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# POWER QUALITY IMPROVEMENT OF A THREE PHASE GRID CONNECTED PV SYSTEM WITH ARTIFICIAL NEURAL NETWORK

**Nishal. K. M[1], Pravin. P[2], Dr. C. Arul Kumar[3], Mr. R. Sathish Kumar[4]**

[1]P.G. Student, Department of EEE, Paavai College of Engineering, Pachal, Namakkal – 637018.

[2]P.G. Student, Department of EEE, Paavai College of Engineering, Pachal, Namakkal – 637018.

[3]M.E., Ph.D., Associate professor, Department of EEE, Paavai College of Engineering, Pachal, Namakkal – 637018.

[4]M.E., Ph.D., Assistant professor, Department of EEE, Paavai College of Engineering, Pachal, Namakkal – 637018.

***Abstract*** A three-phase Photovoltaic (PV) plant with grid-connected output that uses the Incremental Conductance Method and Maximum Power Point Tracking (MPPT). Due to interactions between different semiconductors and variable loads, the input source contains harmonic distortion, voltage sags and swell, and other power quality problems in the previous convolutional method. The proposed method having dual Photovoltaic (P.V) based ANN (Artificial Neural Network) system for improving the delivery of as much power into the grid as possible without sacrificing power quality. A PV module converts solar energy into electricity. Fixed collectors and tracked collectors are the two most common types of solar collecting. Partial shade problems and other unbalanced elements that typically impact PV arrays are addressed by the incremental conductance technique-based MPPT technology. The setup uses two PV panels and is built in series, with each PV cell having identical properties. The relationship between this PV array and various irradiation patterns may be utilized to forecast the PV array in question. The Artificial Neural Network technique is a suggested method for decreasing the Total Harmonic Distortion (THD) for improving convergence and accuracy rates. Simulated output analyzed such proposed strategies have a great efficiency moreover a high response time with excellent precision.

***Index Terms:*** *DC-DC converter, DC-DC Inverter, Low Pass Filter, Battery, MPPT, Artificial Neural Network.*

## 1. INTRODUCTION

Grid-connected output systems are made to convert as much solar energy as possible into usable electricity. Artificial Neural Network (ANN) and the Incremental Conductance Technique method are two recommended techniques interface with DC link controller with the reference voltage in a variety of situations. Maximum power point about dual Photovoltaic set remains automatically detected using this method, which employs an ANN algorithm and a predetermined number of power assessments about Photovoltaic method. With use of such technique, features may be automatically extracted from the I-V curve, irradiance, and temperature.

Utilizing PV cells and regulating them to our wants is the typical technique about capturing this solar energy. The implementation of power management mechanisms known as Maximum Power Point Tracking (MPPT) systems is increased and the effectiveness of solar module operation, making it useful in the field of using renewable power sources. Solar energy technologies have grown to be an important source of power for many applications. The amount of electricity produced from photovoltaic cells varies significantly regarding climate conditions, so this becomes a major problem for solar energy production technologies. The rate of conversion of electrical energy production is fairly low (9–17%), particularly in lower irradiance scenarios.

The V-I characteristic of photovoltaic cells is also not linear and then varies with temperature and radiation. A unique point on the V-I or V-P curve is known as the Maximum Power Point (MPP), when the whole photovoltaic (PV) system operates most efficiently and produces its most electric energy. Since the MPP's location is unknown, it can be located by computation models or search techniques. The temperature and amount of solar irradiation have a big impact on how much electricity a PV array can produce.

