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REAL TIME SIMULATION BASED MPPT FOR HYBRID SYSTEM

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Abstract

The major challenge of non-conventional energy resources is their dependencies on changing environmental conditions. To fulfill the power requirements and resolve the challenge of varying ecological conditions, this paper proposed a hybrid non-conventional energy system containing a combination of sources like Photovoltaic (PV), Fuel Cell (FC) and battery systems working jointly to provide uninterrupted and maximum power. A lot of research is done to improve the system's efficiency by using the various maximum power point tracking (MPPT) algorithms. They perturb and observe (P&O) MPPT method and Fuzzy logic control techniques (FLC) have been used to compare the simulation model of PV with boost converters. The comparative results of MPPTs are shown with the help of MATLAB, where it is found that FLC control methods provide better results in terms of power, efficiency and tracking speed than the P&O MPPT control method.

1. Introduction

As we know that renewable energy sources such as photovoltaic (PV) and fuel cells (FC) are considered as prominent power sources due to recent advancement in the last decade. These sources are not only economical, pollution free and are available in abundance in nature. Apart from solar,

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wind energy, fuel cells, biomass and hydro power sources are also been used to increase generation as the power demand is being increased [1, 2]. The hybrid renewable energy system (HRES) contributes a meritorious chance for increasing continuous distributed power generation.

As in few studies of hybrid sources related to managing the power of power systems [3, 4]. Among them, Yashwant and Gupta proposed an energy management approach for an ac-linked hybrid FC/PV/wind energy system, While ahmed and omar has also presented an energy management strategy for a hybrid FC/PV/wind energy system with ultra-capacitor bank [5,6]. MPPT not only allows the growth in the extraction of power from the PV module to the load, it also improves the working period of the PV [7, 8, 9]. A few MPPT Techniques have been created and executed for PV systems. The rest of the paper is arranged as follows. In section I Overview of Maximum Power Point Tracking Techniques is explained, while in section II proposed Hybrid Renewable Energy System for continuous supply also hardware setup boost converter designing is being explained in section III, Simulation Analysis of fuzzy logic and Perturb and observe has been clarifying in section IV. In section V The author has proposed a simulation model of PV system with boost converter while the Results and Discussion are shown in graphical output and Concluding remarks are mentioned.

2. Overview of Maximum Power Point Tracking

MPPT techniques are usually combined with a sensor and DC-DC electric power converter system. It can be a boost (step–up) or buck (step–down) converter that provides voltage or current increase or decrease as required which is also regulated in transferring power to load. MPPT provides I-V characteristics of a solar PV system. The MPPT techniques provide maximum power at one point in a solar PV system. It can extract maximum power (PM) from the system, the maximum voltage (VM) and maximum current (IM) under given environmental conditions [10, 11]. The boost converter is used for the purpose to step up the voltage at desired level and modification in duty cycle is done to reach at maximum power point. The performance of MPPT techniques are based on following properties, like efficiency, response time, static and dynamic error, sensor etc.

3. Proposed Hybrid Renewable Energy System

The arrangement of the hybrid system is shown in Figure 1 the power generation subsystem includes a solar emulator, fuel cell and a battery. All three systems connected to a step up converter which converts DC voltage into the 120V output. In the proposed system solar emulator is used as main source and other two source fuel cell and battery is used for making hybrid system as well as backup as we know that solar is not constantly available every time therefore battery is used as a backup, if the solar radiation is absence and varying weather condition then the switch is move on the fuel cell or if the both device are unable to work then the sensor senses less than 24V then relay operated and makes the system to works on DC battery The voltage and current sensor are measure the input voltage and input current therefore this measured value is given to relay as well as arduino. The Relay provides a supply to step up converter and load. This switches the boost converter and improves the control behavior with the help of arduino to obtain a maximum power. In this paper a Perturb and observe MPPT Algorithm has been used for hardware by increasing the voltage manually from 0V to 80 V and sources give only constant DC voltage. We know that perturb and observe are very common and economic techniques but it has some drawbacks therefore other modified techniques like the fuzzy logic control techniques, neural network can be used in the future. The algorithm also improves the overall efficiency, required tracking time and overall stability. But due to the intensity of sun rays changes the perturb and observe techniques are mostly unsuccessful to trace the MPP due to the change of irradiation.

