ANN Based Mppt Techniques For Solar Power System

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***Abstract** – In this explores the application of Artificial Neural Networks (ANN) in Maximum Power Point Tracking (MPPT) for solar power systems, aiming to optimize power quality and system efficiency. Traditional MPPT techniques often fall short under rapidly changing environmental conditions, leading to decreased performance and energy yield. This research proposes an ANN-based MPPT approach that leverages the learning and predictive capabilities of neural networks to dynamically and accurately determine the maximum power point (MPP) in real-time.*

The ANN model is trained using historical data on solar irradiance, temperature, and corresponding output power, enabling it to predict the optimal operating point for varying conditions. The performance of the proposed ANN-based MPPT is evaluated through extensive simulations and experimental setups, comparing its efficiency, tracking speed, and accuracy against conventional methods such as Perturb and Observe (P&O) and Incremental Conductance (IncCond).

Results indicate that the ANN-based approach significantly enhances the MPPT performance, achieving faster convergence to the MPP and higher energy harvest under diverse and fluctuating environmental scenarios. The study concludes that integrating ANN into MPPT systems not only improves the power quality and efficiency of solar power installations but also demonstrates the potential for artificial intelligence to drive advancements in renewable energy technologies.

***Keywords:** Artificial Neural Networks (ANN), Maximum Power Point Tracking (MPPT), Solar Power, System, Power Quality Optimization, Renewable Energy, Real-time Prediction. Energy Efficiency*

I. INTRODUCTION

Energy consumption is on the rise worldwide, driven by population growth and industrial expansion. Presently, the majority of electricity production relies on nonrenewable sources such as coal, natural gas, and oil, which pose significant environmental hazards.

The progression of clean and renewable energy sources, such as solar, wind, and bioenergy, is imperative. Unlike nonrenewable resources that diminish with time, renewable energies offer an endless supply. They not only uphold ecological balance but also play a pivotal role in mitigating CO2 emissions. Furthermore, their capacity for small-scale or local production enhances accessibility and sustainability.

Currently, solar and wind energy are experiencing significant growth, with solar energy leading the preference due to several advantages. Photovoltaic energy production tends to be more consistent on a daily basis compared to wind energy, which is subject to intermittent wind activity. Additionally, solar generators have fewer moving parts, resulting in lower recurring operating and maintenance costs.

Solar energy boasts numerous applications and greater flexibility, making it highly practical. Various equipment is interconnected with the photovoltaic generator to facilitate optimal energy transfer. The generated power is contingent upon factors such as temperature, irradiance, and the load. To ensure the photovoltaic generator operates at maximum power, the implementation of a Maximum Power Point Tracking (MPPT) algorithm is essential, with numerous options available in existing literature.

II. LITERATURE SURVEY

Izhar UlHaq and colleagues devised a novel approach utilizing a nonlinear Generalized Global Sliding Mode Controller (GGSMC) in conjunction with a DC-DC buck-boost converter for optimal power extraction from photovoltaic (PV) arrays. They integrated a Feed-Forward Neural Network (FFNN) to establish a reference voltage, adapting to variations in temperature and sunlight. Unlike traditional methods, their strategy, incorporating modified sliding mode control, eliminates the reaching phase, ensuring continuous sliding mode operation. This design effectively mitigates system chattering and harmonic distortion. Through MATLAB/Simulink simulations, the proposed methodology demonstrated remarkable effectiveness, precision, and swiftness. Additionally, its performance was benchmarked against a standard nonlinear backstepping controller, showcasing superior adaptability to sudden environmental changes [1].

Sajib Ahmed and collaborators explored the design characteristics and operational intricacies of six widely recognized conventional Maximum Power Point Tracking (MPPT) techniques. Their study delved into the analysis and review of modifications made to these

conventional methods. By assessing factors such as tracking time, steady-state oscillations, conversion efficiency, algorithm complexity, implementation cost, and adaptability to partial shading conditions, they conducted a comprehensive comparative evaluation of twenty-eight adaptive MPPT algorithms. Visualized through a radar graph diagram, the performance of the selected methods was depicted, with the contour area aiding in the identification of the most effective techniques. Ultimately, the paper offers readers a straightforward approach for selecting suitable MPPT methodologies [2].

