EAI Endorsed Transactions
on Energy Web
Research Article EAI.EU

A Novel Comparative Analysis of Solar P&O, ANN-based MPPT Controller under Different Irradiance Condition

Pavithra C[1], Dhayalan R[2], AnandhaKumar S[2], Dharshan Y[2], Haridharan R[2], Vijayadharshini M[2]

[1]Assistant Professor, Department of Electrical and Electronics Engineering, Sri Krishna College of Engineering and Technology Coimbatore, India
[2]Student, Department of Electrical and Electronics Engineering, Sri Krishna College of Engineering and Technology Coimbatore, India

Abstract

The depletion of fossil fuels and rising energy demand have increased the use of renewable energy. Among all SolarPVs, system-based electricity production is increased due to multiple advantages. In this paper a Solar PV system with an Artificial Neural Network (ANN)-based Maximum Power Point Tracking (MPPT) controller is developed. ANN has multiple advantageslike stability, improved dynamic response, and fast and precise output. The System is modelled with a DC-DC boost converter with Perturb and Observe (P&O)-based MPPT controller which is operated in MATLAB-based Simulink model. Both the controller output is analyzed and compared, among these two controllers ANN has very fast and more precise output under dynamic conditions.

Keywords: PV system, P&O, ANN, MPPT

Received on 30 November 2023, accepted on 19 January 2024, published on 26 January 2024

doi: 10.4108/ew.4942

*Corresponding author. Email: pavithra@skcet.ac.in

1. Introduction:

Due to an increased population, the need for electrical energy is high and at the same time, fossil fuel has been depleted. So, the researcher's eye is on renewable energy for electrical power generation. Even though much renewable power generation is available like hydro, wind, and geothermal, tidal and biomass [1]. Solar PV model plays a significant role in power generation due to abundantly available, reduced maintenance cost, and no harmful heat and gas generation [2]. But the challenging side of implementing a PV system is the high establishment cost and reduced efficiency [3]. To work on this grey area MPPT method is implemented for the power generation to improve the efficiency and enhancing the power generation [4] [5]. There are many solar MPPT methods available, among which the P&O algorithm is conventionally available. The ANN-based MPPT method is developed which has many advantages like decreased oscillation and improved tracking efficiency [6] [7]. In this paper, the uniform irradiance is considered to be 1000 W/m2. The variable irradiance is 400, 600, 800, and 1000 W/m2 which is depicted in Fig.1.[8] [9].

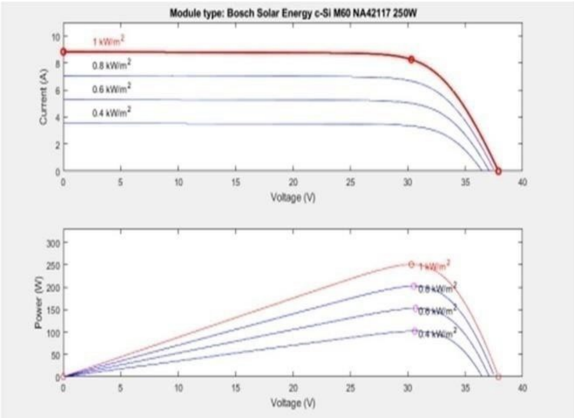

Figure 1. Comparison of power, current, and voltage at different irradiance

2. PV Solar Cell Model

The PV cell is made up of semiconductors, which has a p-n junction in the middle to absorb solar energy's irradiance (G) and temperature with nonlinear characteristics and convert it to DC current? Both series and parallel connections can be made between the cells. Maximum voltage and current are found in series and parallel, respectively.