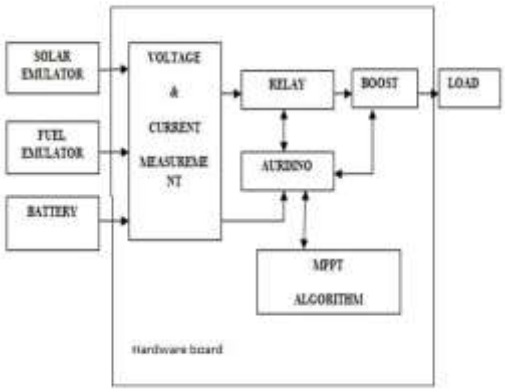

Figure 1. Layout of proposed hybrid system.

Different methods have been used to improve the efficiency of the system like fuzzy logic. The Artificial intelligence technique known as fuzzy logic controller here the result of both the MPPT techniques is compared. The proposed system was simulated in matlab 2016a.

4. Hardware Setup of Boost converter

The hardware setup consists of boost converter and implement the perturb and Observe MPPT Technique to increase efficiency and reliability of the systems shown in figure 2.

4.1 Design of Boost Converter. A DC-DC converter is used which increases voltage as well as decreases voltage. This depends on different applications. If voltage increase is required the converter is called boost converter and if voltage is decreased it is also known as buck converter. The converter is required as we know that the DC cannot be simply stepped up or down using a transformer. Hence the efficiency of PV system is performed

$$V_{out} = (1/1 - D) * V_{IN} \tag{1}$$

In this paper boost converter is designed for producing an output DC voltage of 120V from 80V and 24V this DC link by load and the MOSFET switch of this converter is controlled by pulse width modulation (PWM) technique. This PWM technique is controlled with ARDUINO as shown in figure 3. The parameter of boost converter in hardware as well as simulation model form as shown in table 1 and figure 2.

Table 1. Boost converter parameter.

ELEMENTS	VALUE
Resistance	100Ω
Inductor	1mHenry
Capacitor	120μF
Mosfet	IR740
Input Voltage	70V-80V DC
Diode	IN4007

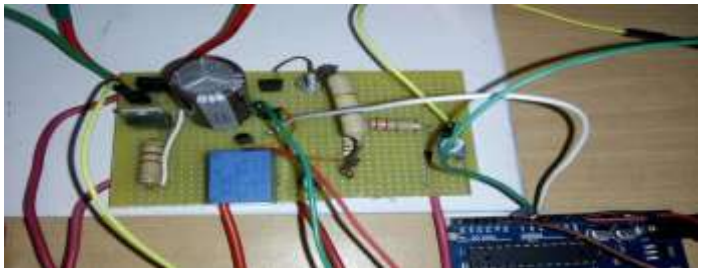

Figure 2. Hardware of boost converter.

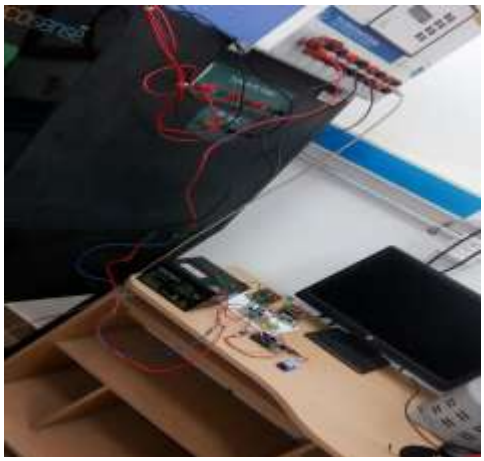

Figure 3. Hardware setup.

5. Simulation Analysis of Perturb and Observe and Fuzzy Logic

MPPT is a logical technique to continuously maintain the impedance of the system to keep the PV system operating at the maximum power in changeable environment conditions and load.

5.1 Perturb and Observe. Perturb and observe (P&O) is the simplest and it is easy to implement too. The algorithm is shown in figure 4 as shown below.

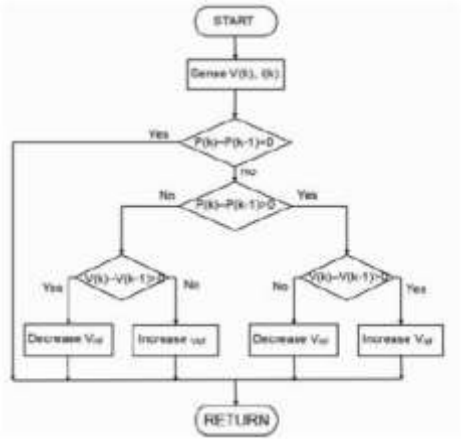

Figure 4. Algorithm of Perturb and observe MPPT Technique.