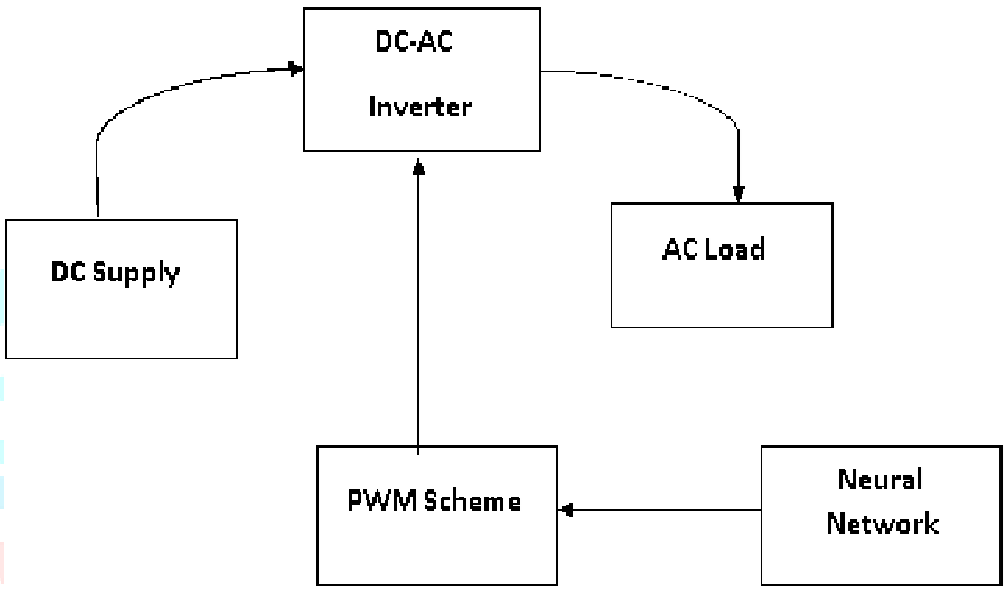



Figure 1 Basic Functional Diagram of DC source-based Neural Network

For photovoltaic arc may utilized to identify a single attest, called as maximum power point (MPP), for each solar irradiation and temperature condition. By MPP, it is determined that the PV array generate high power. Providing a maximum power point tracking (MPPT) technique to identify MPP seems possible by managing DC-DC converter linked towards the photovoltaic module.

As much solar energy as feasible is converted into actual power (current entering the grid at a voltage synchronized with the utility-defined voltage) via grid-connected PV power system configurations. This design objective is suitable for a technology that lacks the installed capacity to approach the normal loads supplied by the infrastructure of the electric power utility. Basic Functional Diagram of DC source-based Neural Network is shown in Figure 1. However, as this technology's ability to produce electricity increases, this presumption will eventually cease to be valid, and PV power systems will need to offer more and more grid support services and be more involved in utility dispatch and operating procedures.

*1.1 Objective*.

- To evaluate the efficiency and effectiveness of various soft computing-based MPPT approaches in increasing PV system efficiency and performance:
- The second goal is to list the benefits and drawbacks of various MPPT strategies based on soft computing.
- The study will evaluate the efficiency of various strategies and pinpoint the elements that restrict or enhance their performance.

## 2. LITERATURE SURVEY

In this study a Photovoltaic-fed non-isolated energy conversion method, a photovoltaic PV cell with a triple diode model relationship is taken into account. If compared with various photovoltaic cell structures, the benefits of the triple diode circuit type solar PV cell include superior performance, an increased consumption factor, with greater extracted output voltage. [1]. The neural network shall be programmed whenever the difference in predicted and output power is greater than a threshold determined on the basis of system dynamics and requirements. The specific design of the PVUSA model based network on grey boxes requires considerably shorter training periods compared to typical Black Box Network models. The prediction scheme an advantage of updating the prediction model parameters from frequent training of neural networks with the change in metrological variables [2].

Analytical derivations using the line impedance for a distribution network with PV are used to study how the position of the PV affects the network power losses and voltage variations. Analyzed are optimization strategies for the PV site that take into account the minimization of voltage variations and network power losses. For the purpose of pinpointing the placement of the PV, a particle swarm optimization (PSO) method is utilized to provide an ideal compromised solution [3]. The photovoltaic (PV) system, loads, and storage system make up the micro grid employing master-slave control, which may be used in either grid-connected mode or islanded mode. Since the master Distributed Generator (DG) uses a different control algorithm depending on the mode of operation, a transitory, decline in voltage and active power output of the micro grid system occurs when the mode is switched [4].

