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Comparative Analysis of Intelligent MPPT Techniques Using Artificial Neural Networks and Cuckoo Search Algorithms for Partially Shaded PV Systems

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Abstract

Solar photovoltaic (PV) systems have drawn a lot of interest lately as a practical and sustainable renewable energy source. Partial shadowing, on the other hand, can significantly impact PV system performance by causing a discrepancy in the power output of individual solar modules. Algorithms for Maximum Power Point Tracking (MPPT) are essential for maximizing the energy extracted from PV systems. The goal of this study is to compare the Cuckoo Search method to Artificial Neural Network method used for maximum power point tracking. The CSA is renowned for its capacity to identify the global optimum of a particular problem and was inspired by the foraging habits of cuckoo birds. The algorithm CSA is marked by extraordinary effectiveness, ensuring prompt convergence along with increased efficiency. ANN has attracted much attention in photovoltaic systems because of its multi-functionality. They are good candidates for MPP tracking because of their ability to predict unknown parameters. A number of criteria, including tracking speed, accuracy, convergence rate, and robustness, are used to evaluate performance. The outcomes shows the comparison ANN andCSA algorithms in terms of accuracy and efficiency. The results of this work

expand MPPT approaches toimprove solar PV systems' energy extraction efficiency, especially in difficult partial shadow situations.

Keywords

Renewable Energy, Photovoltaic System, Cuckoo Search Algorithm, Artificial Neural Network, Maximum Power Point Techniques.

Introduction

Sun is a huge source of energy from which a very negligible portion is used by the earth's eco-system and atmospheric condition. Utilizing this solar energy for harvesting electrical energy can be a reliable low carbon emission alternative. It is observed from the graph that coal and natural gases are the highest CO2 emitting sources and solar energy is having quite fewer emissions compared to the other two.

S. Fuller discovered PV cell that directly converts solar energy into electrical energy at Bell Telephone Laboratories and the PV cells were having efficiency nearly 6%. In the year 1956 the solar modules were made commercially available, but the cost was very high. In the late 1960s the PV system was used for powering satellites with improved efficiency of 14% [18]. Various advancements in solar energy production and variety of policies carried out by the Indian government made India is emerging as a leading country in green power utilization worldwide. The country's economy can also experience great development as electrical energy usage has a huge impact on the Gross Domestic Product (GDP) of the country. As much as the per capita usage of electricity increases the development of the country also enhances.

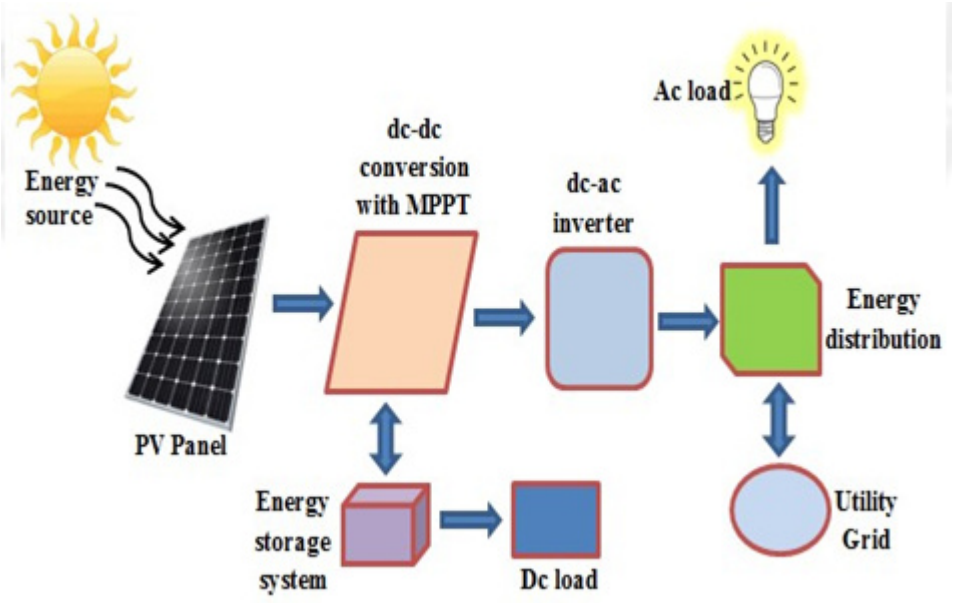

Figure 1. PV Conversion System Line Diagram

The word photovoltaic is derived by combining two words photo andvoltaic. Photo means light and voltaic is used for voltage. Therefore a PV systemconverts the solar irradiance incident on its surface to electrical energy. As thesource of energy is highly intermittent so it needs power conditioning elements withvarious conversion stages for a stable and continuous power supply. Basically, a PVgenerating system comprises PV panels, dc-dc converters, MPPT control technique,dc-ac inverter setup, storage systems, and grid integration elements and so on. In figure 1PV conversion system with all necessary elements is given.

