Grid-Connected Dual PV Management and Reliability Improvement based on Back Propagation Neural Network (BPNN-PSO)

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Abstract

A single-phase grid-connected Photovoltaic (PV) system based on the Maximum Power Point Tracking Perturb and Observe Algorithm (P&O) technique MPPT. Due to interactions between different semiconductors and variable loads, the input source contains harmonic distortion, voltage sags and surges, and other power quality problems. As a solution, the Grid-connected Photovoltaic (P.V.) and neural network system for boosting electricity quality was proposed. The P&O-based MPPT technology addresses partial shadow issues and other imbalanced components that commonly affect PV arrays. The system consists of two PV panels connected in series, with each PV cell having identical attributes. This PV array's interaction with various irradiation patterns can be used to anticipate the PV array in question. The Back Propagation Neural Network (BPNN-PSO) technology has been proposed for lowering the Total Harmonic Distortion (THD) of PV array systems while increasing convergence and accuracy rates.

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1. INTRODUCTION

Grid-connected output systems are designed to transform as much solar energy into useful power as feasible. Two recommended strategies are the Back Propagation Neural Network (BPNN-PSO) and the perturb and observe method. (P&O) In several conditions, the algorithms supply the reference voltage to the DC link controller. This solution, which utilizes a BPNN-PSO-based algorithm and a specified number of power evaluations of the PV system, automatically detects the maximum power point of the dual PV array.

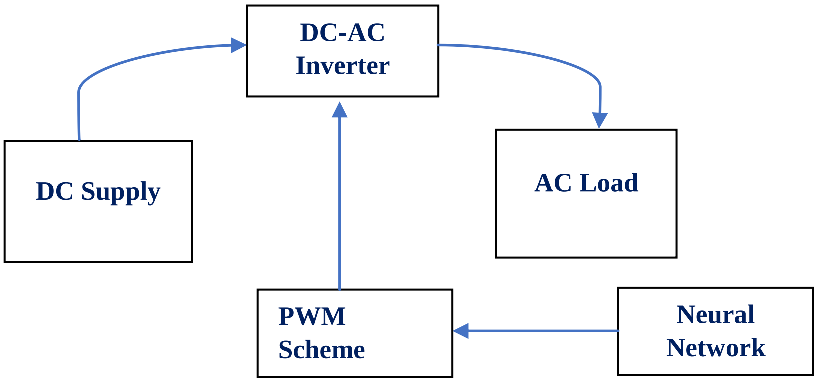

Figure 1 Basic Functional Diagram of DC source-based Neural Network

This approach can automatically extract characteristics from the I-V curve, irradiance, and temperature.The conventional approach to capturing this solar energy is to use PV cells and regulate them to our needs. The adoption of power management methods known as Maximum Power Point Tracking (MPPT) algorithms has boosted the working efficiency of solar modules, making them helpful in the field of renewable energy. Figure 1 depicts how PV systems have evolved into a substantial source of power for a variety of applications. Electric power generation conversion efficiency is fairly poor (9-17%), especially in low irradiation settings, and the quantity of electric power generated by solar arrays varies often with the weather, which is a significant disadvantage for PV generation systems.

The BPNN is a mathematical description of biological brain networks, which are used to solve difficult problems. Its outcome is to anticipate an output based on the network's inputs and training objectives. Layer 1 multilayer perception (MLP) networks and neural networks are two forms of neural networks. The multilayer perception network is made up of layers with basic, two-state sigmoid transfer functions and processing terminals that communicate with one another via weighted connections. The three primary layers of a conventional feed-forward multilayer sensory neural network are the input layer, output layer, and output layers.

In typical step-up circumstances, the voltage can be increased using ordinary DC-DC converters such as boost converters and fly-back converters. However, they are less effective when a big step up is needed. Because using a high turn ratio and a high duty cycle causes copper loss, leakage inductance, and conduction loss. Using the proper power electronic controllers, the DG linked to the battery storage may be connected to the main grid.

Furthermore, the V-I characteristic of a solar cell is nonlinear and fluctuates with temperature and radiation. In general, the Maximum Power Point (MPP) is a defined point on the V-I or V-P curve at which the entire PV system performs with the highest efficiency and generates its maximum output power. Although the location of the MPP is unknown, it can be determined using search techniques or computing models.

1.2 Objective of the work

The Particle Swarm Optimization (PSO) enhanced back Propagation Neural Network (BPNN) provides considerable advantages in dealing with multi-input parameters and non-linear fitting. PSO-BPNN models, which are based on BPNN, exhibit higher robustness and accuracy. A strain-predictive PSO-BPNN model was developed for a full-scale static experiment of a specific wind turbine blade based on the benefits of the neural network in solving complicated issues. The strain values for the unmeasured sites were also predicted. By contrasting it with the BPNN model and performing a simulation test, the PSO-BPNN prediction model's accuracy was confirmed. By contrasting the prediction findings with simulation results, strain-predictive neural network models' applicability and usability were both confirmed. The comparative findings demonstrate that PSO-BPNN may be used to forecast the strain at unmeasured wind turbine blade sites during static testing, adding extra information for calculating typical structural characteristics.