In addition, terminal voltage fluctuations on the MPP lead to a loss of power. To compensate for such fluctuations, it is possible to use the minimal disruption phase size. Again, the minor phase slows down algorithms that start to be transient and adjusts system weather responsiveness [5]. The P-V curve has many peaks under the Partial Shading Condition (PSC), in which certain modules get less radiation as a result of shading. To get the most power out solar-power setup, a Maximum Power Point Tracking (MPPT) algorithm seeks to identify total peak point under all conditions then adjust array's voltage or current to this point. In order to regulate the array's voltage or energy consumption, it is common to use a DC/DC converter as interface between an array and its load. [6].

As a direct consequence, the impact of harmonic distortion on industrial power systems has also increased. This is based on real harmonic studies of 480V, three phase, variable speed drives and the effects of harmonics on transformers in these systems. The recommendations on how to correct problems caused by the distortion of sound are also included. [7]. It is recommended to correct voltage violation queries when lowering network power loss using the real-time combined central and local Volt/Var control (VVC) technique. The Centralized Controller (CC) executes load flow and optimal power flow operations based on historical PV and load data to get various voltages with the most efficient power configuration for each photovoltaic (PV) array. The Local Controller (LC) uses those idealized scatter to create voltage control curves. To increase the voltage control impact, a special 3-Dimension voltage control curve was created. [8].

Maximum Power Point Tracking (MPPT) although methods involving artificial neural networks and fuzzy logic controllers produce sufficient outcomes, they come at the cost of increased memory and processing strain. Recent attempts to monitor optimal PowerPoint by including exploration and exploitation of natural phenomena have shown good results by avoiding convergence to local maxima and putting less stress on the processor. [9]. A battery energy storage system (BESS)-based voltage restoration control (VRC) that may be utilized for both voltage correction and support power supply. When there are utility disruptions, voltage restoration is a crucial responsibility for The small grid's power management. One of the disruptions is a short circuit on the micro grid's power line, which might create voltage sags or even a blackout of the system. In order to address this problem, the recurrent wavelet Petri fuzzy neural network (RWPFNN) controller is discussed in this study for the VRC of BESS. It provides a rapid control response to lessen the transitory impact. [10].

A cutting-edge architecture known as fuzzy convolution mixes convolution techniques and fuzzy logic at the microscopic level. We create a network known as the Hybrid Fuzzy Convolutional Neural Network (HFCNN) by combining the fuzzy convolution with the conventional convolution. When compared to convolutional neural networks (CNNs), HFCNN can enhance accuracy with fewer parameters by addressing the uncertainties of PV cell data, allowing us to use our technology in smart cameras [11]. This evaluation is primarily concerned with inverter technology for joining PV modules to a single-phase grid. According to the number of power processing stages in cascade, the type of power decoupling between the PV module(s) and the single-phase grid, the use of a transformer (either line or high frequency), and the type of grid-connected power stage, inverters are divided into four categories. The needs, longevity, component ratings, and cost of several inverter topologies are described, contrasted, and assessed [12].

The various methods for tracking photovoltaic (PV) arrays' highest power points are explained. The procedures are based on literature that dates back to the first techniques. It is demonstrated that there have been at least 19 different approaches introduced in the literature, with several implementation changes. This article should be used as a reference for further PV power generation [13]. For solar systems that are linked to the grid, there are two maximum power point tracking techniques. To evaluate the performances of photovoltaic systems, the optimal perturbation and observation and incremental conductance operating conditions are examined. With the optimal modification of the sample rate and perturbation size, these approaches may be made better [14].