Proposed Methodology

Artificial Neural Network

Neural networks are also an alternative method for implementing MPPT that is well suited to microcontrollers. Neural networks usually have 3 layers: input, hidden, and output. Each layer of number nodes varies and depends on the user. PV array parameters such as VOCs, ISCs, atmospheric data such as radiation and temperature, or any combination may be the

input variables. In general, the output is one or more reference signals, such as a duty cycle signal used to drive the power converter at or near the MPP.

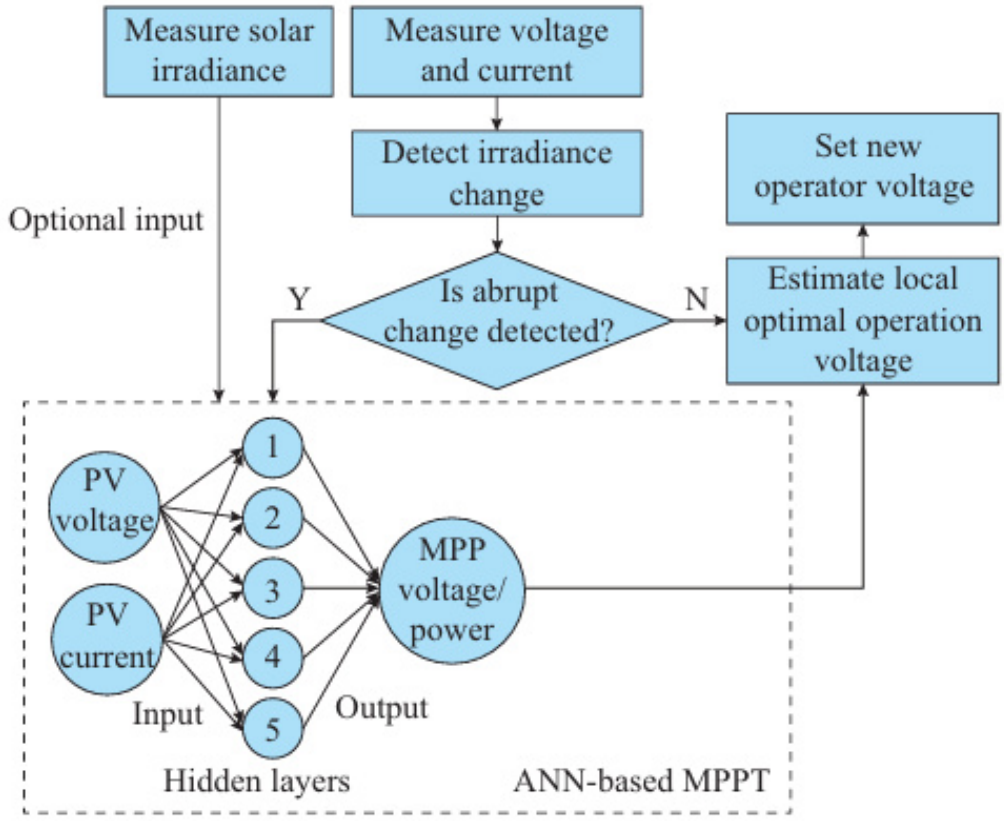

Figure 2. Modeling of Solar PV System Using ANN Based MPPT

Maximum Power Point Tracking Using Cuckoo Search Algorithm

Cuckoo quest in task research is a calculation of optimisation developed by Xin-she Yang and Suash Deb in 2009. It was inspired by the committed parasites in other feathered animals (of different types) in some cuckoo species. Some host winged animals will directly interact with the cuckoo barges. For example, if a host fed animal discovers that the eggs are not their own, it will either throw away or essentially give up his home and create another home. Some cuckoo species such as the Tapera of the Brood-Parasite of the New World have evolved so that the female parasite cucoo are unusually frequent in imitation with hues and examples of some species of picked eggs. Cuckoo quest has admired this rearing behaviour and therefore it is possible to apply it to different problems in the areas of optimisation.The photovoltaic generator reveals the I-V non-direct trademark with solar insolation and its MPP change.