2. Previous research work

A. A. Shah (et al., 2021), In a Prediction Error-Based Power Forecasting (PEBF) approach for a Photovoltaic (PV) system, a grey box neural network based on the Photovoltaics for Utility Scale Applications (PVUSA) model is employed. The differential equation-based PVUSA model is first turned into a neural network. Depending on system dynamics and demands, the neural network is configured to train in the suggested PEBF manner if the difference between predicted and output powers exceeds a predefined threshold.

P. Wang (et al., 2022),Increased Photovoltaic (PV) grid integration has exacerbated the unpredictability of distribution network operations. The influence of the PV site on network power losses and voltage fluctuations is investigated for a distribution network with PV using analytical derivations represented by line impedance. Humans investigate placement tasks were assigned that take into account two factors: low network power losses and minimal voltage fluctuations. A Particle Swarm Optimization (PSO) approach is used to generate an optimal compromised solution and find the PV. PSCAD/EMTDC, a time-domain simulation platform, is used to set up a 10 kV distribution network with a single PV.

R. B. Roy (et al, 2021)**,** The P&O algorithm using the controller struggles briefly to surpass the MPP during a sudden irradiance shift that distorts the operational characteristics of the PV system. Even yet, the controller lowers the algorithm's error as it slightly delays tracking the MPP once more. Furthermore, power loss is caused by the MPP's terminal voltage oscillation. The smallest possible disruption phase size is employed to counteract these oscillations. Once more, the minor phase slows down the algorithms' initial transient and modifies the system's sensitivity to the weather. The INC Algorithm with the Proportional Integral (PI) controller reduces the rip oscillation throughout the MPP and fits well in the sudden changes in irradiance.

K. -H. Tan (et al 2021)**,** A Petri Recurrent Wavelet Fuzzy Neural Network (PETRIRWFNN) controller and a simple pre-synchronization estimator are proposed for the tasks of smooth switching and grid reconnection in a micro grid system. The photovoltaic (PV) system, loads, and storage system comprise the micro grid, which uses master-slave control and may be employed in grid-connected or islanded mode. Because the master Distributed Generator (DG) utilizes a different control algorithm based on the mode of operation, switching modes causes a temporary decrease in voltage and active power output of the micro grid system.

C. Ge (et al 2021)The intelligent manufacturing process of solar Photovoltaic (PV) cells now includes an automatic fault detection system that uses Industrial Internet of Things (IIoT) smart cameras and sensors linked in IIoT. Many research on data-driven approaches for fault detection in PV cells have been conducted. However, because of the subjectivity and fuzziness of human annotation, the data contains a substantial amount of noise and unforeseen ambiguity, making robotic defect discovery extremely difficult.

C. Liu et al., (2021) in partially shaded Photovoltaic (PV) arrays, the power-voltage curve contains several maxima, one of which is the global Maximum Power Point (GMPP). One of the primary difficulties with PV systems that attempt to boost efficiency is locating and monitoring the GMPP under all situations. To be speedy and precise, a unique two-stage global Maximum Power Point Tracking (GMPPT) technique has been developed that combines the classic Hill Climbing (HC) algorithm with Artificial Neural Networks (ANN). Furthermore, neither temperature nor irradiance sensors are required. In the first step, the current-voltage (I-V) curve is gathered at certain points based on the array IV curve analysis to take the fewest samples necessary to capture changes in temperature and irradiance than a standard feedforward ANN.

S. R. Kiran (et al 2022)**,** The PV system's nonlinear power versus voltage characteristics are created by integrating the triple diode type circuit model solar strings and the PV array. Finding the Maximum PowerPoint (MPP) is thus a very difficult task. According to previously published studies, there are numerous types of MPPT procedures on the market. The most widely studied MPPT approaches include classical, metaheuristic, artificial intelligence, and soft computing efficiency strategies.

X. Sun (et al 2021)Active Distribution Networks (ADN) are becoming more and more populated with photovoltaics (PVs), which causes serious voltage violation issues. PV inverters are now permitted to take part in the voltage regulation process and can offer quick and flexible reactive power supply. The real-time combined central and local Volt/Var control (VVC) approach is suggested in this study to address voltage violation issues while reducing network power loss. To get multiple voltages and the best power settings for each PV system, the centralized controller (CC) performs load flow and optimal power flow operations based on historical PV and load data. This ideal scatters are then used by the Local Controller (LC) to produce voltage control curves. A unique 3-Dimension voltage control curve was developed to enhance the voltage control impact. The purpose of voltage/var control (VVC) is to reduce voltage. Violations and minimize AND.

I. Pervez (et al., 2021) To reduce the impact of Partial Shading (PS), the PV array's output terminal can be outfitted with bypass diodes, albeit this results in multiple power peaks. Traditional hill climbing and perturb and observe methods are unable to locate the optimal location during partial shading occurrences for several peaks on the Power-Voltage (P-V) curve that correspond to varied shading patterns. Maximum Power Point Tracking (MPPT) methods based on fuzzy logic controllers and artificial neural networks produce satisfactory results at the price of increased memory and computational burden. Recent efforts to monitor optimal PowerPoint by including exploration and exploitation of natural occurrences have shown positive results by limiting convergence to local maxima and putting less burden on the processor.