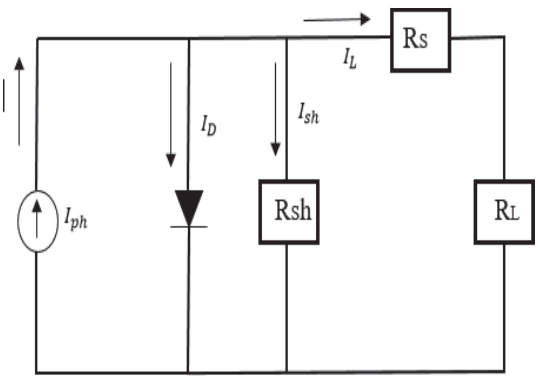

Figure 2. Circuit diagram of PV Cell

It has a diode and two resistances i.e., Rs and Rl connected in series with the source [10]. The voltage-current relation of the PV system defines solar cell modelling as follows: $\mathbf{Is = Isc,n + K1\Delta T/exp\ (Voc,n + Kv\Delta T)/a(NsKT/q) - 1}$

3. Proposed Model

The block diagram of the solar photovoltaic model shows that the solar panel is generating electricity from a solar PV module, in which light energy from sun is converted into electrical energy. Since irradiation varies time to time, the panel output is not a constant voltage. This variable output has to be converted into a constant DC output. To get the maximum output voltage from solar PV system MPPT method is used.

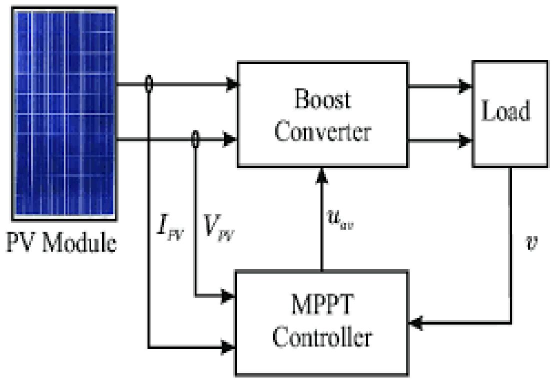

Figure 3. Schematic diagram of the proposed concept

The turn-ton time of the power electronic switch is chosen based on the MPPT algorithm used. Hence the PWM wave is generated according to the duty cycle and the gate turn on/off pulse is given to the IGBT used. The MPPT continuously checks the voltage and inputs the required duty cycle, by lowering the current and the output voltage is maintained at its peak.

3.1 Boost Converter

The output voltage from the solar panel is very low and varies, making it unsuitable for high-voltage applications. The boost converter increases the voltage by increasing the duty cycle depending on the load attached to it.
The most popular type of chopper for increasing output voltage is the step-up chopper converter. The duty cycle determines the IGBT's switching, and the voltage is increased in accordance with the connected load. In this investigation, a boost converter is used.

3.2 Perturb and Observe Algorithm

A significant part of the solar PV module is finding the efficient operating point of a solar cell due to the nonlinear nature of the PV output [11]. The easiest way to track the MPP in a panel is with the P&O algorithm. In this method, the power generated at the present moment P(k) is compared to the power generated at the previous moment P(K-1) based on the oscillating duty cycle to reach the MPP point [12].

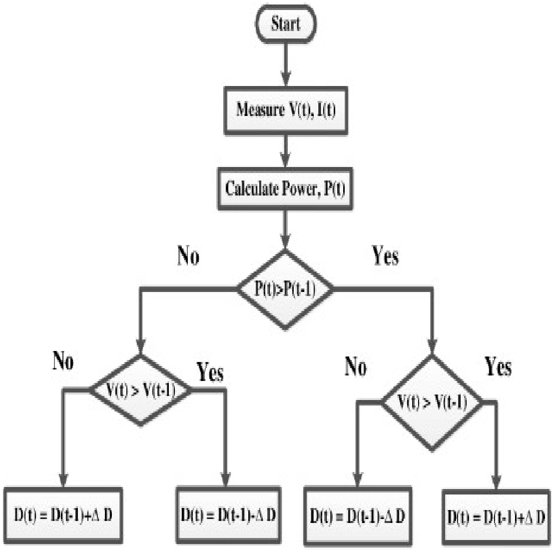

Figure 4. Flowchart of P&O in MATLAB

Simulink Model of Solar-based PV cells Simulink diagram of P&O Based solar PV system:

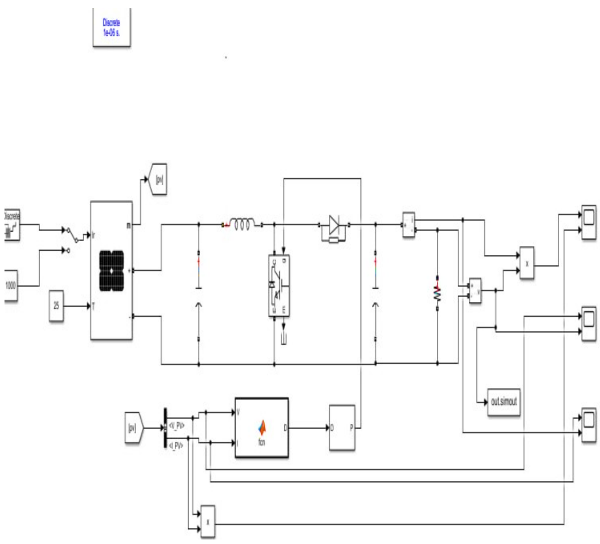

Figure 5. Matlab Simulink model-based PV system P&O-based MPPT controller

3.3 ANN Algorithm

ANN is a computer-generated human genius. It's based on the similarity of organic neural networks. In order to teach network permanency, we use a backpropagation coaching approach. It employs the supervised training process, which is used in Error Detection and Correction, and has an organic process for network education [13] [14] [15]. It is divided into three sections: entering strata, turning bed, and layer stealing (10). This approach over the MPPT workshop is more accurate and faster than the imitation of the P and O and Fuzzy Logic algorithms [16] [17].

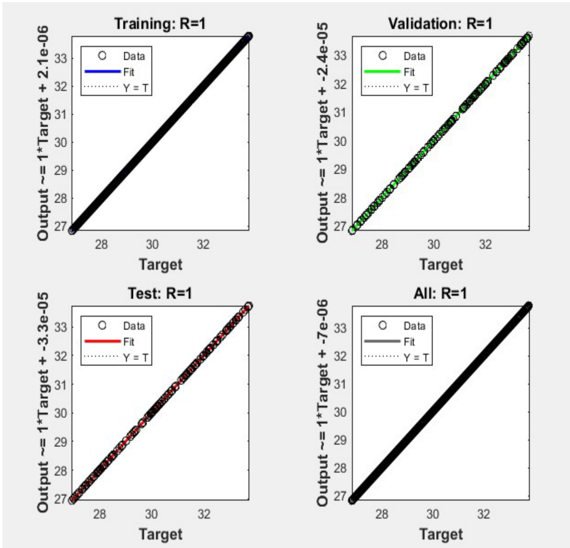

Figure 6. ANN Regression Diagram

LEVENBERG MARQUARDT is the training algorithm used here. As shown in Fig.6, the error in output and the difference in present error, and the previous value of output error are very low.

Simulink diagram of ANN Based solar PV module:

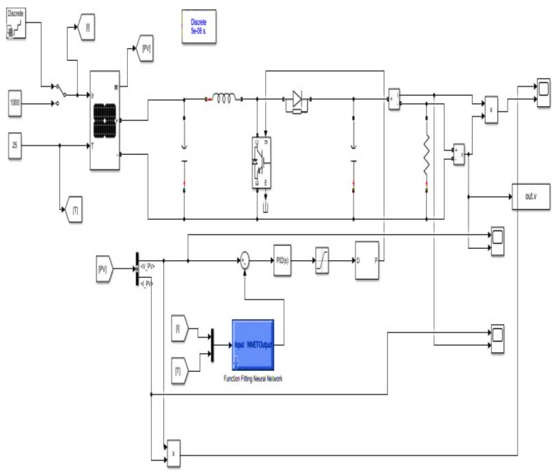

Figure 7. Matlab Simulink-based solar PV system with ANN-based MPPT controller

4. Results and Output based on Simulation

4.1 P&O power at constant irradiance =1000W/m^2

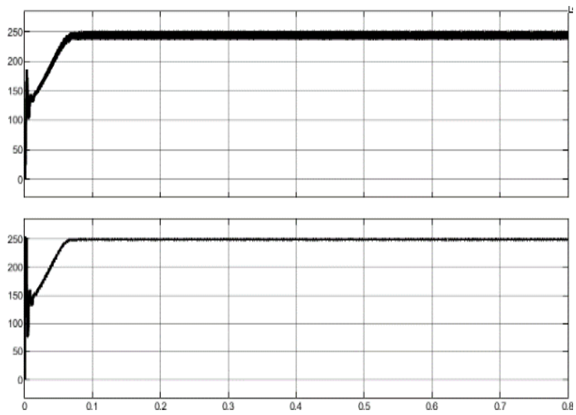

Figure 8. P&O power at constant irradiance =1000W/m^2

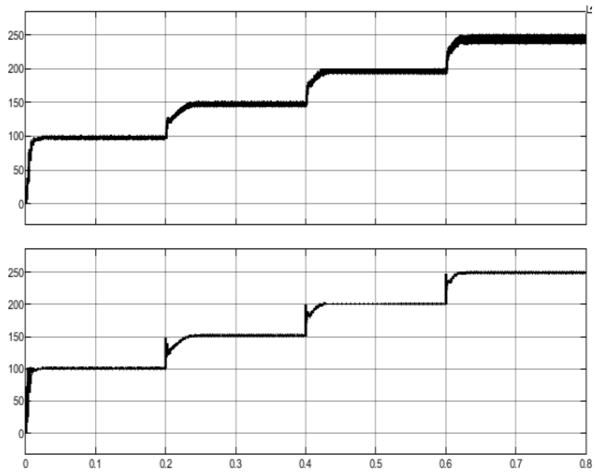

Figure 9. P&O Power at variable irradiance

4.2 ANN power at constant irradiance = 1000W/m^2

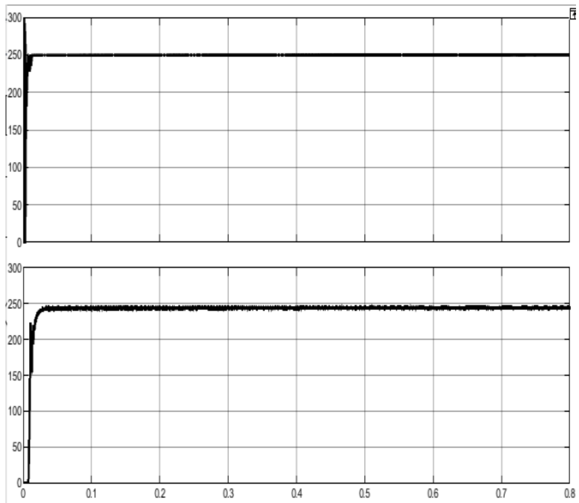

Figure 10. ANN Power at constant irradiance

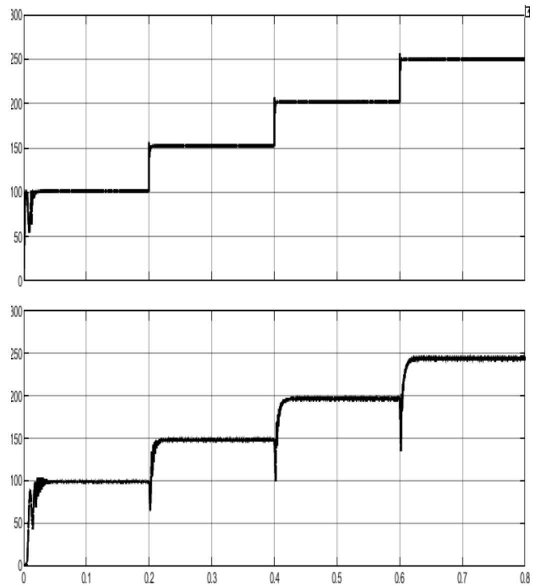

Figure 11. ANN Power at variable irradiance

5. Comparison of the Simulation Output of P&O and ANN-Based MPPT Controller

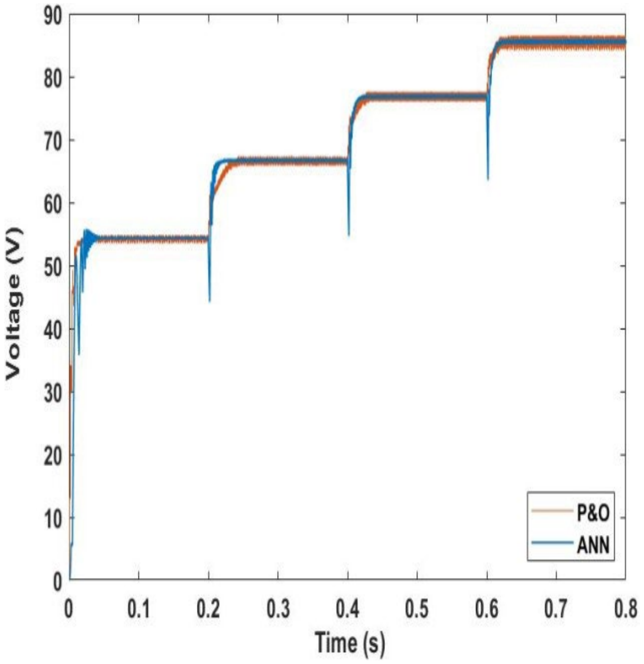

Figure 12. Comparison of solar PV output power of P&O, ANN controller at variable irradiance

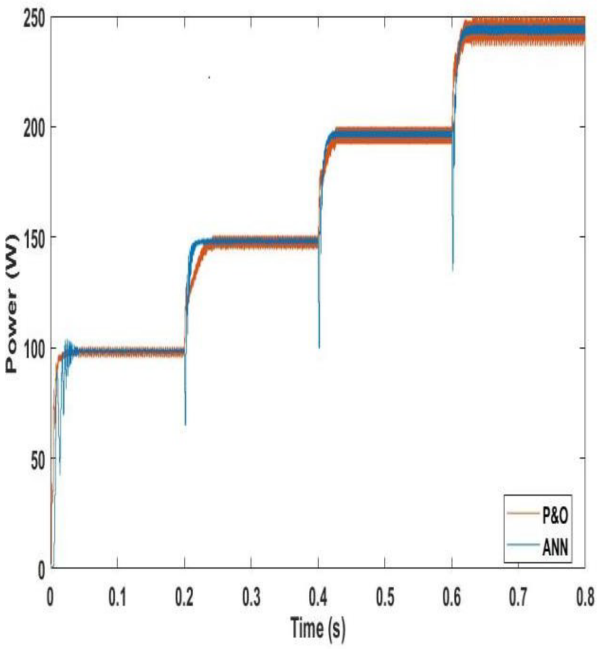

Figure 13. Comparison of solar PV output voltage of P&O, ANN controller at variable irradiance

Table.1: Voltage, Current and Power output

Controller/ Irradiance W/m^2	400	600	800	1000
P&O	V:55V I: 1.8A P: 99W	V: 67V I: 2.2A P: 148W	V: 76V I: 2.6A P:199W	V: 86V I: 2.9A P: 250W
ANN	V: 56.6V I: 1.76A P: 100W	V: 67.6V I: 2.22A P: 150W	V: 77V I: 2.6A P: 200W	V: 86.5V I: 2.9A P: 250W

Conclusion:

The design of the MPPT controller for the solar-based PV system using ANN is discussed in this paper, and a comparison with the traditional P&O controller-based MPPT method is made. The simulation results for bothmethods under the same irradiance condition are compared. When compared to the traditional P&O-based MPPT method, it is seen that the proposed ANN method improves efficiency around the MPP point and decreases oscillation power loss.