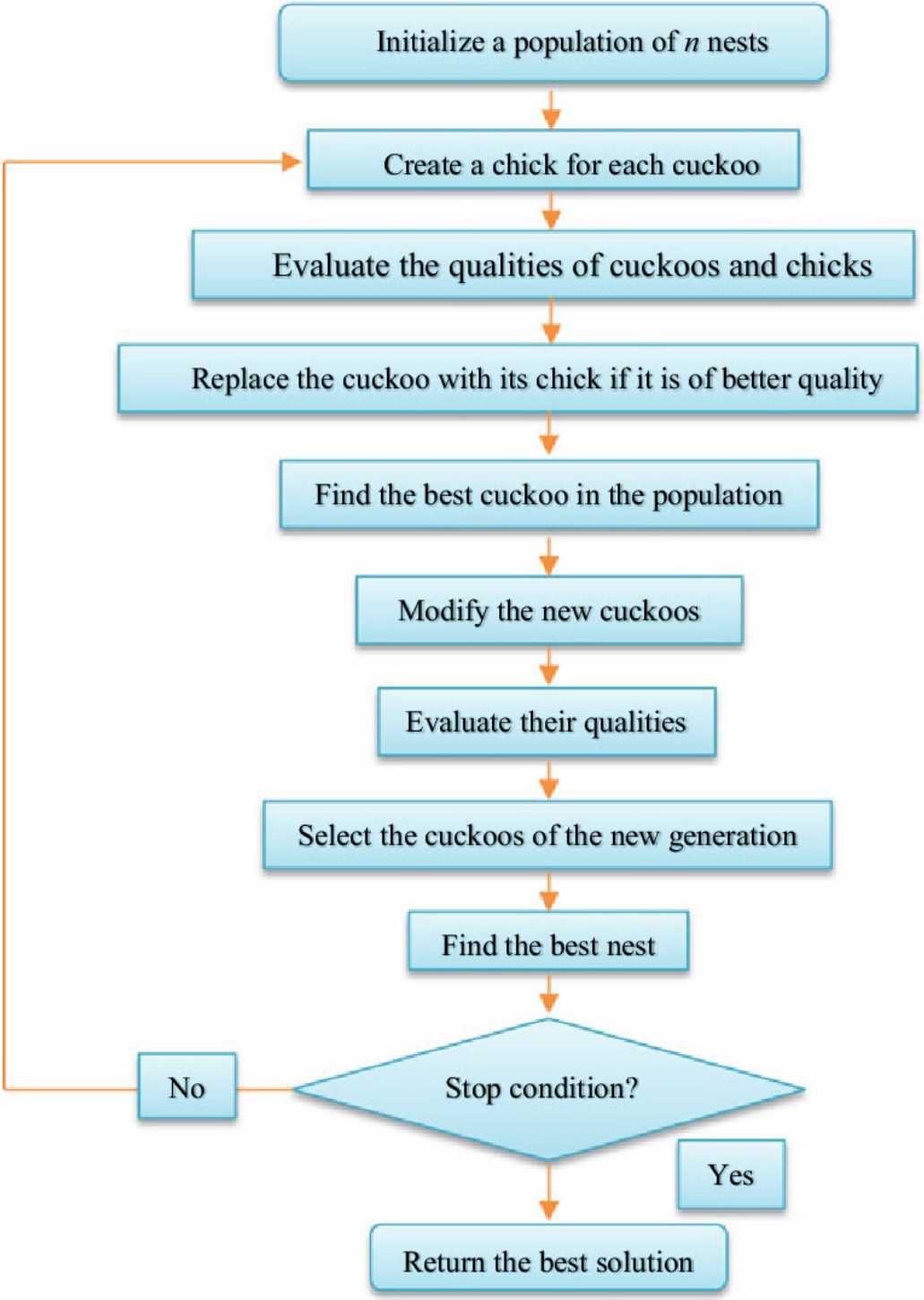

Figure 3.Modeling of Solar PV System Using Cuckoo Search Based Algorithm

Results

Results Obtained from Cuckoo Search Based MPPT Method

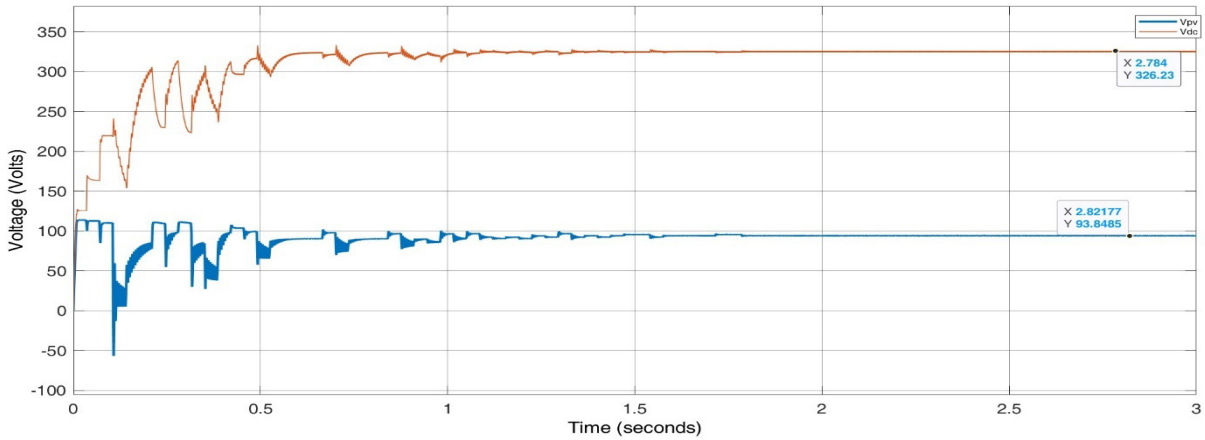

Figure 4. Output Voltages of Solar array and after dc-dc converter for Cuckoo Search

From the fig 4, voltages are Oscillate for around 1.8 seconds, after that these are in stable condition. Solar PV Array voltage is approximate 93.85 Volts while after using the boost converter which operate on Cukoo search based MPPT gives the output voltage 326.23 Volts. It Boost the voltage around 3.5 times (325.23 / 93.85 = 3.48) of the input voltage.