F. -J. Lin (et al., 2022)aBattery Energy Storage System (BESS)-based Voltage Restoration Control (VRC) that may be utilized for both voltage correction and support power supply. Voltage restoration is a critical obligation for the power control of the micro grid when utilities are disrupted. One of the interruptions is a short circuit on the micro grid's power line, which might cause voltage sags or even a system shutdown. As a solution to this problem, the recurrent wavelet Petri Fuzzy Neural Network (RWPFNN) controller is discussed in this study for the VRC of BESS to provide a rapid control response and lessen the transient impact.

Rajaram. K et.al [2010] proposed a detection system for identifying malicious node in mobile ad hoc networks and also proposed power-aware routing system using on-demand multipath routing protocol for efficient packet transfer without any packet loss and for better communication in MANET.

Palaniswami, S et.al [2012] suggested an enhanced distributed certificate authority scheme for authentication in mobile ad hoc networks and trust based cross-layer security protocol malicious node detection. The modified security scheme for data integrity for manet was suggested for security in network communication.

Premanand, R. P et.al [2020] Enhanced data accuracy-based PATH discovery using backing route selection algorithm in MANET was proposed for better network communication.

Anand, R. P et.al [2020] suggested Effective timer count scheduling with spectator routing using stifle restriction algorithm in manet for timely scheduling packets and rapidly communication at emergency situations.

Rajaram, A et.al. [2019] presented Energy efficient and node mobility-based data replication algorithm and a high certificate authority scheme for authentication for MANET an approach for stable path routing scheme for improving packet delivery.

3. Materials and Method

In the existing method, a single-phase symmetrical Z-source converter is employed, as well as the accompanying modulation approach. Furthermore, because of the extensive operation required, impedance source networks cannot be directly linked between PV panels and transformer-less topologies. The issue with this technology is to adjust modulation schemes or switching patterns to reduce common-mode voltage variance. This approach covers a single-phase symmetric Z-source transformer-less converter with minimal leakage currents.It is an attempt in PV applications to employ the Highly Efficient and Reliable Concept with an impedance source (Z-source) network to maintain a steady common-mode voltage and hence minimal leakage currents. Although two more active switches are required, the operating frequency of the two switches is the same as the line frequency, resulting in negligible losses. More notably, low leakage currents and harmonics performance have been improved.

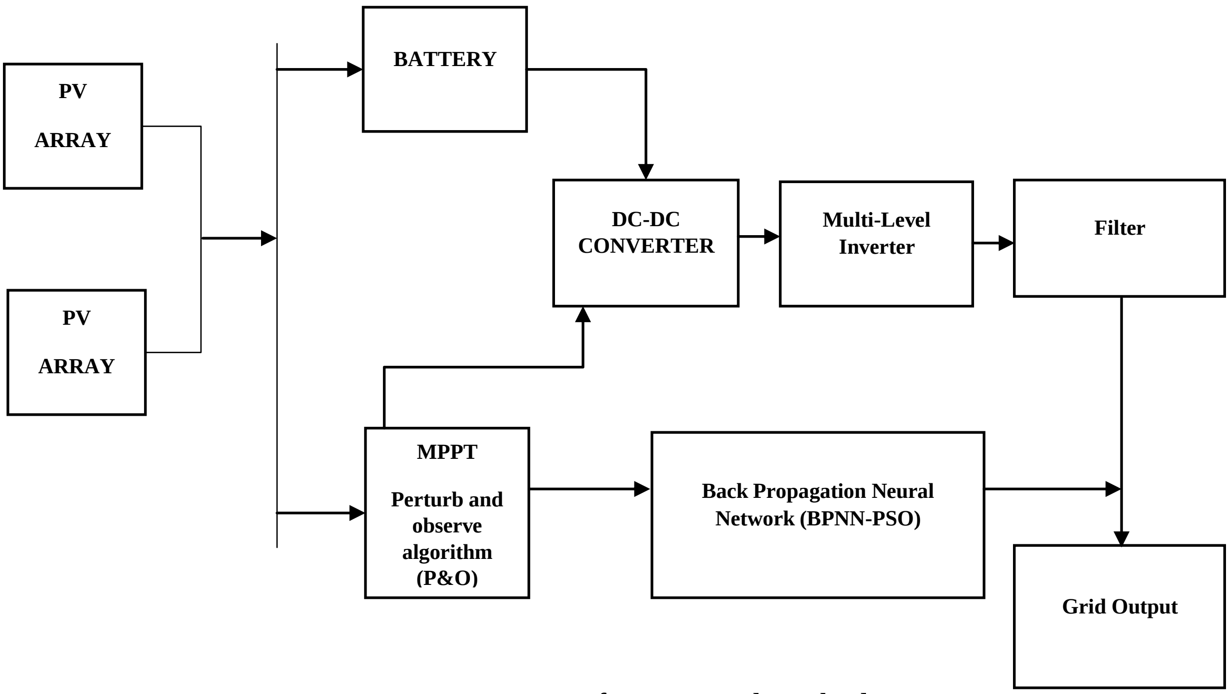

Figure 2 Diagram for Proposed Method

The proposed method implementation of MPPT (Maximum Power Point Tracking) for identifying the fault and defects. Voltage and current are maximum tracking's without the negative value while getting the input source of the three P.V. (Photovoltaic) mechanisms used in this method. The condition analysis status in P.V. and caused by constraints such as low voltage and low backup storage. If any defects of solar panels easily identify while using a centralized MPPT control technique. The Multi-level converter converts the DC input voltage to an AC output voltage, while the DC capacitor supplies the voltage source converter with a steady DC voltage. Between the VSC output and the Power System is a transformer. Also, a Back Propagation Neural Network is unidirectional in which information only flows in one way and is made up of many nodes in more than three layers, namely, input, hidden, and output and overall block diagram are shown in Figure 2.