In this method the voltage and current is measured by the help of sensors from the PV panel while perturbing the voltage and comparing the power received and the previous value of voltage. If higher power was measured at new voltage the next perturbation will be in the same direction as the last otherwise move in opposite direction using the below eq2 and eq3 are used as mentioned below.

$$Dp(n)/dV(n) = P(n) - P(n-1)/V(n) - V(n-1) \tag{2}$$

$$P(n) = V(n) * I(n) \tag{3}$$

5.2 Fuzzy Logic Algorithm. Fuzzy logic is an artificial intelligence method used to find out the maximum power from the PV panel to Increase Efficiency. MPPT algorithm consists of three stages fuzzification, the rules, and defuzzification shown in figure 5.

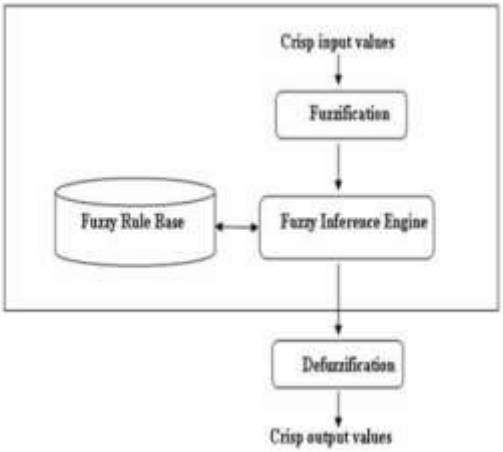

Figure 5. Stages of fuzzy logic.

For a few years Fuzzy logic based MPPTs have been vigorously in the research area of the solar system. As the concept of Fuzzy logic is achieved by linguisting which picks the behavior of human beings, Fuzzy logic does not require any complicated mathematical calculations, as the fuzzification is processed, the numerical input variable is converted into a fuzzy input through the different membership functions. The input variables error(E) and change of error (dE). Different types of input and output membership functions and the arrangement of logic of Fuzzy technique are shownin figure

6, figure 7 and figure 8 respectively. The different membership functions that are negative large(nl),negative medium(nmd), negative small(nsm), zero(zee), positive small(psm), positive medium(pmd), positive large (pla) have also been mentioned in table 2.

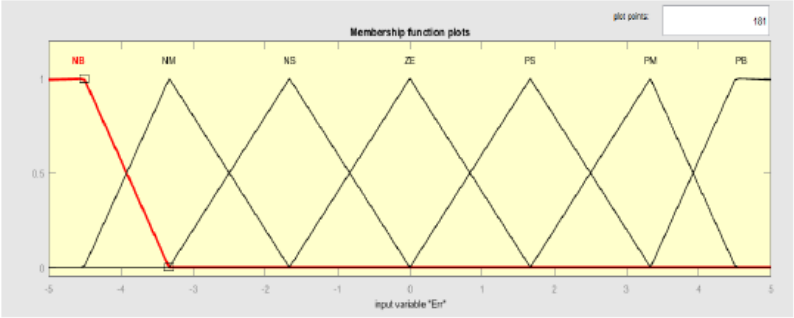

Figure 6. Membership function of input variables 1.

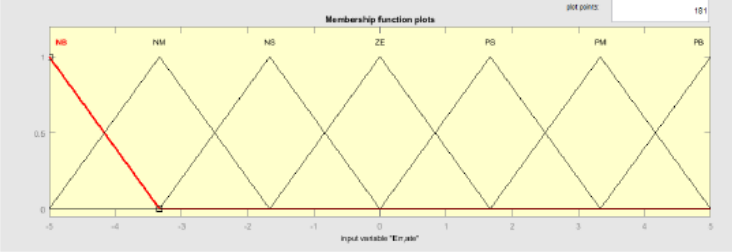

Figure 7. Membership function of input variables 2.