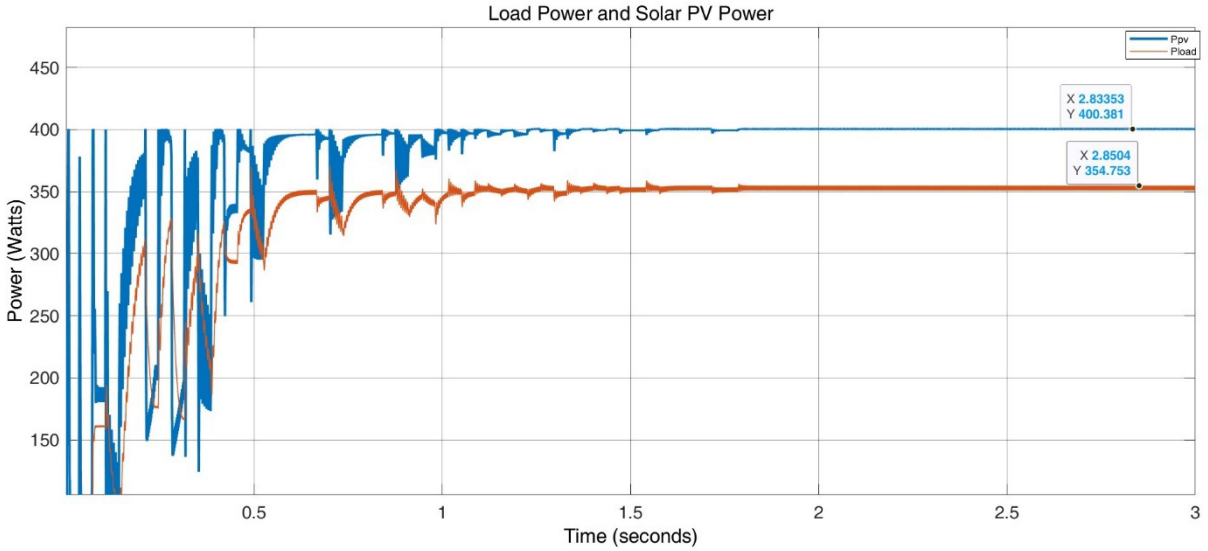

Figure 5. Output Power of Solar array and after dc-d converter for Cuckoo Search

The output power from solar PV array is around 400 Watts, by implementing the Cuckoo Search Method to give pulses to MOSFET the output power from the Boost converter is approx. 355 Watts. There is loss of power of 45 Watt in the boost converter. That shows that efficiency of the converter is 88%, as shown in fig. 5 also.

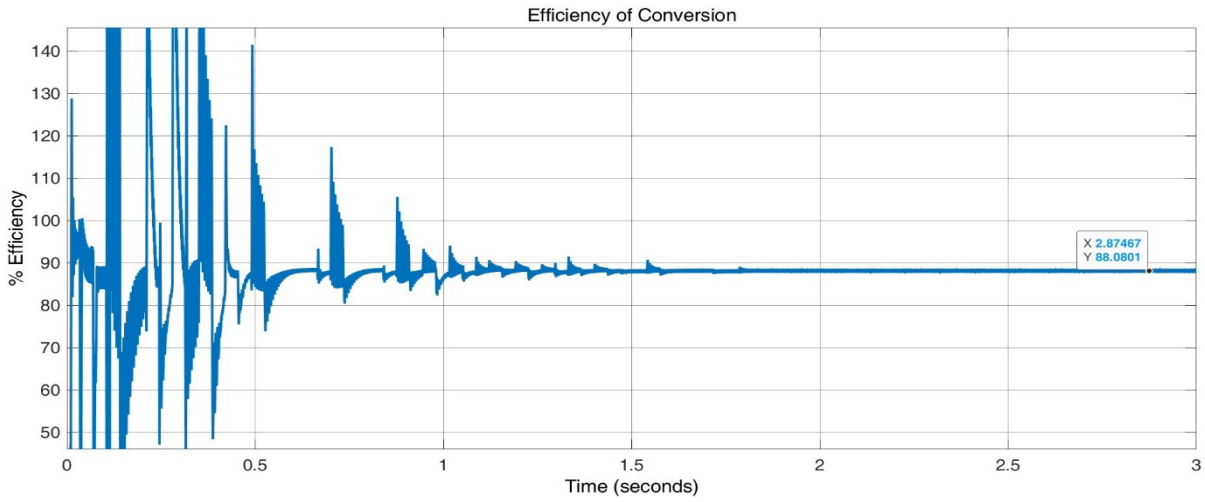

Figure 6. Efficiency of Converter for Cuckoo Search

Results Obtained from Artificial Neural Network Based MPPT Method

By changing the switch position in MATALB Simulink model the ANN MPPT method is applied to on and off the MOSFET. Waveform applied to the Gate terminal of MOSFET is shown in fig. 6.