3.1 PV Array

The sun is a massive source of energy that travels as electromagnetic radiation. These radiations can be classed as light, radio waves, and so on, depending on their wavelength. Visible light accounts for a relatively minor part of the sun's radiations that penetrate the planet's atmosphere. In solar cells, visible light generates electrons. Light of different wavelengths is used by different solar cells.

Electricity is generated via a solar power system that is connected to the utility grid. This photovoltaic system is linked to the operating system and consists of a solar panel, an inverter, and the equipment required to connect to the grid. Grid-connected systems are suitable for a wide range of applications, including residential ones. Commercial and large-scale grid-connected solar power systems are distinct from off-grid solar power systems. Grid-connected devices do not require battery backup since they immediately move to the linked utility grid when their energy generation exceeds their load (as shown in Figure 3). Residential grid-connected rooftop PV systems generally have a capacity of around kilowatts, which is enough to supply the majority of average residential demands.

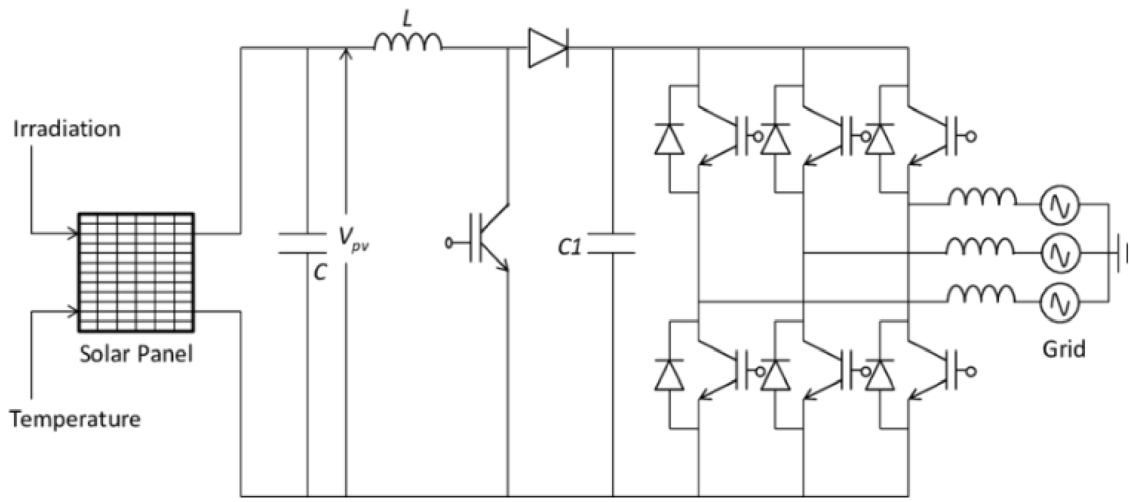

Figure 3 Circuit Diagram for PV-based grid-connected System**.**

The reactive power generator output must closely match the reactive power voltage level. The voltage in the system will rise with a leading power factor (induced by capacitive loads) and fall with a trailing power factor (caused by inductive loads). The network voltage may increase or fall to the point that generators must shut down to protect themselves, lowering generation and causing additional problems if reactive power is either under or oversupplied.

3.2 MPPT Perturb and observe algorithm (P&O)

Monitoring the voltage and current produced by PVA are the inputs to the MPPT system, and the MPPT algorithm's task is to establish the reference voltage. MPPT systems contain two control loops for maximum power. The inner loop contains both the MPPT algorithm block and the comparator used to generate the switching pulses. The external control loop includes the PI controller, which adjusts the converter's input voltage. The PI controller seeks to decrease the error between d V/d p generated by the MPPT block) and the output voltage of the DC-DC converter by adjusting the duty cycle. Except for the MPP, the MPPT block generates a non-zero error signal at the majority of operating points. This approach is simpler to use than alternative approaches, but it cannot follow the MPP when the irradiance fluctuates fast over time.

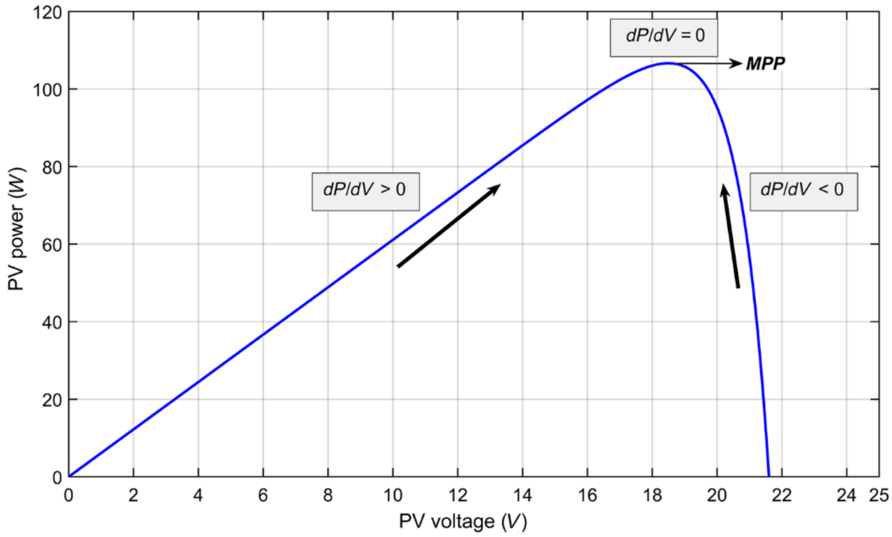

Figure 4 Graph Output of Perturb and Observe Algorithm (P&O)