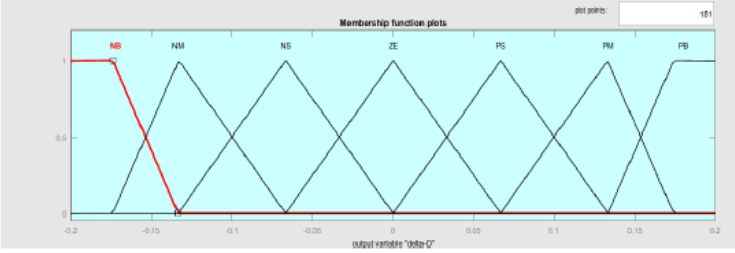

Figure 8. Membership function of output variables.

Table 2. Membership function.

E/C(E) \ Delta D	nlo	nmd	nsm	zee	psm	pmd	pla
nlo	vlo	vlo	mlo	bav	msm	vsm	vsm
nmd	vlo	mlo	aav	bav	bav	msm	vsm
nsm	mla	aav	aav	aav	bav	bav	vsm
zee	vsm	msm	aav	aav	aav	mlo	vla
psm	msm	bav	aav	aav	aav	aav	mla
pmd	vsm	msm	aav	aav	aav	mla	vla
pla	vsa	vsa	msa	mla	mla	vla	vla

6. Proposed Simulation Model of PV System with Boost Converter

The Author has used the simulation model of solar PV systems that were done in MATLAB 2016a software. This simulation model comprises a PV panel, MPPT Controller (fuzzy and P&O), boost converter. The used simulation model is given below figure 9 and figure 10. The voltage and current from the module keep varying with variation in irradiation and temperature. MPPT techniques are used to maximize power from the module .In order the required result they are connected in parallel. The parameters of PV shown in table 3.

Table 3. Parameters of photovoltaic module.

Parameters	Value
Peak Power	249 W
Voltage at Maximum Power	32.7V
Current at maximum power	7.6A
voltage at Open circuit	40V
current at Short circuit	8A
No of cell connected in series.	72
No of cell connected in parallel	1

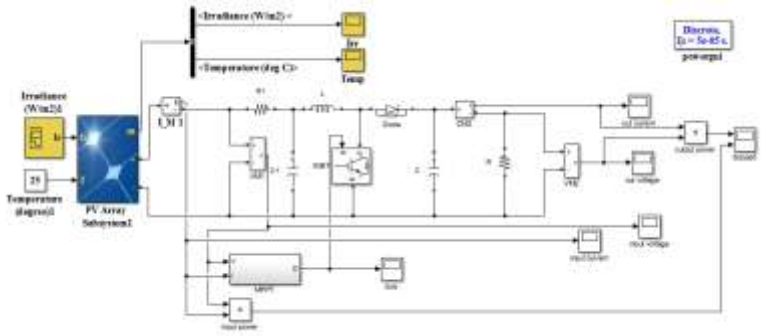

Figure 9. Simulation model of solar using Perturb and Observe technique.

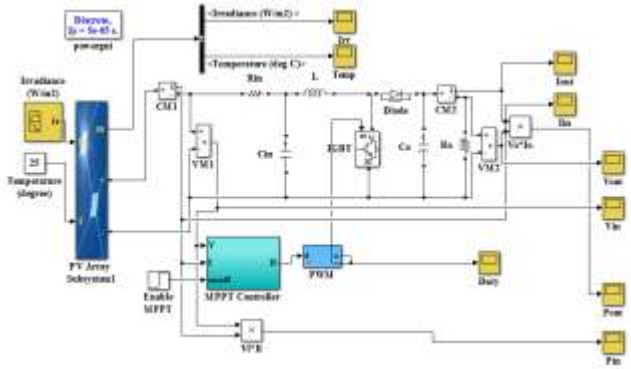

Figure 10. Simulation model of Solar PV with fuzzy logic control technique.

7. Results and Discussions

Case 1. (PV alone without MPPT).

In this case PV emulator source is used, in which DC supply is given to the boost converter and then to the load and the graph is plotted without MPPT as shown in figure 11. As the system starts, initially the voltage is zero and the value of voltage increases thus the power also increases and current decreases at last as the voltage reaches to the value of 80V and thus the power is obtained at 60V.

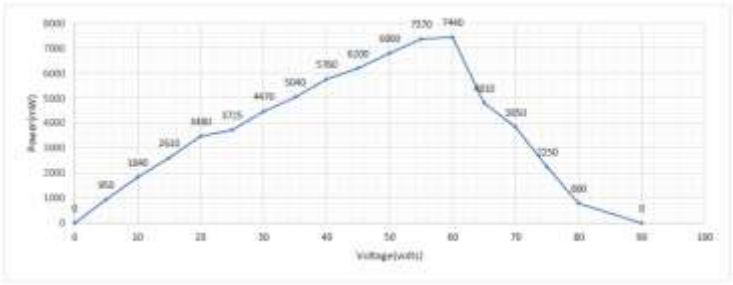

Figure 11. P-V Graph of without MPPT.