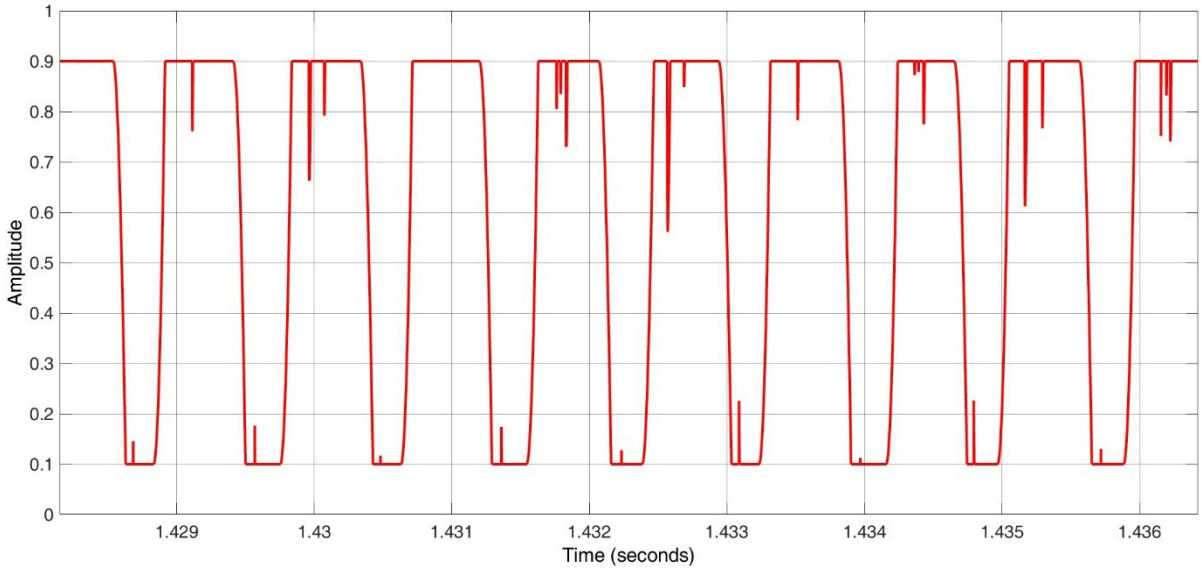

Figure 7. Duty Cycle Waveform for ANN

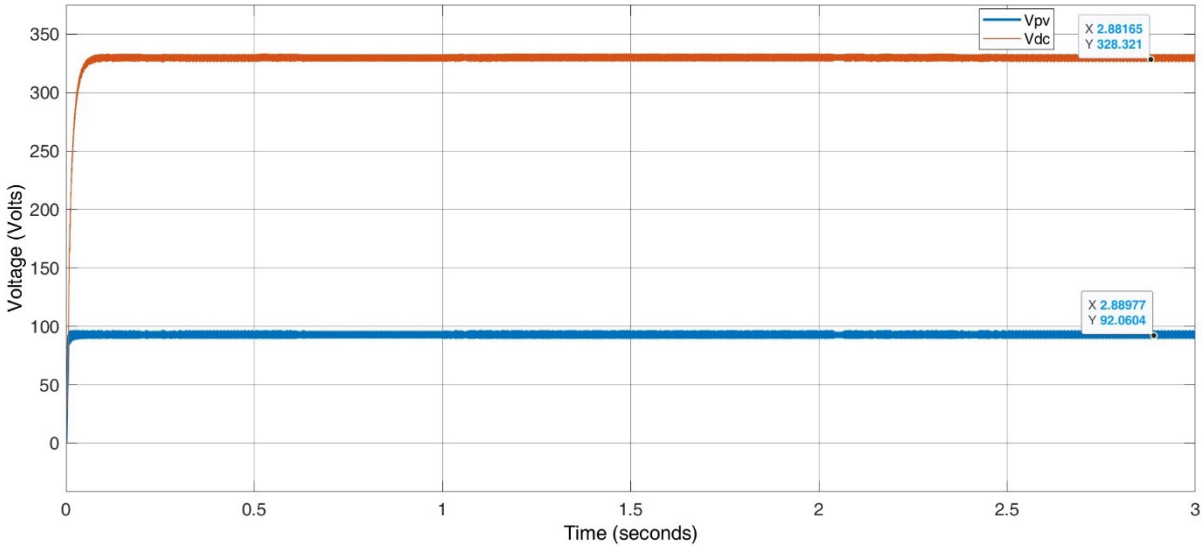

Figure 8. Output Voltages of Solar array and after dc-dc converter for ANN

From the fig 8, voltages are reaching to stable condition within 0.1 second . Solar PV Array voltage is approximate 92 Volts while after using the boost converter which operate on ANN based MPPT gives the output voltage 328.31 Volts.

It Boost the voltage around 3.57 times (328.31 / 92 = 3.57) of the input voltage. Which is 0.09 (3.57-3.48 = 0.09) times high compare to Cuckoo Search Method.

