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An Assessment Of The Implementation Of Mppt Algorithm For Pv Pumping Based On Perturb And Observe Logic (P&O) Controller

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Abstract

Solar cells convert solar light into electricity, but their major drawbacks include high initial costs, low photo conversion efficiency, and unreliable power generation. The maximum power point (MPP) of solar cells depends on solar insolation level and temperature, which causes the current-voltage characteristics to vary. Utilizing an MPPT technique to maximize the production of power from solar panels is among the most interesting areas of research in photovoltaic (PV) systems.The main parts of the PV system consist of PV panel, converter, controller and load. Converter and controller play a major role in the system. Controller is used to extract the maximum power from the PV panel. In this paper, a suitable converter topology to extract maximum power is suggested and performance of the converter is also tested with P&O fuzzy logic controller. The performance of the proposed controller and converter topology is appraised with conventional boost converter topology in terms of output power. It confirms that the proposed topology performed better than the conventional boost converter. The results show that the designed MPPT controller improves the efficiency of the PV panel when compared to conventional charge controllers.

Key words: PV panel, MPPT, Boost converter, Perturb & Observe (P&O), Fuzzy logic controller and fuzzy logic controller

1. Introduction

Global climate change and the energy crisis calls for more renewable electricity to be generated by solar cells, which poses a major concern for today's civilized world.Solar panels face two major challenges: low efficiency and intermittency, making solar one of the most important renewable energy resources in the world. Because solar is inexhaustible and environmentally friendly, it has been used for light, heat, and electricity.Stand-alone solar photovoltaic systems are most expensive when it comes to the PV modules and batteries. When the batteries are directly connected to the PV modules, they have no protection against overcharging, which decreases their life-span.Solar panels utilize PV cells to convert sunlight into electrical energy, which is one of the most cost-effective and energy-efficient methods for generating electrical energy.Researchers around the world are becoming increasingly interested in renewable energy sources, particularly solar cells that directly convert light into electricity.A PV output power measurement is conducted periodically and compared to the previous result.The literature suggests that solar technology has performed well across all green sources (GS).The solar power technology uses many solar cells connected in series and parallel to generate a large voltage as well as a large current.

Firstly the radiation of sunlight is incident on the solar panel and the semiconductor layer in the panel absorbs the incident light. The light has photons in it and these photons are responsible for energy in light. Photons transfer their energy to the electrons in the semiconductor and hence the electrons become excited. These electrons in their excited state travel in the cell and this movement of electrons results in the current. The current produced is DC and an inverter can be used to convert it into AC.

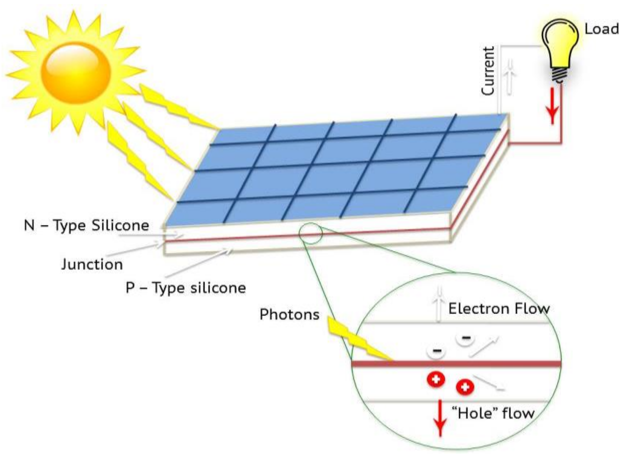

Fig.1.Modelling of PV panel

2. Literature Survey

PV cell is a device which converts light energy into electrical energy by using the principle of photoelectric effect. A solar PV cell mostly uses natural solar radiation as a light energy. A solar panel is a combination of individual solar PV cells combined in series or parallel combination. Solar panel can intake more light energy and hence gives maximum electrical energy.In [1] scaling MPPT algorithm is proposed. It has good dynamic response and efficiency irrespective of PV cells. Here OrCADPspice is used for system simulation.HairulNissahet al. [2] compared two most popular MPPT techniques Perturb & Observe method and Incremental Conductance method. Three converters buck, boost and cuk converters are connected to the controllers. One standard value of isolation and temperature is maintained through the entire simulation.

