers 2007;22(2):439e49.
[16] Khateb AE, Rahim NA, Selvaraj J, Uddin MN. Fuzzy-logic controller-based SEPIC converter for maximum power point tracking. IEEE Trans Industry Appl 2014;50(4):2349e58.
[17] Anurag A, Bal S, Sourav S, Nanda M. A review of maximum power-point tracking techniques for photovoltaic systems. Int J Sustain Energy 2016;35(5):478e501.