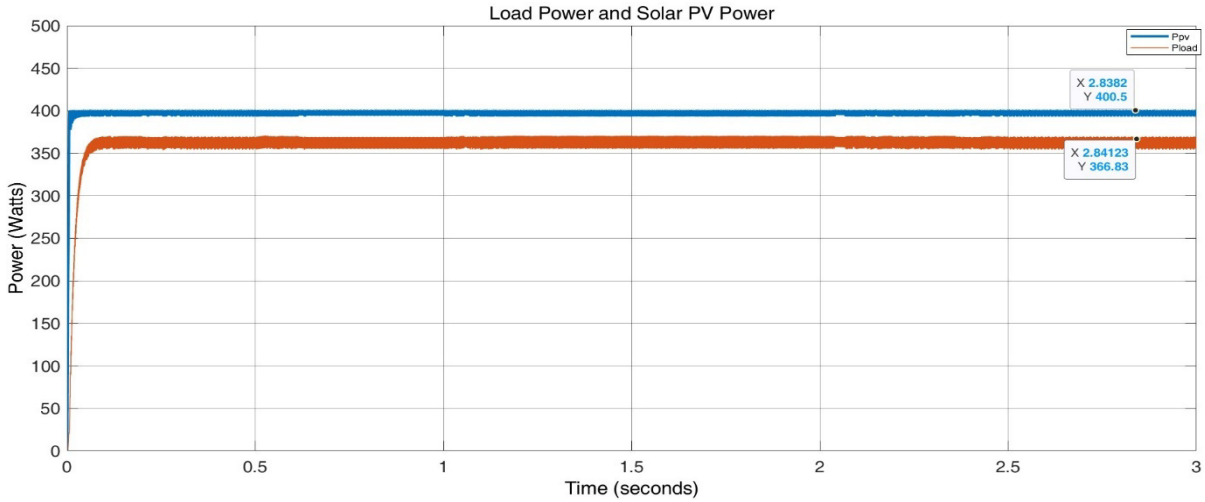

Figure 9. Output Power of Solar array and after dc-dc converter for ANN

The output power from solar PV array is around 400 Watts, by implementing the ANN Method to give pulses to Mosfet the output power from the Boost converter is approx. 367 Watts as shoen in fig. 9.

There is less loss of power here, only 33 watts in the boost converter compare to Cuckoo search method. This demonstrates that utilizing ANN instead of the Cuckoo Search algorithm for the specified solar PV array results in reduced losses.

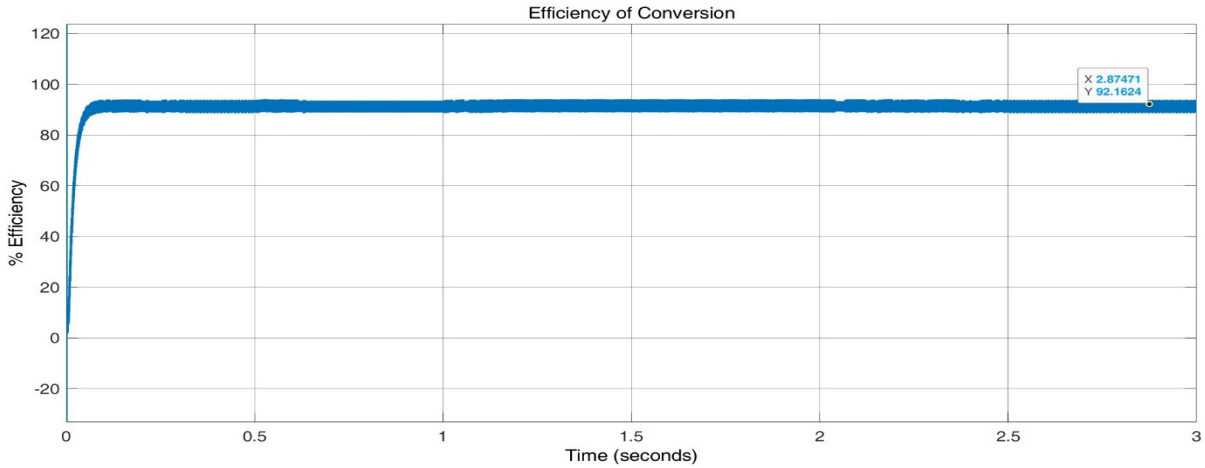

Figure 10. Efficiency of Converter for ANN

Fig. 10 shows that the effienciecy of the converter is more than 92%, which is 4% more to the Cuckoo Search Method.

From the above comparison of both method in terms of voltage, power and efficiency, we can depicted that ANN method is best for the specified parameter of solar Array compare to Cuckoo Search Method.

Conclusion

The presented MPPT techniques are both effective under uniform and non-uniform environmental conditions.