Kavya M. and colleagues proposed a refinement to the Perturb and Observe (P&O) Maximum Power Point Tracking (MPPT) algorithm, aiming to address its inherent drawbacks: operating point divergence and the tradeoff between fast convergence and balanced state oscillations. While previous enhancements in the literature tended to increase complexity, their approach maintains simplicity while enhancing tracking efficiency. Their algorithm consists of three control modes, with Modes 1 and 2 focusing on fast convergence and Mode 3 on regulating stable state oscillations. Simulation comparisons demonstrated that their technique achieves faster convergence, reduced balanced state oscillations, improved tracking efficiency, and lower transient power loss compared to alternative methods [3].

Kulsoom Fatima and co-authors highlighted the urgent need to combat global warming by transitioning from hydrocarbon-based energy systems to renewable alternatives like solar and wind power. They emphasized the importance of enhancing the efficiency of renewable energy systems through optimal maximum power point tracking (MPPT) algorithms. Their chapter compared various MPPT algorithms based on artificial intelligence, drawing insights from a review of existing literature and simulations conducted in MATLAB/SIMULINK under both uniform and partial shading conditions. The overarching aim is to develop intelligent, optimized, and efficient algorithms to ensure maximum power extraction from photovoltaic modules, thus contributing to the broader goal of sustainable energy production [4].

III. PROPOSED METHODOLOGY

A novel MPPT technique is proposed by A for optimizing DC/DC converter performance in connecting a PV array with a load stage. The proposed MPPT control method utilizes neural network controllers, offering precise MPP tracking and rapid dynamic response to changes in climatic parameters, surpassing conventional MPPT control methods. The advantages of employing neural networks include the elimination of the need for internal PV system parameter knowledge, reduced computational complexity, and provision of a concise solution for multivariable problems.

A Neural Network Maximum Power Point Tracking (MPPT) Controller is an advanced algorithm used in photovoltaic (PV) systems to efficiently optimize power generation. Unlike traditional MPPT methods, which rely on heuristic or analytical approaches, neural network-based controllers leverage the capabilities of artificial intelligence to dynamically adjust the operating point of the PV array.

This controller employs a neural network model that learns the complex relationships between the input variables, such as solar irradiance, temperature, and voltage-current characteristics of the PV array, and the desired output, which is the maximum power point (MPP). During operation, the neural network continuously analyzes the input data and predicts the optimal operating voltage and current that correspond to the MPP.

One of the key advantages of using a neural network MPPT controller is its ability to adapt to changing environmental conditions and system dynamics. The neural network can learn from historical data and real-time feedback to improve its performance over time, ensuring robust and accurate MPPT operation even under partial shading or non-uniform irradiance.

NN can generally be thought of as black box device that accepts inputs and generates outputs. In our application, it is used to estimate the optimum voltage which corresponds to the MPP at any given solar radiation and PV array temperature. For that purpose, we elaborated a linear network that, when presented with a set of given input vectors, produces output of corresponding target vectors. For each input vector we can calculate the network's output vector. The difference between an output vector and its target vector is the error. Unlike most other network architectures, NNs can be designed directly if input/target vector pairs are known. The main goal of linear NN is to find values for the network weights and biases such that the sum of the squares of the errors is minimized or below a specific value by using the function "newlind". The following formula expresses the average of the sum of these errors:

$$E = \frac{1}{Q} \sum_{k=1}^{Q} (t(k) - a(k))^2$$

Where Q the number of elements is in the input vector read by the network, t is the target vector and a is the output vector.

As shown in fig.1, the NN controller consists of three layers. The input layer is composed of two nodes in inputs that are, the PV array temperature T and the solar radiation G. The hidden layer composed of one hundred nodes whose function of activation is "purelin".

The output layer is composed of one node that the optimum voltage which corresponds to MPP.
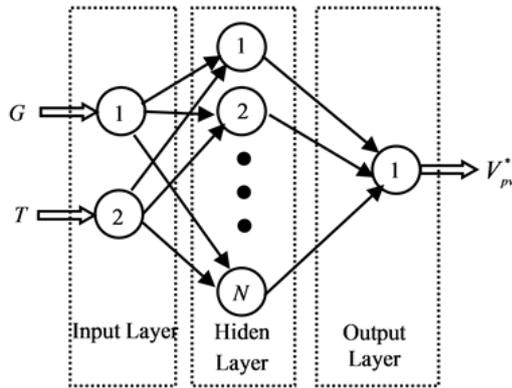

Figure.1. The neural network architecture

IV. SIMULATION RESULT

Here is Proposed model. In this figure 2 is basically divided three part one is source that we used PV and wind renewal energy source to reduce power demand from conventional source. This is our primary power source. In this proposed model also used batter as a storage and alternate dc power source of proposed model then we are using neural network.