Roberto Faranda, Sonia Leva [3] proposed a paper for comparing the different MPPT techniques with their implementation and performance costs. Furthermore comparison is made by considering the cost of sensors, controllers and additional equipments. Analysis results along with hardware and computational costs shows that Perturb & Observe and Incremental Conductance methods have good performance in all aspects.

TrishanEsram, Patrick L. Chapman [4] compared different MPPT tracker techniques with different parameters. This compared MPPT tracker techniques are most commonly used one and are discussed, analyzed with their pros and cons. This paper gives a good idea for selecting proper techniques.

Weidong Xiao, Nathan Ozog et.al [5] shows the performance of PV modules under non ideal conditions. In order to minimize the performance of PV modules caused by non-ideal conditions, individual power interface is provided for each PV module.In [6] seven MPPT techniques are compared by varying the solar irradiation levels in relation to their energy performance. Results show that P & O method has higher efficiency.

MahlaghaMahdavi, Li Li et.al [7] compares fuzzy logic controller with the proposed Adaptive Neuro Fuzzy controller method. Adaptive Neuro Fuzzy Controller is the combination of FLC and artificial neural network. The proposed Adaptive Neuro Fuzzy controller method works better with buck-boost converter. This method is simpler to understand as it is a rule based system and can also be used for nonlinear systems.NanditaGarg, Er.Daljeetkaur et.al [8] proposed a system with adaptive Neuro Fuzzy to transfer the maximum power. The proposed system is compared with Incremental conductance method. This system is applied for multi junction solar cells to provide better efficiency.

In [9] most frequently used MPPT techniques are compared. This paper infers new technique which is better suited for the PV systems for extracting the maximum power point.Roberto F. Coelho, Filipe M. Concer et.al [10] compares the different DC-DC converters which are mainly used like buck, boost and buck-boost. Buck and boost converters are not suitable for maximum power point tracker systems, because these converters cannot ensure that operating point will match the maximum power point at changing weather conditions i.e.., solar irradiance and temperature.Soedibyo, Budi Amri et.al [11] compares different converters like buck-boost, sepic, cuk and zeta type converters. It is observed that tracking the maximum power point has better occurred in zeta type converter.From the papers considered, it is observed that there are different types of controllers and converters which are used for extracting the maximum power from the PV panel. So in order to reduce the ambiguity between these topologies, four different cases are compared.

3. Propose Methodology

3.1Conventional Boost Converter

Generally converters are mainly used for converting one form of power to another form. A boost converter is a DC-DC converter preferred in the cases where used for increasing the voltage.

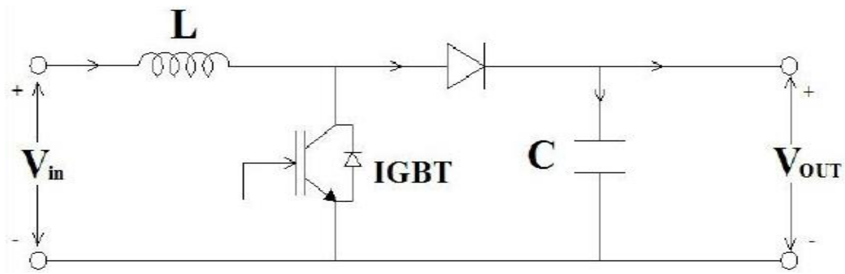

Fig.2. circuit diagram for Boost Converter

The circuit diagram shown above for boost converter consists of Inductor 'L', capacitor 'C' diode 'D', switch 'S' i.e.., IGBT and load. The function of capacitor is to keep the load voltage constant. The inductor stores energy and releases when required. If the output voltage V_0 is greater than V_s, it is called as boost converter. The simplest type of switch mode converter is boost converter.

When the switch 'S' is ON, inductor 'L' stores energy. When the switch 'S' is OFF, the inductor current cannot die down instantaneously as it opposes the sudden changes in current. Therefore, inductor current flows to load through diode 'D'. As the current decreases, the polarity of emf induced in 'L' changes and as a result voltage across the load exceeds the source voltage V_s.