Figure 4 represents the Photovoltaic (PV) systems, Maximum Power Point Tracking (MPPT) techniques are used to track the Maximum Power Point (MPP), which relies on panel temperature and irradiance conditions, continually. The problem of MPPT has been addressed in the field in a variety of ways, but due to its simplicity, the Perturb and Observe (P&O) maximum power point tracking algorithm is the most often used approach, particularly for low-cost implementations. The operating point of P&O oscillates about the MPP at a steady state, consuming some of the available energy. Additionally, it is well known that the P&O algorithm can become confused during certain periods marked by rapidly changing meteorological conditions.

3.4 Back Propagation Neural Network (BPNN-PSO)

It is preferred that PV systems operate at the Maximum Power Point, which is the maximum power of PV systems for any irradiance and temperature conditions (MPP). To overcome undesirable effects on the output power, it is, therefore, conceivable to integrate a DC/DC converter with a computational system that will adjust the duty cycle following the search technique and implicitly the converter's input impedance until the system meets the MPP. Maximum PowerPoint Tracking is the method used to look for this operation point.

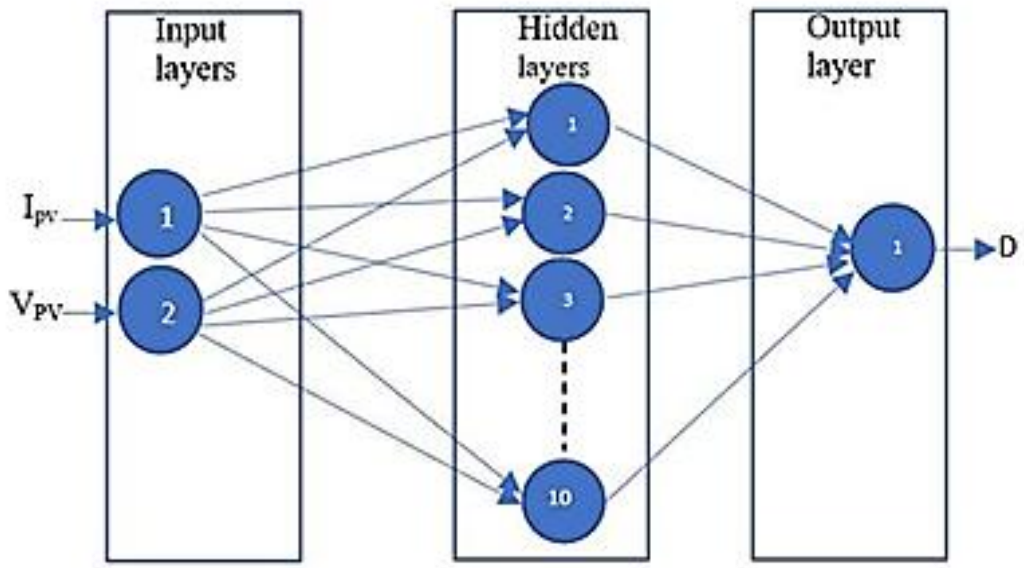

Figure 5 Working Principle of Back Propagation Neural Network

The PV current d p and voltage d V PV systems recorded at various temperatures and levels of irradiation are the inputs to the network in the first layer. The second layer, the hidden layer, has ten input layers that receive information from the input layer and relay it to the output layer. The third layer is the output layer, which consists of one action potential duty cycle (D) with a linear activation function. The sigmoid functions are its activation functions.Figure 5 shows the working of the BP-PSO technique, which combines the local search capability of the BP neural network with the global search capability of the PSO. The prediction of problems in the PV array can be done more quickly by using this hybrid technique. This combination, together with the concept of incorporating the PSO into deep learning, results in high-efficiency fault-type prediction, which is regarded as a significant addition.

In the training phase, the PV array's voltage d and P current d V, which correspond to particular solar radiation and ambient temperature conditions, are employed as the ANN's input variables, while the duty cycle D is chosen as the output. This data set was collected via the P&O method simulation of the PV array in Mat-lab/Simulink. Using the Toolbox in Mat-lab, a neural network may be constructed, trained, verified, and tested. The data set has been divided into three sections: 70% for training, 15% for validation, and 15% for testing.

3.5 Multi-Level Inverter

Figure 6 The main principle behind this inverter is the use of diodes, which give varying voltage levels to capacitor banks linked in series via various phases. A diode relieves the load on other electrical components by transmitting just a small amount of electricity. The maximum output voltage is half of the DC input voltage. It is the major defect of the diode-clamped multilevel inverter. This problem may be solved by increasing the number of switches, diodes, and capacitors. Due to capacitor balancing issues, they are limited to three tiers. This type of inverter is more efficient due to the common frequency used by all switching devices and the simple back-to-back power transfer technique.