A maximum power point tracking control of photovoltaic array using fuzzy control; the controller only uses the output power. Thus, the implementation of this control method in a genuine system is easy. Furthermore, even if an optimum operating point is modified, this method may rapidly determine the maximum power points by means of fuzzy inference. Experiments conducted using a step resistive down helicopter with continuous rod confirm the usefulness of this control method [15]. It uses IGBT's Source Voltage Inverters for parallel active filtering. The control algorithm is derived from the detection of line voltage and load current by means of an assessment of active and reaction power. The power is divided according to its average and alternate components by the use of appropriate low pass filters. Consideration is given to the time patterns and frequency spectrum of the resulting line currents, with respect to features in relation to certain specific techniques for control [16].

Maximum energy from solar arrays to the grid for all sunlight conditions, and also at the same time creating power conditioning which will control distortions in transmission lines. To maximize the output of inverters from photovoltaic arrays and to prevent current harmonics in electricity lines, a new monitoring strategy based on single inverter configuration has been developed. [17]. For PV (photovoltaic) power systems linked in parallel with the AC system line, a new MPPT (maximum power point tracking) control technique. Its distinctive feature is the use of power balance at the DC link under steady-state circumstances, which eliminates the need for an array output power detector and results in functioning without one [18].

The DC-DC converter uses a fuzzy logic controller (FLC) to extract the PV panel's peak power point, after which the FLC generates a switching signal for the DC-DC converter. In the voltage source converter (VSC), a unit vector template (UVT)/adaptive linear neuron (ADALINE)-based least mean square (LMS) controller is used [19]. Artificial neural networks (ANN) and genetic algorithms (GA) are used to control solar sources. Additionally, the ANN and GA are employed for tracking the maximum point. Data are optimized via GA, and the best results are then utilized to train neural networks [20].

A. *Problem Statement*

- Variations in electrical energy are generated by the random nature of a solar array.
- This volatility is affecting the stability and energy quality of electrical power systems.
- In order to enhance the energy quality of Solar Power Systems, a new and comprehensive approach based on optimization techniques should be developed.
- Consequently, the utility grid is of considerable concern because it presents a threat to the system as far as THD, voltage control and stability are concerned given the high level of penetration of photovoltaic energy in distribution systems.

## 3. MATERIALS AND METHOD

Depending on module temperature, solar isolation, load change, etc., the output power of the two photovoltaic solar PV modules varies. To control the output power of the three phase grid connected PV system according to the output power of the PV arrays. A dual photovoltaics system, in conjunction with the ANN Artificial Neural Network, providing grid voltage support and compensation of Harmonic Distortion at a time when Incremental Conductance method is applied. A Maximum Power Point Tracking (MPPT) method that depends on the gradually increasing conductance technique and has been especially altered to regulate the phase of the photovoltaic (PV) inverter voltage is used to regulate the electrical power output of the photovoltaic panels. A DC to DC converter is then used to further regulate the photovoltaic panel's results. A simulation circuit with MATLABSIMLINK is developed to investigate the performance of a control circuit. The simulation results at Mat Lab demonstrate that the current method is more efficient.