Case 2. (PV Emulator with MPPT).

In this case, supply is given from the solar module only but now MPPT algorithm perturb and observe algorithm is applied using the Arduino. A graph is obtained and analyzed with MPPT algorithm. Hence we analyzed that power is increased with MPPT algorithm and system efficiency and also achieved the more power at less time and less voltage value means tracking speed is also fast shown in figure 12.

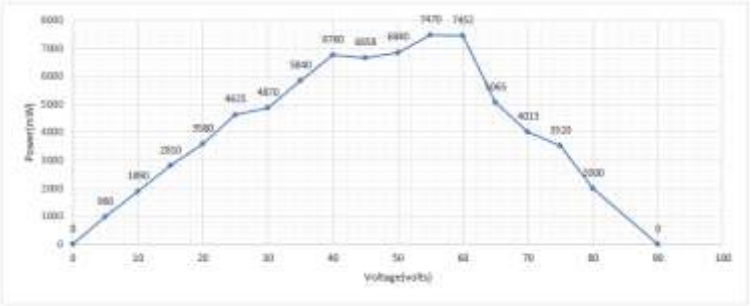

Figure 12. P-V Graph of with MPPT.

Case 3. (Battery).

In this case, supply is fed through a DC battery. This case is used as a back up when environmental conditions are not suitable. Then a DC supply is fed and output is obtained from DC load. A graph is obtained as we vary the battery voltage shown in figure 13.

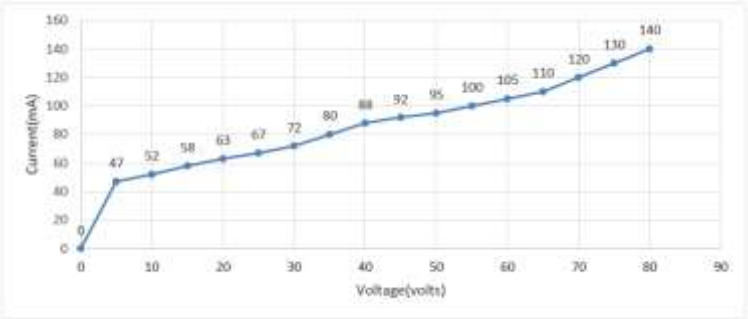

Figure 13. I-V Graph of Dc Battery.

Case 4. (Fuel Cell).

In this case, the fuel cell is used as backup when environmental conditions are not suitable as the solar power is varied by varying weather conditions and is used to provide a continuous power. Then a DC supply is fed and output is obtained from DC load. A graph is obtained as shown in figure 14. This situation occurs for bad weather condition shows the irradiance pattern with constant temperature 250C which is taken as fixed in simulation.

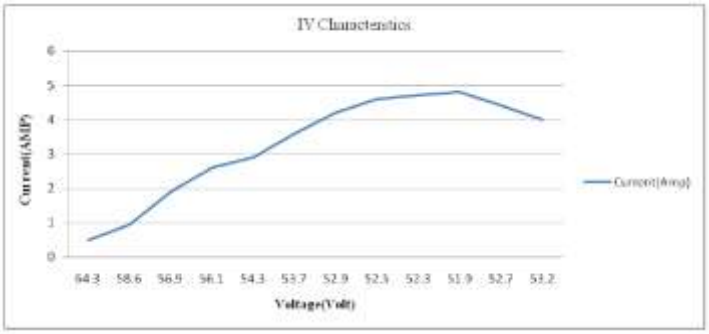

Figure 14. I-V Graph of Fuel Cell.

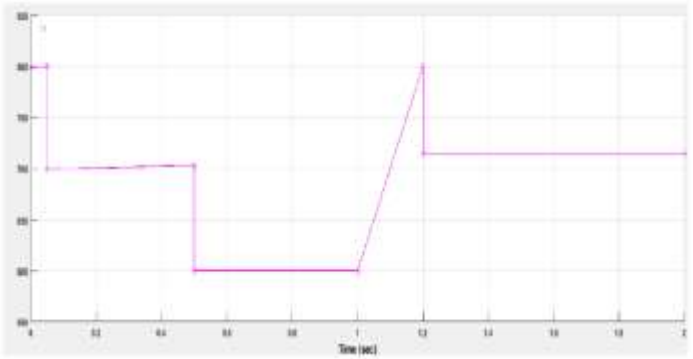

Figure 15. Irradiation pattern.