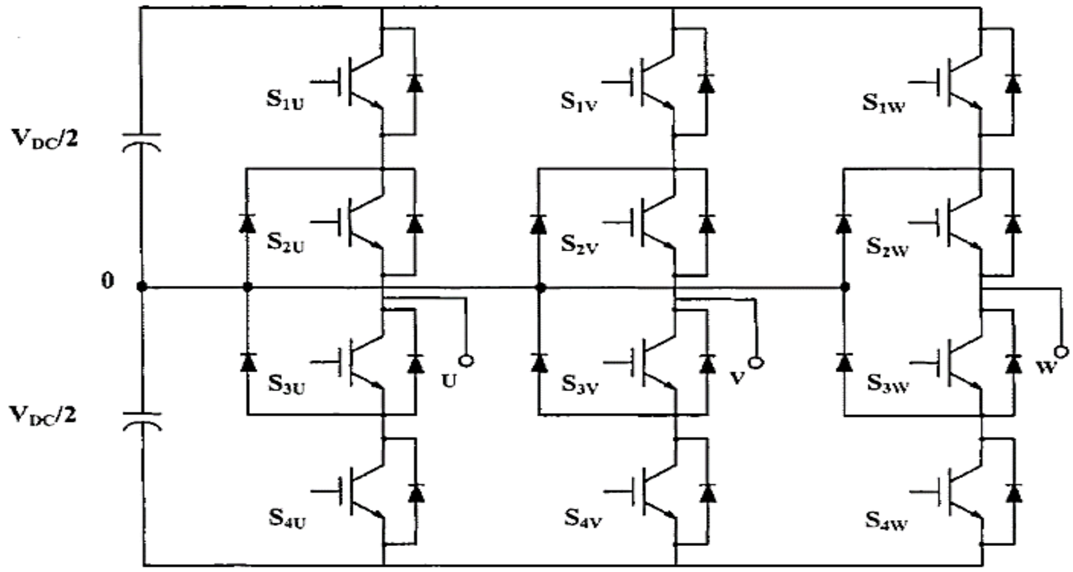

Figure 6 Circuit diagram of Multilevel Inverter

A variety of power semiconductors and capacitor voltage sources are used in multilevel inverters to produce voltages with stepped waveforms at their output. The three-level inverter is where the name "multilevel" originates. The output voltages have more steps, or a staircase waveform, with less harmonic distortion when the inverter's level count is increased. Compared to a traditional two-level inverter using high switching frequency pulse width modulation. A multilevel inverter's primary selling point is Low stress (DV/DT) Multilevel inverters can lower the DP and $d_v$stresses in addition to producing output voltages with extremely little distortion. 2) Common-mode voltage (CM voltage): Multilevel inverters generate less CM voltage

3.6 Filter and Gird Output

At the point of common coupling to the grid, active front-end converters are utilized to enhance the power quality of drives and semiconductor loads. These converters are often connected to the grid using a straightforward first-order low-pass filter. However, such a filter would not be able to connect harmonic loads to the grid in accordance with regulatory standards because it would be cumbersome and ineffective. The design process for higher-order filters (LC, LCL) for medium to high-power three-phase converters are covered in this work. The results are generalized at medium power levels because the design calculations are based on per-unit values.

The essential components of a renewable energy system are filters. L-type first-order passive filters are typically used to regulate grid-connected inverters. This sort of filter's drawback is its large size. LC filters are a different class of passive filters (second-order). The size of this filter is large due to the large size of the inductor. Additionally, LC filters include resonance frequency and time delay as downsides. In applications exceeding several kilowatts, a third-order LCL filter has a lower cost and smaller size compared to a first-order and second-order filter. Frequency range is still a problem with these filters, though. The two alternative current control strategies for three-phase grid-connected inverters based on LCL filters have been thoroughly examined in this work.