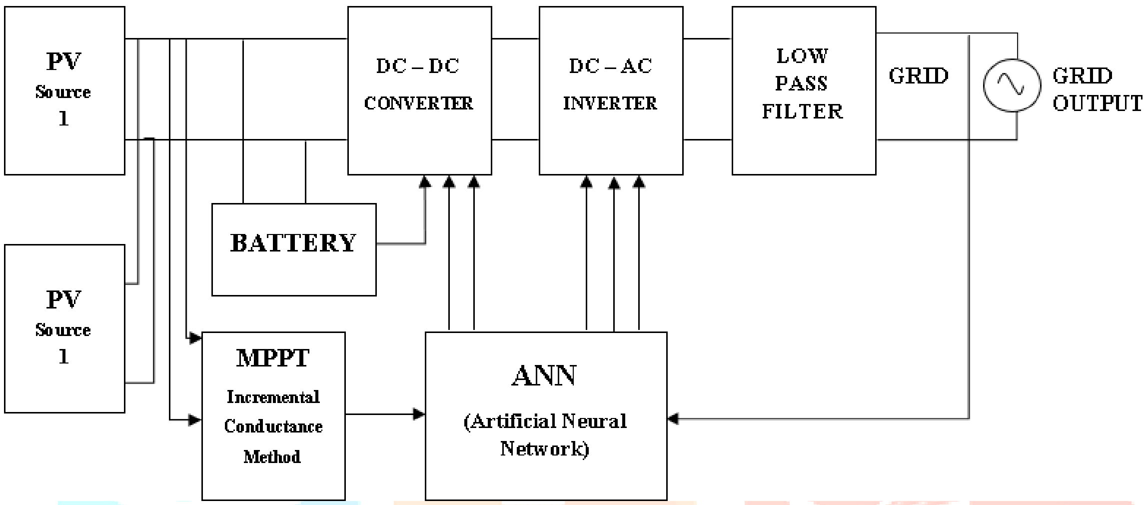



Figure 2. Block Diagram of a Three-Phase Grid-Connected Photovoltaic Systems with an Artificial Neural Network Improving the Quality of the Energy

Systems that are linked to the grids are useful in numerous arrangements, such as those for residential use. Grid-tied arrangements that are residential and of greater size are distinct from off-grid solar power systems. A Block Diagram of Power Quality Improvement of a Three-Phase Grid- Connected PV System with Artificial Neural Network was shown in Figure 2. Residential grid-connected rooftop PV systems typically have a capacity of approximately kilowatts, which is sufficient to power most typical home needs.

### *3.1 PV Array*

The generator output of reactive power must closely match the voltage level of reactive power. A Circuit Diagram for PV-based grid-connected System was shown in Figure 3. The sun's a big source of energy, which comes in the form of electromagnetism. These radiations can be distinguished from light, radio waves and so on depending on the wavelength of their release. Most of the solar radiation that passes into our planet's atmosphere is visible light. The electrons created by those visible light will be generated in photovoltaic cells. Light with a broad range of wavelengths is used by the different Solar Cells.

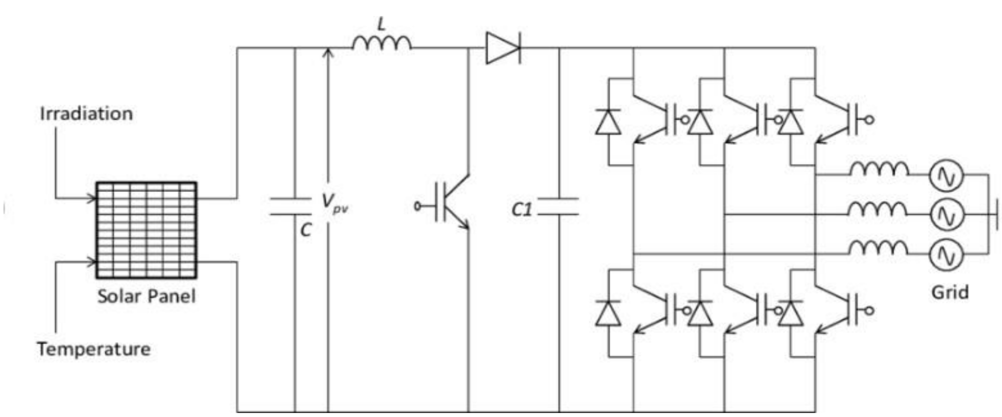



Figure 3. Circuit Diagram for PV-based grid-connected System.