The results of our proposed model. We analyze the architecture design and evaluate its performance under various operating conditions, including variations in energy source output and load demand. Through comprehensive analysis, we aim to assess the effectiveness and robustness of our proposed hybrid power system in meeting energy requirements while maintaining system stability and reliability.

Figure 4.6 illustrates the state of charge (SoC) and voltage of the battery, which serves as a power source within the proposed model. This figure provides insights into the performance and status of the battery, including its charge level and voltage output. Monitoring the SoC and voltage of the battery is crucial for ensuring efficient utilization and management of energy storage resources within the system. By tracking these parameters, the proposed model can optimize the operation of the battery and maintain stable power supply, contributing to the overall reliability and effectiveness of the system.

Figure 3. illustrates the smooth power generation in response to Electric Vehicle (EV) loads. The x-axis represents time, while the y-axis denotes voltage and current. The upper section of the figure displays the output generation of the power source, while the lower section represents the output of the source.
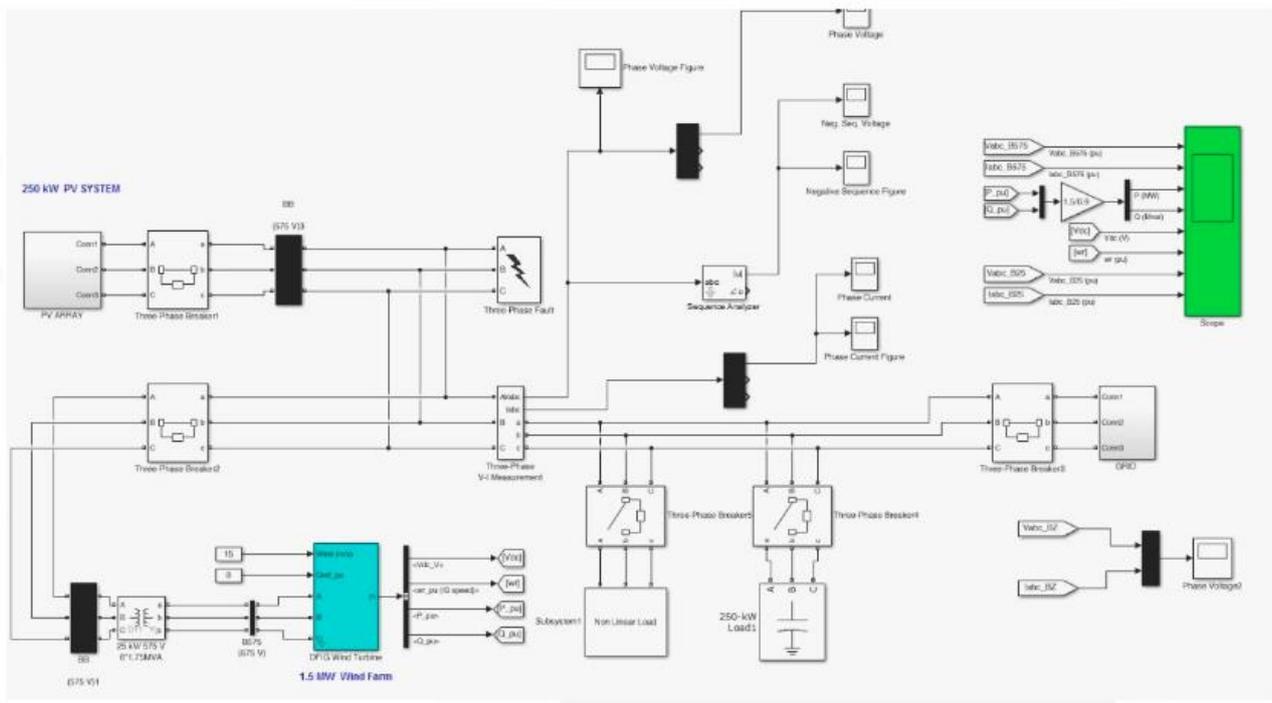