4. Result and Discussion

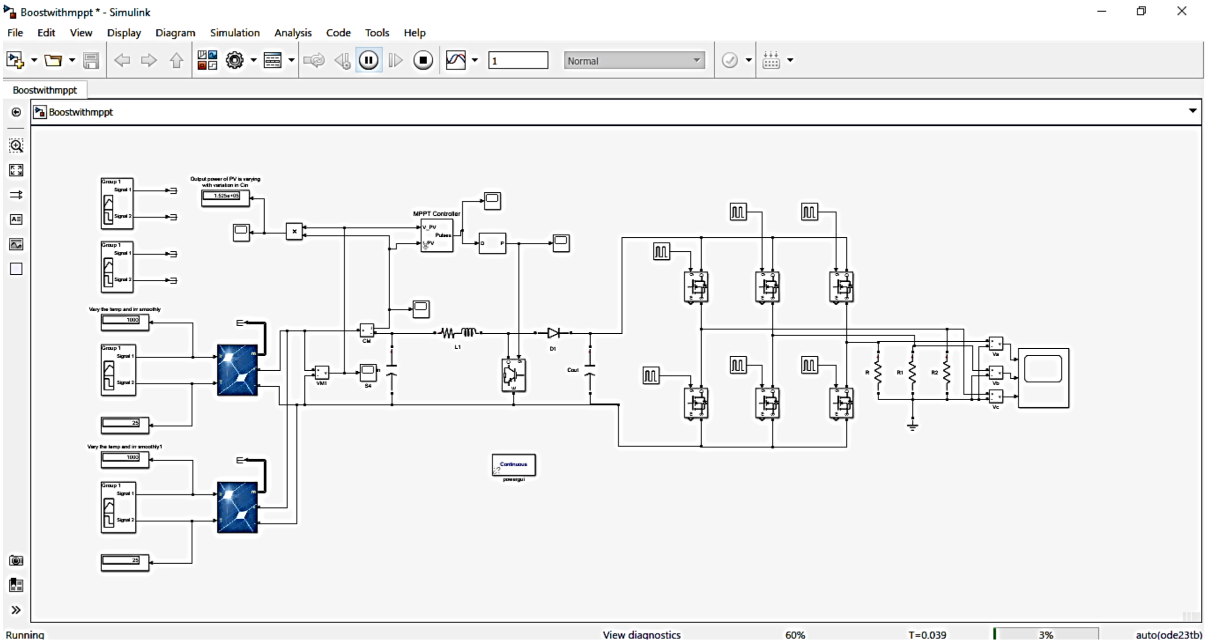

Figure 7: Simulation Implementation of Proposed Method

Simulation is made using MATLAB/SIMULINK is shown in Figure 7, Circuit diagram is made using blank model of MATLAB and using power-GUI, simulation is executed. By switching properly using a pulse generator, output voltage levels can be generated. An input voltage of 20 Volt is given as voltage at the input side. The pulse generator is set with a switching frequency of 50Hz and the corresponding switching is given Output voltage waveform and gate pulses are observed.

Figure 8shows Photovoltaic modules or panels made up of numerous basic cells that are modelled. The word array will henceforth refer to any photovoltaic device made up of many basic cells. Because the power provided by a single module is rarely sufficient for commercial usage, modules are linked to form an array to supply the load. The connections between modules in an array are the same as those between cells in a module. Modules can also be linked in series to raise voltage or in parallel to boost current.

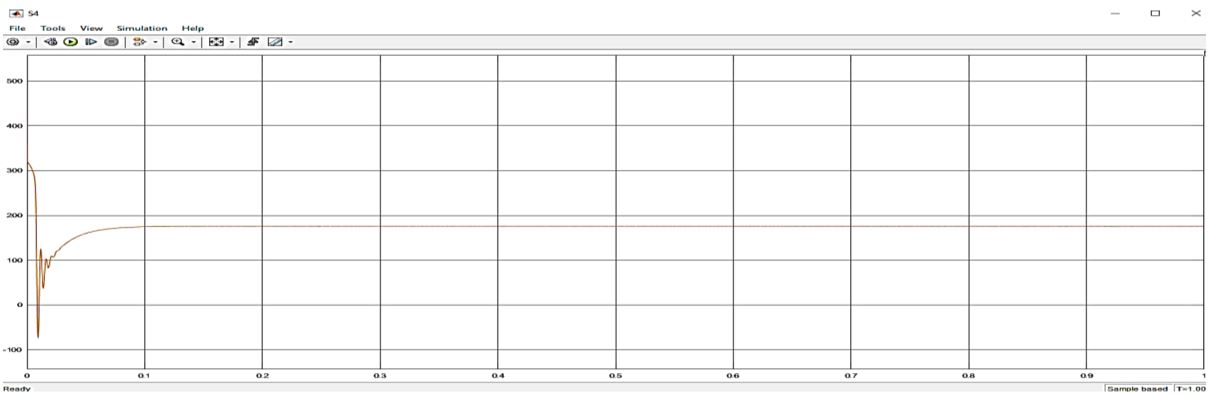

Figure 8: PV output wave from

The Neural Network algorithm, one of the finest indicators to assess the correlation of variables in the neural network algorithm, retains all of the information acquired from the network throughout the variable screening phase and may eliminate the impact of variables that interfere with the model. Additionally, the (PSO) practical swarm optimization method may quantify the significance of the influence of independent variables in the model to enhance the analytical effect of the model and represent the matrix change of the weight of each variable in the neural network. As a result, using the algorithm to evaluate the risk factors for hypertension in the area, this work proposes a hypertension risk prediction mode based on the PSO-BP neural network and Figure 9displays the mat lab circuit diagram of Back Propagation Neural Network (BPNN-PSO).