*3.2 Incremental Conductance MPPT Algorithm*

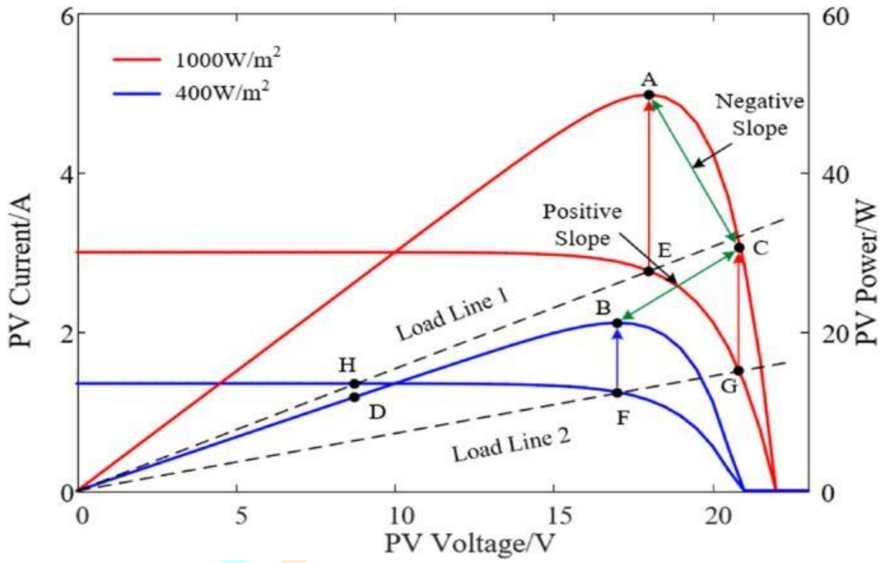



Figure 4 Performance of Incremental Conductance MPPT Algorithm

In order to increase the efficiency of photovoltaic panels, a technique for tracking maximum power points shall be used. According to maximum power transfer theorem, the power output of a circuit is maximum when the even in impedance of the circuit (source impedance) matches with the load impedance. Thus, the problem of detecting the maximum power point is reduced to being an impedance mismatch. The MPPT can be monitored using various techniques, but the Incremental Conductance Method IC is a method of measuring and comparing incremental and instantaneous conductance for PV modules to determine terminal voltage. The performance of each MPPT technique/algorithm/method was evaluated in terms of ease of implementation, cost of implementation, ability to detect multiple maxima, speed of convergence, and efficiency over a wide range of power outputs. A Performance of Incremental Conductance MPPT Algorithm was shown in Figure 4.

*3.3 ANN (Artificial Neural Network)*

Neural Network is most effective algorithm that has been implemented correctly in machine learning during the past improvement for a range of real-world applications (such as speech and handwriting recognition). The maximum power transfer theorem states, if an even in impedance of a circuit's conductor source is matched to its load capacity, it provides the optimum power output for that circuit. This may be described as a PC model that imitates the way that neural systems function biologically, learning from the data to achieve the intended outcomes. The primary advantage of the neural network algorithm is its capacity to handle nonlinear issues and determine outcomes through a very intricate relationship between inputs and outputs. Each neural network has three layers, each of which is represented by a node. Based on the systems, these nodes are frequently connected. A working principle of Artificial Neural Network was shown in Figure 5.

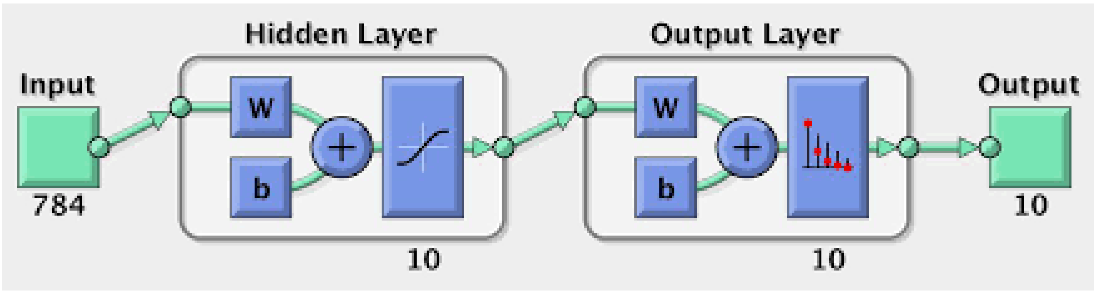



Figure 5. Working Principle of Artificial Neural Network

Through further connections, each of which is weighted, the output of this function is eventually sent as the input to more neurons. The network's functioning is determined by these weights. . As regards normal and abnormal operating conditions of the electricity system, faults to be addressed in subsequent sections entailing impedance from one line or two lines to the ground. The primary component to the creation of AI networks is referred to as 'artificial neurons'. They're performing the functions of biological neurons in the human brain, but they're doing them in a mathematical way, so they're able to deal with the various problems in different areas.