3.2 Operation of Proposed DC-DC Boost Converter

The proposed DC-DC converter is also a type of Boost converter.

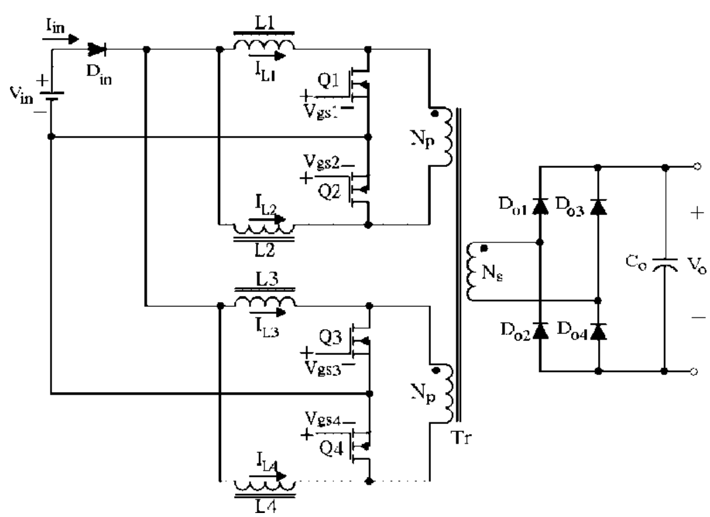

Fig.3. Circuit Diagram for proposed DC-DC converter

3.4 The proposed DC-DC converter operates in four modes

First in Mode I, switches Q_1 and Q_3 are in ON condition. Inductor currents $I_{L1}$and I_{L3} flows to voltage source. The current in the inductor I_{L2} flows to first primary winding of transformer and I_{L4} flows to second primary winding of transformer.

In Mode II, with switches Q_1 and Q_3 open, the power switches Q_2 and Q_4 are turned ON with soft switching feature because the transformer leakage inductance serves as a snubber inductor for the ON switches.

Now all the four switches Q_1-Q_4 are in ON state. The current through the Inductors I_{L1} and I_{L3} increases linearly and flows back to voltage source (V_{in}) through the switches Q_1 and Q_3. Also the current through the Inductors I_{L2} and I_{L4} increases and flows back to voltage source (V_{in}) through the switches Q_2 and Q_4.

In Mode III, Q_1 and Q_3 are kept in OFF condition. Q_2 and Q_4 are in ON state. The Inductor currents I_{L2} an I_{L4} flows to voltage source through the switches Q_2 and Q_4. The current in the inductor I_{L4} flows to first primary winding and I_{L3} flows to second primary winding of transformer. The current through the switches Q_2 and Q_4 increases linearly and flows to voltage source (V_{in}). Now the energy from source to load is transferred through rectifying diodes D_1 and D_4.

Mode IV is similar to that of Mode II. In this mode, all the power switches are in ON condition. The leakage inductors have surviving energy in them and through the transformer this surviving energy is delivered to the load. Gradually, the current in the transformer secondary winding becomes zero after surviving complete energy. Hence all the diodes (D_1-D_4) become OFF and now capacitor C_0 supplies the power to the load. This makes the voltage across the two primary windings to zero during this overlapping period. Hence it can be observed that soft switching is obtained when Q_2 and Q_4 are turned OFF. This constitutes of one operating cycle proceed back to Mode I.

4. Fuzzy logic controller

Fuzzy logic control is a heuristic approach that easily embeds the knowledge and key elements of human thinking in the design of nonlinear controllers. Fuzzy logic controllers are used because of its simplicity and for increasing the power. It takes the values between 0 and 1. FLC involves mainly three steps:

1. Fuzzification: In Fuzzification, fuzzier is used to convert crisp inputs into fuzzy inputs.
2. Rule Evaluation: In this step, some rules are framed by the designer depending on membership functions. Based on these rules, controller automatically sets the fuzzy output.
3. Defuzzification: Defuzzifier converts fuzzy values to crisp values.