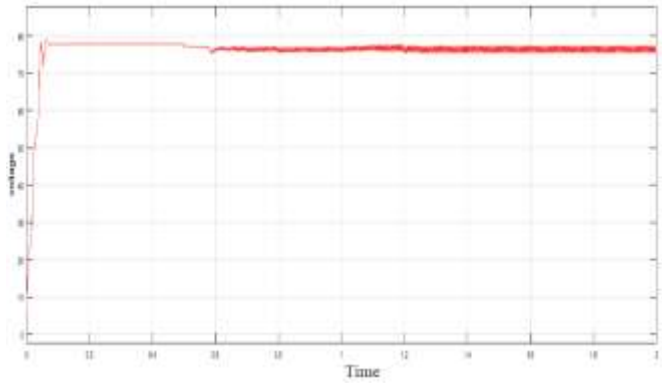

Figure 16. Output Voltage without MPPT.

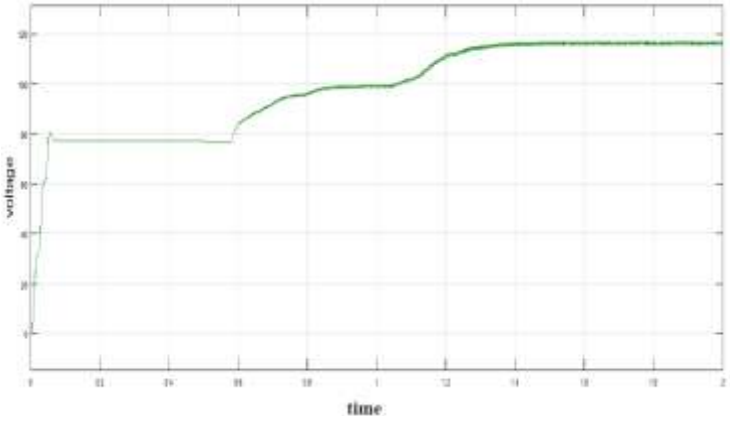

Figure 17. Output Voltage with P&O MPPT.

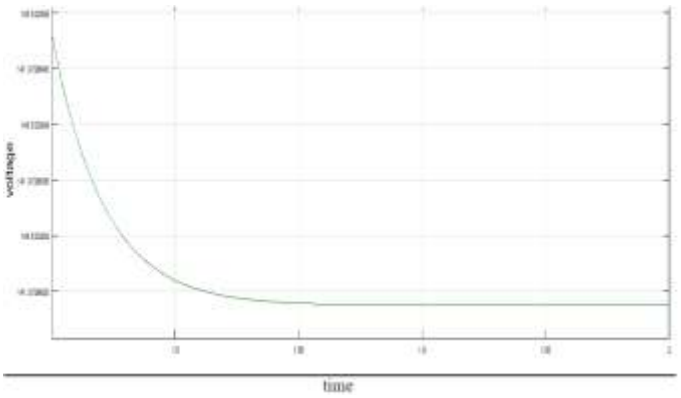

Figure 18. Output Voltage with Fuzzy MPPT.

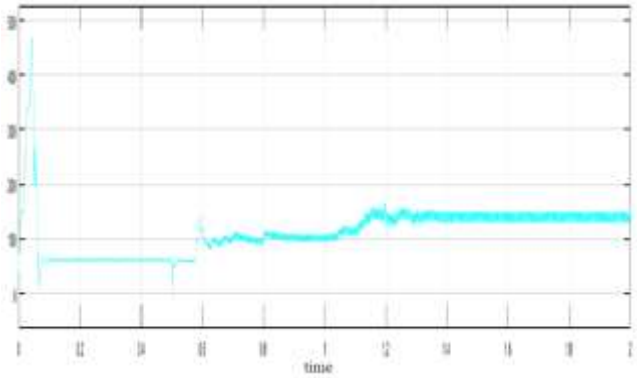

Figure 19. Power without P&O MPPT.