### *3.4 Filter and Grid Output*

At the location where the grid and common coupling meet, 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 also reduced 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. SIMULATION RESULT:

### *4.1 Simulation Diagram Of Power Quality Improvement Of A Three-Phase Grid- Connected Pv System With Artificial Neural Network*

Simulation is made using MATLAB/SIMULINK. Circuit diagram is made using blank model of MATLAB and using power-GUI, simulation is executed. By switching properly using pulse generator, output voltage levels can be generated. Input voltage of 20 Volt is given as voltage at the input side. Pulse generator is set with a switching frequency of 50Hz and corresponding switching is given and Output voltage waveform and gate pulses are observed. In Figure 6, the simulated diagram was showed.

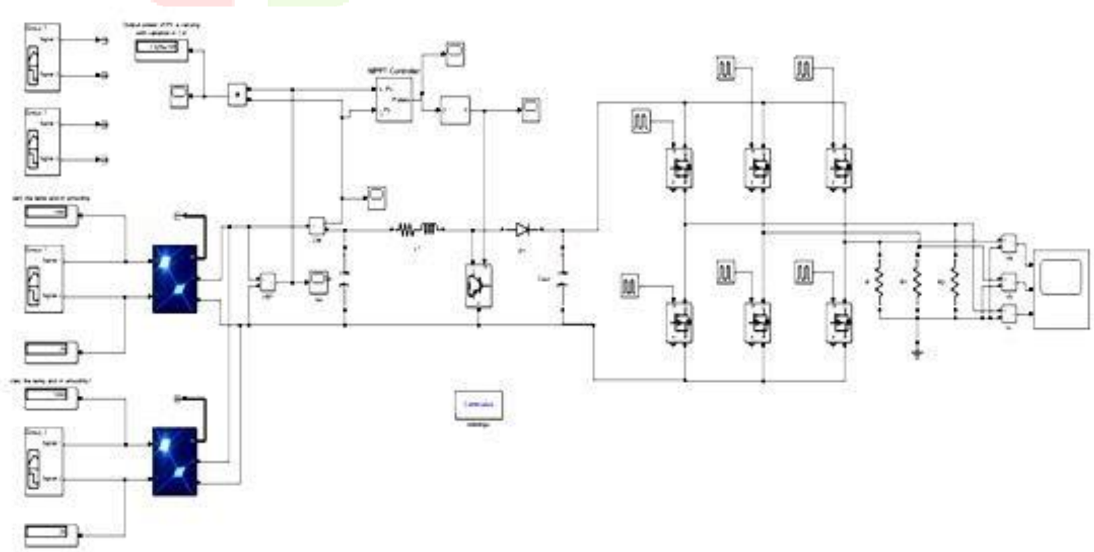
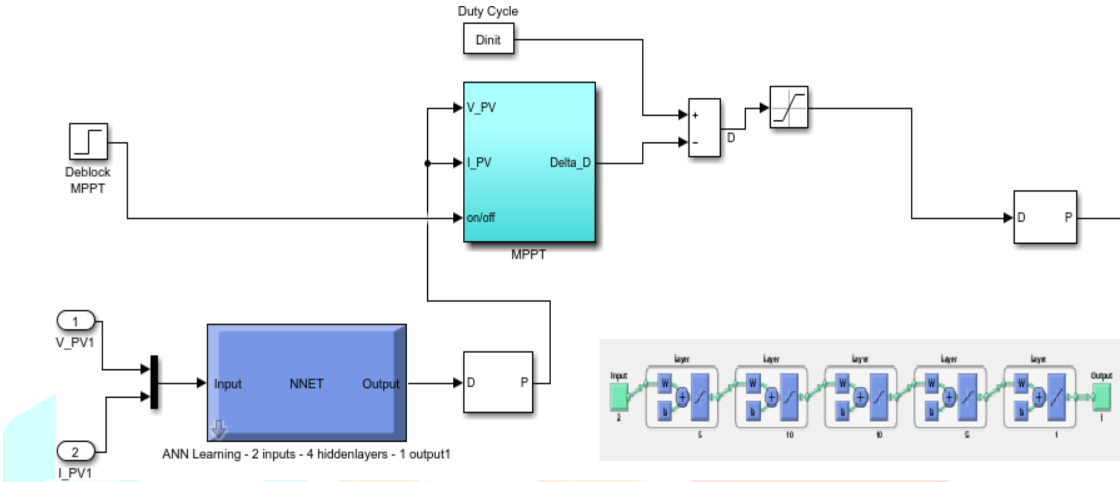