References:

[1] Vijay K Sood, Haytham Abdel Gawad. Power converter solutions and controls for green energy. DERM. 2019; 357-387.

[2] Zegaoui, Aillerie M, Petit P, Sawicki J P, Charles J P, Belarbi A W. Dynamic behaviour of PV engine converting energy trackers under dissemination and heat changes. SE. 2011; 85; 2953–2964.

[3] Babu W R, Pushpalatha N, Catherine L, Janani K, Kanase S S and Patil P. Review and Comparison on Types of Solar Tracking using PNT Systems. ICICCS. 2023; 1697-1701.

[4] Pushpalatha N, Devi B P, Sharma V and Alkhayyat A. A Comprehensive Study of AI-based Optimal Potential Point Tracking for Solar PV Frameworks. GlobConET. 2023; 1-5.

[5] Pushpalatha N, Jabeera S, Hemalatha N, Sharma V, Balusamy B and Yuvaraj R. A Succinct Summary of the Solar MPPT Utilizing a Diverse Optimizing Compiler. IC3I. 2022; 1177-1181.

[6] Dutta R and Gupta R P. Performance analysis of MPPT based PV system: A case study. ICEFEET, 2022; 1-6

[7] Pavithra C, Pooja Singh B, Venkatesa Prabhu S. A brief overview of maximum power point tracking algorithm for solar PV system. MTP. 2021.

[8] Kaushik C, Garg R and Priya Mahajan P. Comparison of MPPT Algorithms Under Uniformly Varying Atmospheric Conditions. ICICICT, 2022.

[9] Pavithra C, Geethamani R. A Noval Improved Variable Step-Size Incremental Resistance MPPT Controller for PV System Under Partial Shading Condition. JCTN. 2019; 16; 740- 744.

[10] Saravanan S, Ramesh Babu N. RBFN-based MPPT algorithm for PV system with high step-up converter. Elsevier BV. 2016; 122; 239-251.

[11] Manna S and Akella A K. Comparative analysis of various P & O MPPT algorithm for PV system under varying radiation condition. ICPEE. 2021; 1-7.

[12] Pavithra C, Geethamani R, Radhakrishnan G, Kishore Kumar S, and Manoj C. A Novel Grid Integrated Perturb and Observe MPPT Controlled Photovoltaic Power Plant for Power Enhancement. JCTN. 2019; 16; 410-416.

[13] Bouakkaz M S, Boukadoum A, Boudebbouz O, Bouraiou A, Boutasseta N and Attoui I. ANN based MPPT Algorithm Design using Real Operating Climatic Condition. ICMIT. 2020; 1-8.

[14] Roy R B, Rokonuzzaman M D, Amin N, Mishu M K, Alahakoon S, Rahman S. A Comparative Performance Analysis of ANN Algorithms for MPPT Energy Harvesting in Solar PV System. IEEE Access. 2021; 9; 102137-102152 2021.

[15] Ujjwal Kumar Kalla, Senior Member. A Normalized Neural Network Based Controller for Power Quality Improved Grid Connected Solar PV System. PIICON. 2016; 1-7.

[16] Bhim Singh, Dilip Tekchand Shahani, Arun Kumar Verma. Neural network-controlled grid interfaced solar photovoltaic power generation. IET. 2014; 7(3); 614-626.

[17] Sathiya Bama S, Dr. K Punitha. Artificial Neural Network for Control and Grid Integration of Floating Solar Photovoltaic System. IJAREEIE. 2018; 7 (11).