5. Pertur&Observe (P&O) Method

P&O method is used for tracking the MPP. In this technique, a minor perturbation is introduced to, cause the power variation of the PV module. The PV output power is periodically measured and compared with the previous power.P&O method is an MPPT technique and is used to track the maximum power from the PV panel. This algorithm uses simple input arrangements and small parameters calculated. In this method, the voltage of the module is perturbed regularly and the resulting output power is compared to that of previously disturbing cycle. Within this algorithm, this method is implemented with a minor perturbation. This disruption is affecting the power of specific solar cell. If the perturbation raises the power then the perturbation proceeds in the same direction. Once the peak output is reached the output of MPP is zero and next instant decreases and the disturbance decreases.

6. Results & Discussion

a. Simulink diagram for Boost Converter with Fuzzy Logic Controller

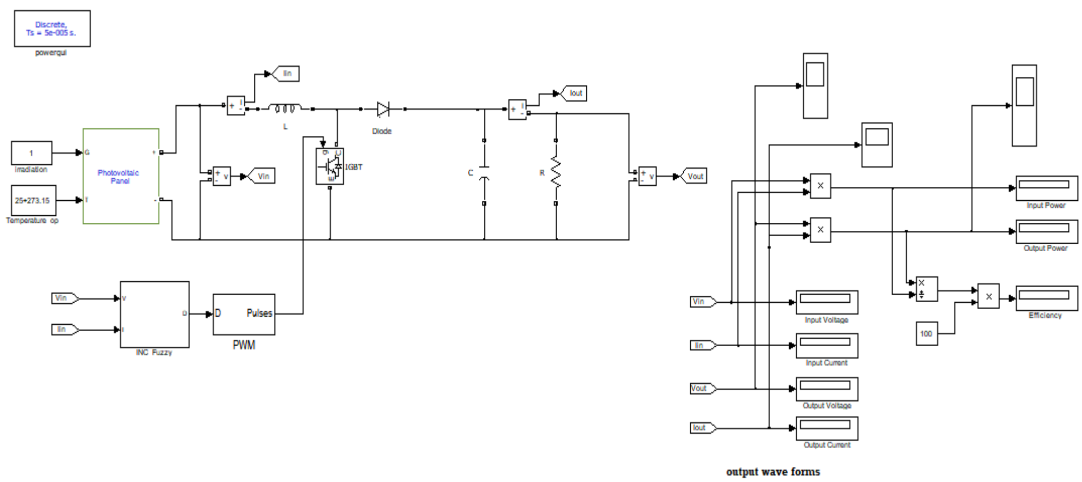

Fig.4 Circuit Model for Boost Converter with FLC

b. Output Power for Boost Converter with FLC

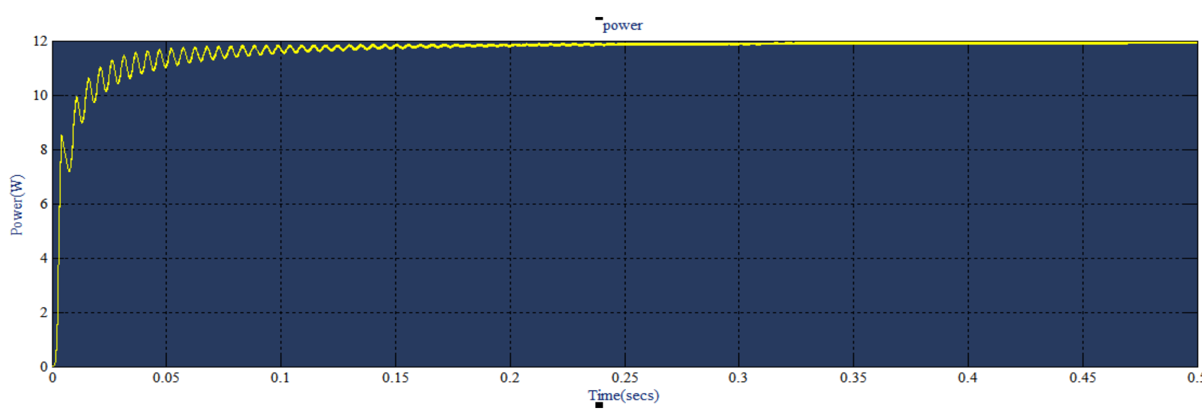

Fig. 5 output power for Boost Converter with FLC

c. Simulink Diagram for Boost Converter with P&O method

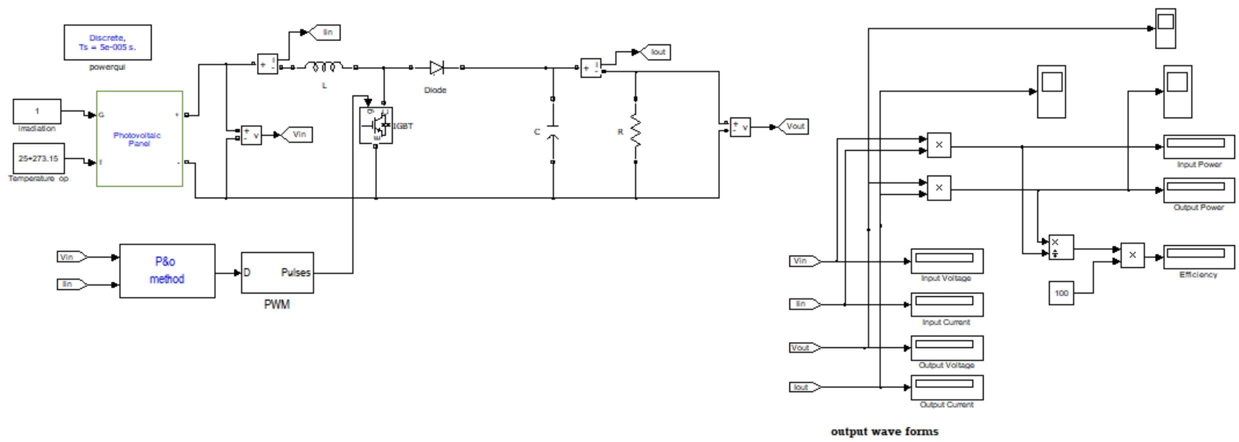

Fig.6. Circuit Model for Boost Converter with P&O method

d. Output Power for Boost Converter with P&O method:

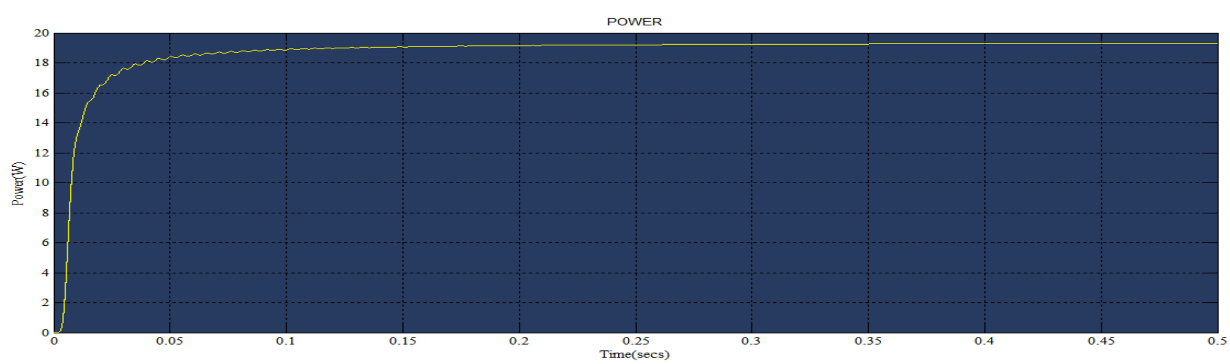

Fig.7. Output Power for Boost Converter with P&O

e. Simulink model for Proposed Converter with FLC

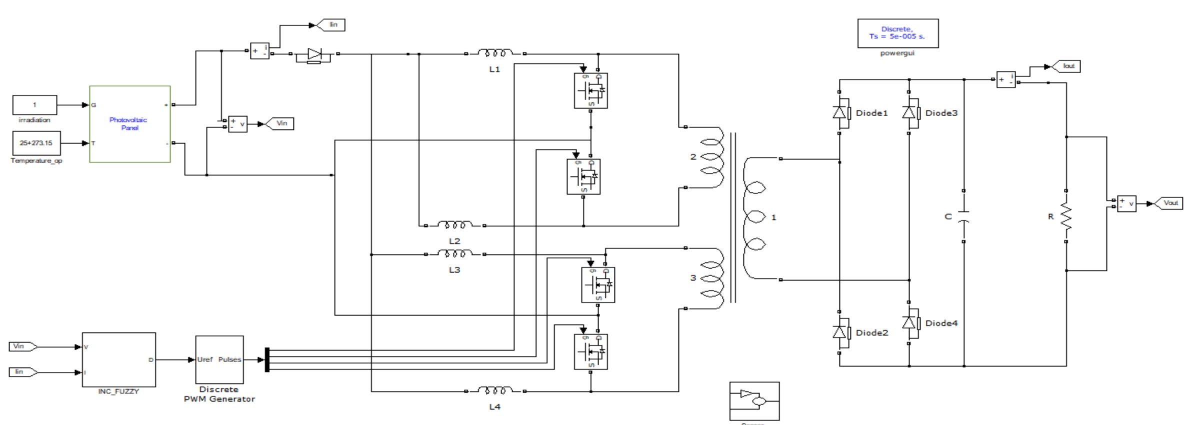

Fig.8. Circuit Model for proposed converter with FLC

f. Output Power for Proposed Converter with FLC

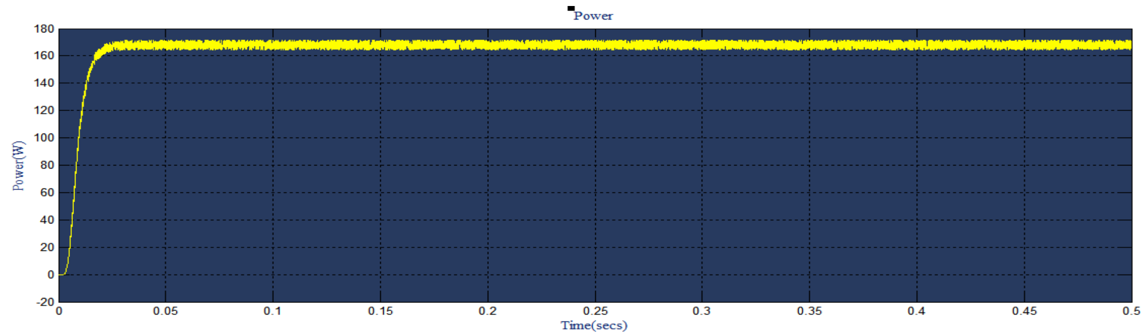

Fig.9. Output Power for proposed converter with FLC

g. Simulink model for Proposed Converter with P&O

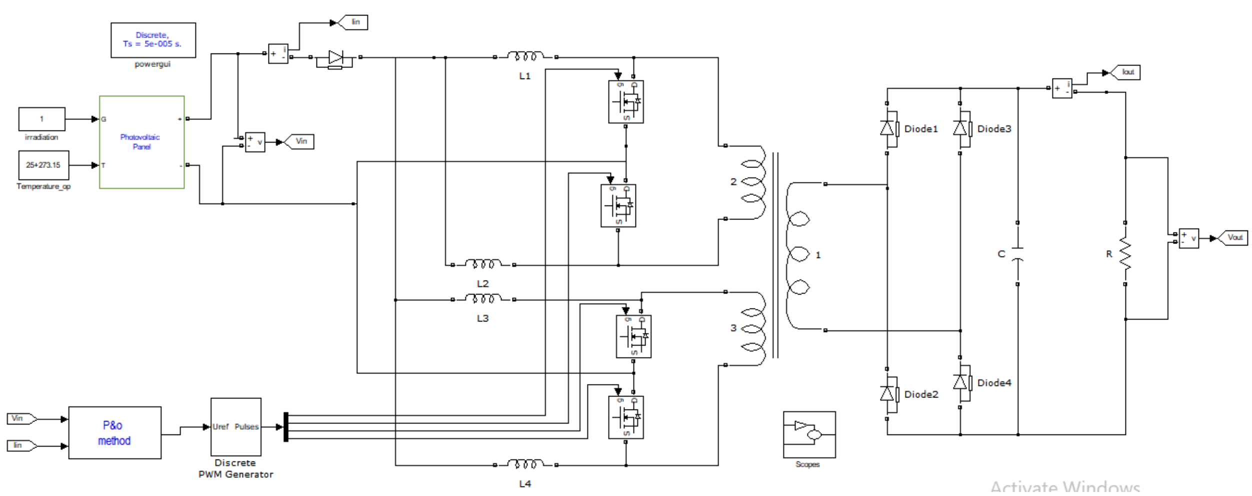

Fig.10. Circuit Model for proposed converter with P&O

h. Output power for Proposed Converter with P&O

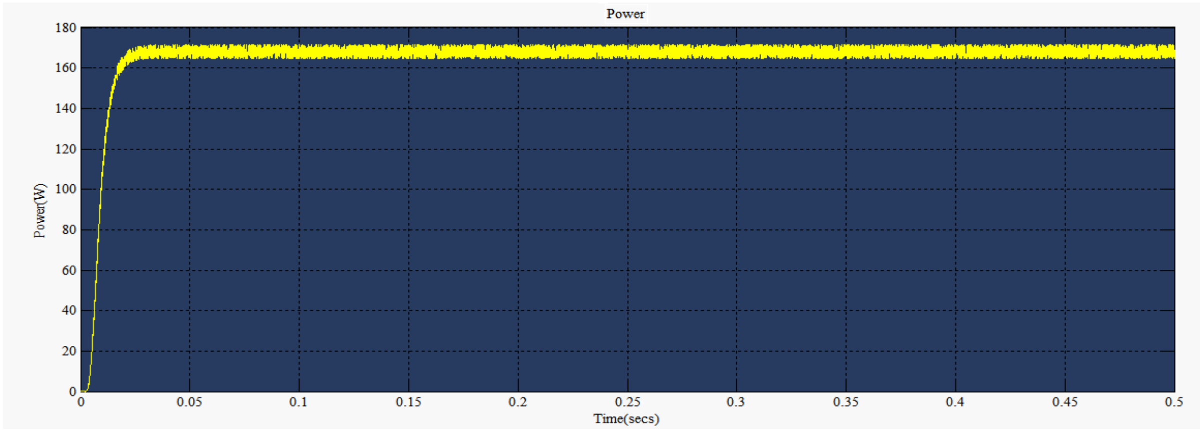

Fig.11. Output Power for Proposed Converter with P&O

Table-1: Comparison between different Topologies

Topologies	V_{in} (V)	I_{in}(A)	P_{in}(W)	$V_{o/p}$(V)	$I_{o/p}$(A)	$P_{o/p}$(W)
Conventional converter with FLC	12.08	1.03	12.44	24.6	0.485	11.93
Conventional converter with P&O	8.5	2.5	21.25	31.30	0.622	19.3
Proposed converter with FLC	12.08	2.932	59.94	35.42	2.785	166.9
Proposed converter with P&O	12.11	2.94	35.61	60.17	2.94	171

7. Conclusion

The presented work is a detailed modeling and simulation of the PV cell and module. Managing the maximum power point (MPPT) is important in photovoltaic (PV) power systems since they maximize a PV system's power output for a given set of conditions and therefore maximize their array efficiency. Four different cases are considered and it is observed that ppower has been increased for the proposed system when compared with parameters like output voltage, output current and output power.Future work can be done on this paper for reducing the cost and reducing the THD.This modification of the conventional algorithm reduces the complexity and improves the performance of the conventional algorithm due to limiting the search space of the algorithm. The proposed Perturb and Observe algorithm applies to uniform or varying weather conditions.Perturb and Observe for standalone solar photovoltaic systems was improved by eliminating steady state oscillations about maximum power point and by reducing the step response.

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