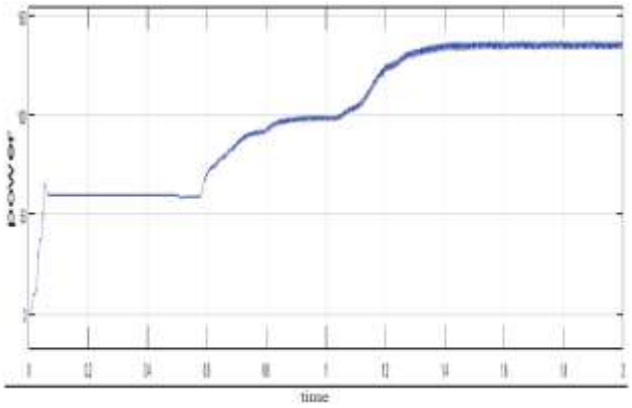

Figure 20. Power P&O MPPT.

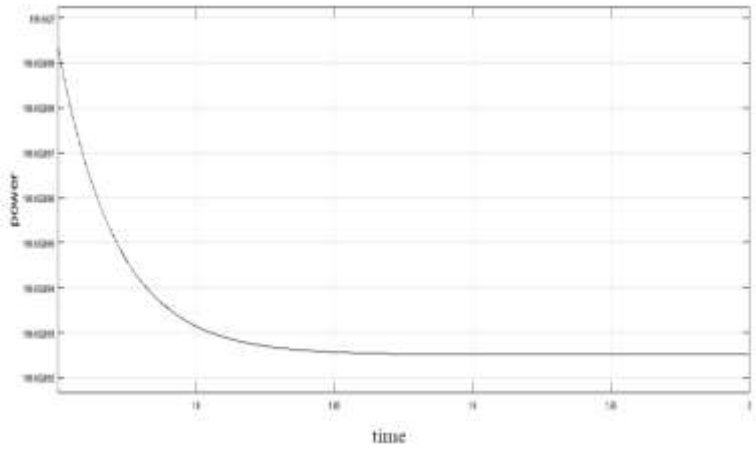

Figure 21. Power with Fuzzy MPPT.

8. Hardware Results

The relationship between input voltage and output voltage as shown below in table 4 as the efficiency and maximum power is increased by the using perturb and observe algorithm with less voltage and also the tracking speed is faster. The maximum power is obtained by the algorithm.

Table 4. Voltage Relation input and output (P&O).

Input Voltage	Output Voltage(P&O)
80V	120 V

9. Comparison Results

The proposed model is designed and simulated under MATLAB 2016 software. The figure 21 shows the graph of irradiations without MPPT, using P&O MPPT by using fuzzy MPPT as shown below figure 15, figure 16, figure 17, figure 18, figure 19, figure 20, figure 21. In the case of simulation the output voltage without MPPT is 80 volt when we use the P&O MPPT the output voltage reaches to 120V and when we use a fuzzy logic MPPT where as it reaches up to 141V and also the comparison given in table 5, table 6, and table 7.

Table 5. Comparison of Fuzzy and P&O.

MPPT Algorithm	P&O	FUZZY
speed of convergence	Low	Fast
Number of Sensor	Two	Two
Digital signal/Analog signal	Analog	Digital
Efficiency of Tracker	Medium	Very high

Table 6. Voltage Relation input and output (P&O and FL).

Input Voltage	Output Voltage(P&O)	Output Voltage(Fuzzy)
70-80	120 V	141 V

The efficiency of both MPPT is shown in table 7. The Input Power in case of P&O is 113 W and Output Power is 99W. Whereas in Fuzzy logic the input power is 212W and the Output Power is 199 W, Therefore the fuzzy logic technique is found better than P&O technique.

Table 7. Efficiency using MPPT Algorithm (Perturb & Observe and Fuzzy logic).

MPPT Algorithm	Tracking Efficiency (%)
Perturb and Observe	87
Fuzzy	93

10. Conclusions

In this paper the work is on diverse systems to obtain maximum power point in hybrid solar systems. The result is also discussed by using hardware setup. It is found that MPPT technique improves the efficiency of the proposed system. Whereas the analysis of the hybrid system is used to achieve higher power with uninterrupted power supply as compared to PV system which is distorted in nature as the solar energy not available every time, while the fuzzy logic techniques gives much better than the perturb and observe technique as shown in above table 7. Further research work can be done on optimizing MPPT to achieve more improve results.

Acknowledgements

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