Input given to Converter in both method is same but Output voltage of DC- DC converter is more in the ANN method, which means duty cycle generated through ANN method boosting the more voltage.

The Output Power at converter is also more by using the ANN based MPPT technique, which implies that efficiency is also more. In terms of convergence time, where voltage and power takes 1.8 seconds to reach in stable condition in case of Cuckoo search method while for ANN method it takes less than 0.1 second only.

The results indicate that the ANN-based MPPT outperforms in both scenarios. However, there are some added complexities associated with training neural networks for the ANN-based approach.

References

[1] Osisioma Ezinwanne, Fu Zhongwen and Li Zhijun, “Energy performance and cost comparison of MPPT techniques for photovoltaics and other aplication”, International conference on energy and environment research, Elsevier, vol. 107, no. 297-303, September 2017

[2] Sandeep Neupane and Ajay Kumar, “Modelling and simulation of PV array in MATLAB/ Simulink for comparison of perturb and observe and incremental conductance algorithms

using buck converter", International research journal of engineering and technology, vol. 4, no. 2479-2486, July 2017

[3] Dr G Saree, V Renuka," Simulation of standalone solar PV system using incremental conductance MPPT", CVR journal of science and technology, vol. 16, no. 53-58, June 2019

[4] K. Kanimozhi, R. Ramesh and P. Gajalakshmi, "Modelling and simulation of PV based MPPT by different method using boost converter", Rev. Tec. Ing. Univ. Zulia, vol. 39, no. 343-341, 2016

[5] Saad Motahhir, Aboubakr El Hammoumi, Abdelaziz El Ghzizal, Photovoltaic system with quantitative comparative between an improved MPPT and existing INC and P&O methods under fast varying of solar irradiation, Energy Reports, Volume 4,2018, Pages 341-350, ISSN 2352-4847, https://doi.org/10.1016/j.egyr.2018.04.003.

[6] Abul Kalam Azad, Md. Masud Rana and Md. Moznuzzaman, "Analysis of P and O and INC MPPT techniques for PV array using MATLAB", IOSR journal of electrical and electronics engineering, vol. 11, no. 80-86, August 2016

[7] Afshan Ilyas, Mohammad Ayyub, M. Rizwan Khan, Abhinandan jain and Mohammed Aslam husain, "Realization of incremental conductance MPPT algorithm for solar photovoltaic system", International journal of ambient energy, Vol. 39, no. 873-884, July 2017

[8] Jubaer Ahmed and Zainal Salam, "An accurate method for MPPT to detect the partial shading occurance in PV system", Industrial informatics, IEEE, vol. 13, no. 2151-2161, October 2017

[9] Ehtisham Lodhi, Rana Noman Shafqat and Kerrouche K. D. E, "Application of particle swarm optimization for extracting global maximum power point in PV system under partial shadow conditions", International journal of electronics and electrical engineering, vol. 5, no. 223-229, June 2017

[10] T. Diana and Dr. K Rama Sudha, "Maximum power point tracking of PV system by particle swarm optimization algorithm", International research journal of engineering and technology, vol. 6, no. 126-130, September 2019

[11] Sridhar, R., S. Jeevananthan, and Pradeep Vishnuram. "Particle swarm optimisation maximum power-tracking approach based on irradiation and temperature measurements for a partially shaded photovoltaic system." *International Journal of Ambient Energy* 38, no. 7 (2017): 685-693.

[12] Nadia Hanis Abd Rahman, Muhammad Shafiq Romli Ismail and Ibrahim Alhamrouni, "Maximum power point tracking for single diode PV model using particle swarm optimization", International journal of ambient energy, vol. 38 , no. 685-693, April 2016

[13] Ahmed Hossam El-din, S. S Mekhamer and Hadi M. El-Helw, "Comparison of MPPT algorithms for photovoltaic systems under uniform irradiance between PSO and P and O", International journal of engineering technologies and management research, vol. 4, no. 68-77, October 2017

[14] Malik Sameeullah and Akhilesh Swarup, "MPPT schemes for PV system under normal and partial shading conditions", International journal of renewable energy development, vol. 5, no. 79-94, 2016

[15] Arti Pandey and Sumati Shrivastava, "Perturb and observe MPPT technique used for PV system under different environmental conditions", International research journal of engineering and technology, vol. 6, no. 2829-2835, April 2019.