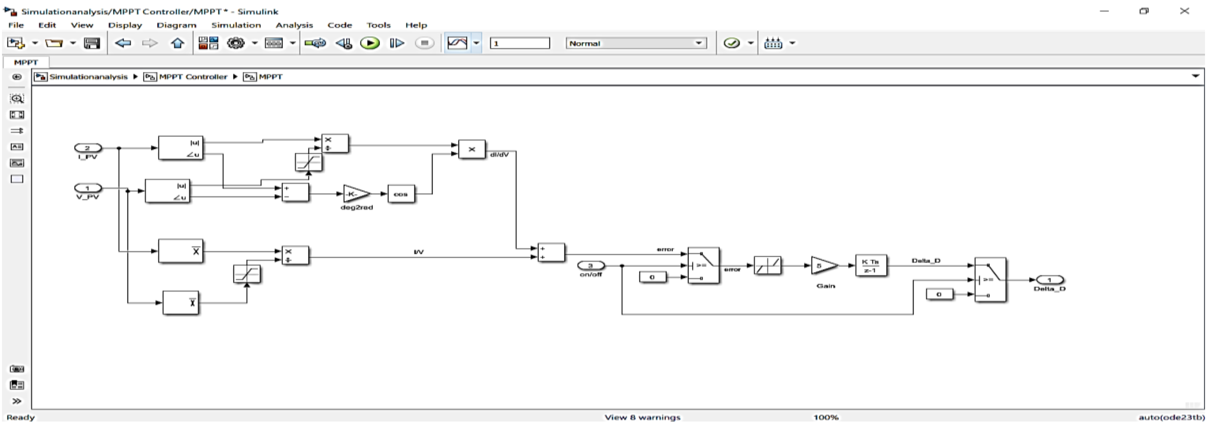

Figure 9. Mat lab circuit of Back Propagation Neural Network (BPNN-PSO.

In industrial settings requiring high power and medium voltage, multilevel inverters are employed. Multilevel inverters (MLIs) produce high voltage levels while also having less harmonic distortion than a typical inverter. The creation of high-quality wave-forms can be aided by the synthesis of many voltage levels. There are three different types of MLIs depending on the components employed. Multilevel Inverter uses the least amount of parts—such as capacitors and diodes—among the three. Figure 10 provides five levels of voltage as an output, the system also needs two voltage sources and eight switches, which adds to its bulk and cost. A modified multilevel inverter with fewer switches and the use of a renewable energy source.

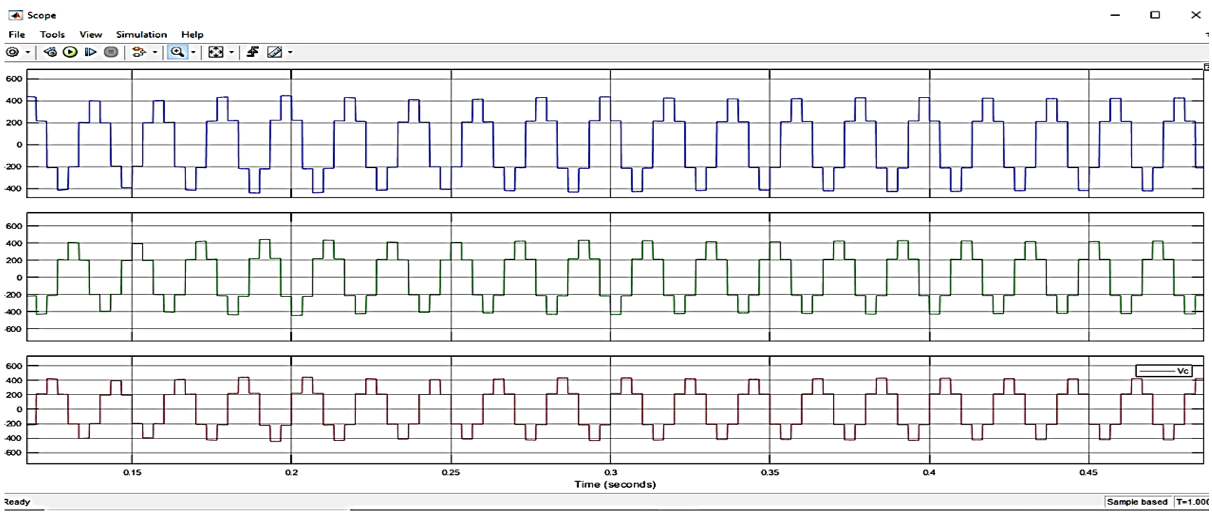

Figure 10 Simulation Output Waveform

In the proposed method we will reduce the total harmonics distortion the gain level of the THD is 1.02 % when compared to the existing 4.32 % and displayed below in Figure 11.

Figure 11. THD (Total Harmonic Distortion)

5. CONCLUSION

The P&O algorithm for the MPPT method and Back Propagation Neural Network (BPNN-PSO) are evaluated in the proposed work. The outcomes of every instance observed during testing demonstrate that perturb and observe algorithm (P&O) techniques effectively enable the practical swarm optimization algorithm in achieving the MPP (Maximum Power Tracking) when the PV system is undergoing the Peace process, leading to a higher power extraction. To calculate, the category of failure that occurs in the PV system, the proposed algorithm of the BP-PSO neural network was used. The test data are normalized before being utilized as inputs to the input layer, where training takes place.

The linear function is then used in the training layer, where learning and classification mechanisms are carried out. The PSO layer is then used to process the PV system fault data to classify the faults. The simulation outcomes show that the proposed method improves continuity and has improved accuracy.

5.1 Future Scope

As was already said, the PSO-BPNN prediction model outperforms the ordinary BP prediction model in terms of prediction performance and predicts outcomes more accurately. Its mistake rate is likewise rather consistent.The PSO algorithm is a typical meta-model swarm intelligence method. The swarm intelligence algorithm's theory and application have made considerable strides in recent years. The current study forecasts models to find a better and more wonderful way to raise the model's prediction precision and create a new strategy for enhancing rainfall prediction accuracy.

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