Figure 2. Proposed Model

Figure 2 depicts the proposed complete hybrid model, which relies primarily on renewable energy sources to consistently generate high-quality output. The hybrid power system is designed to integrate battery storage, photovoltaic (PV) panels, and wind turbines. Table 4.1 presents the basic parameters of the system, outlining key specifications and characteristics.
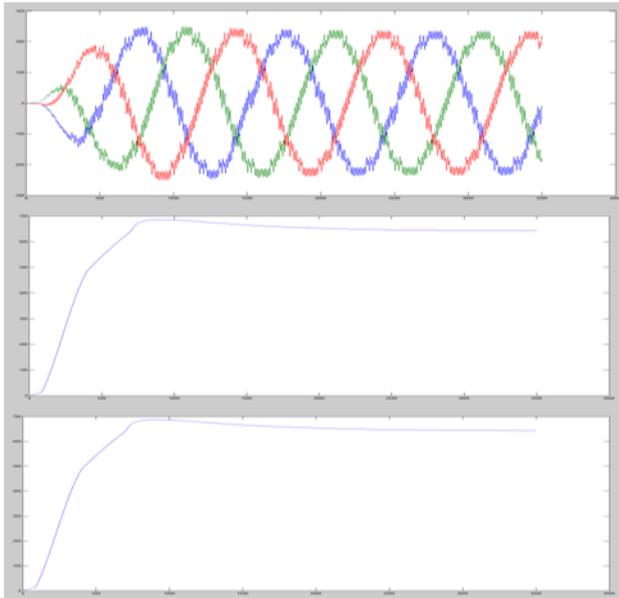
Figure. 3 Power Generation of Hybrid System

Figure 4 is show total harmonic generation of system that is less than 5%. Our proposed model current total harmonic value for one cycle is 0.47%.
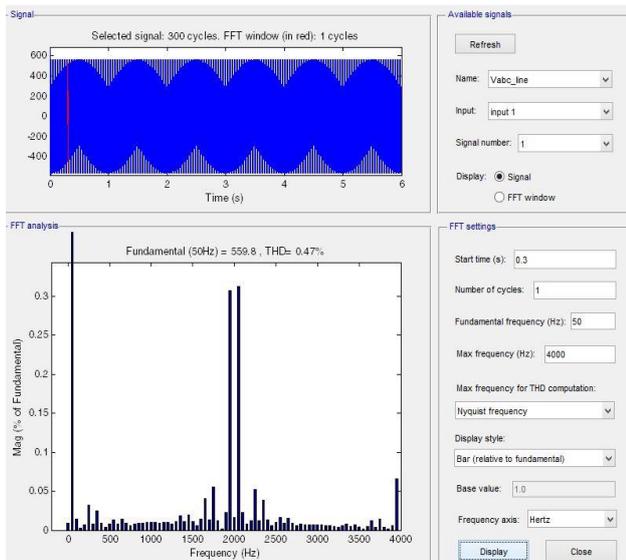

Figure 4. THD Value of Proposed Model

IV. CONCLUSION

This paper focuses on the development of a hybrid renewable energy-based power quality optimization system utilizing neural network technology. The primary sources of power utilized are renewable energy sources like photovoltaic (PV) and wind energy, complemented by a battery serving as an alternative source of DC power. The paper details the modeling of a DC hybrid

system that integrates inputs from both wind and solar energy.

The control logic governing the hybrid setup encompasses battery bank charge control, which is optimized using neural network-based techniques. This charge controller constantly monitors errors, ensuring efficient utilization of the battery bank to maintain power quality. In cases of power mismatches, the control logic optimizes the inverter operation, while pitch control mechanisms prevent overvoltage situations in the rectifier voltage. Additionally, current programmed control methods are implemented to safeguard the converter from potential overcurrent scenarios.

A modification to the conventional Perturb and Observe (P&O) algorithm for Maximum Power Point Tracking (MPPT) is proposed, offering a more effective and simplified implementation. The paper also presents the development of a hybrid wind-battery system along with its control logic using MATLAB/SIMULINK, validated through simulation experiments using a wind profile. These experiments demonstrate enhanced system performance and stability by mitigating voltage flickers and harmonics.

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