Figure 6. Simulation Diagram of Power Quality Improvement of a ThreePhase Grid- Connected PV System with Artificial Neural Network

The Artificial Neural Network (ANN), one of finest indicators to assess such 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, Using Incremental Conductance may quantify the significance of the influence of independent variables in the model in order to enhance the analytical effect of the model and represent the matrix change of the weight of each variable in the neural network. A MATLAB circuit of Artificial Neural Network was shown in Figure 6.2. 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 ANN- Incremental Conductance Method.

Figure 7. MATLAB circuit of Artificial Neural Network




## 5. RESULT ANALYSIS:

### *5.1 Non-Linear Load based Results*

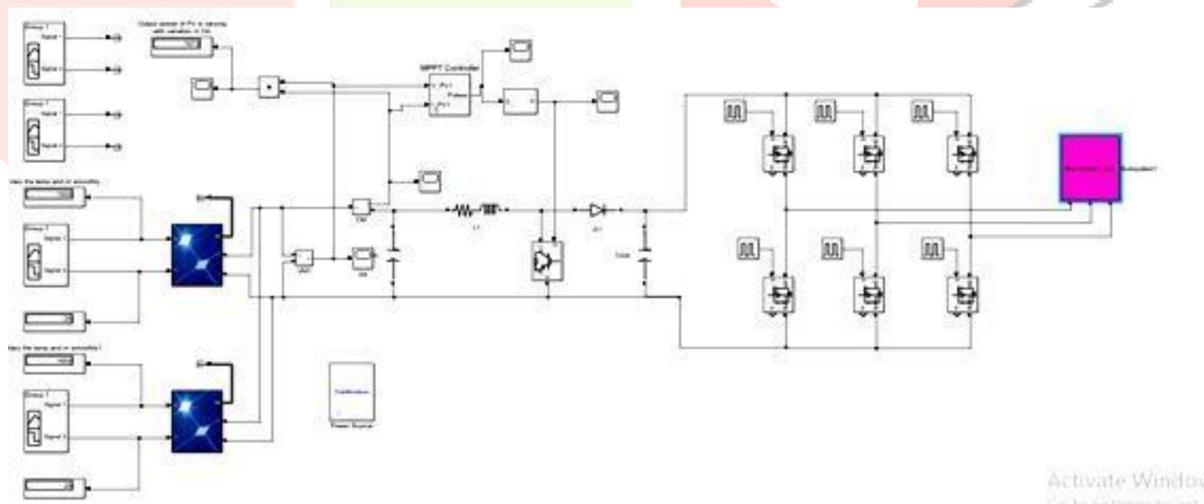


Figure 8. Non-Linear Load based Simulation Diagram

It is a circuit implemented by MATLAB software. Here a non-linear load isconnected as a load. The simulation diagram was shown in figure 8.

*DC Output Waveform*

The term "non linear" is used for AC load in which the voltage does not have an equal relationship with the current. Figure 9 shows an output waveform based on a nonLinear load DC. The voltage and current were in the Y axis, time was in the Xaxis.

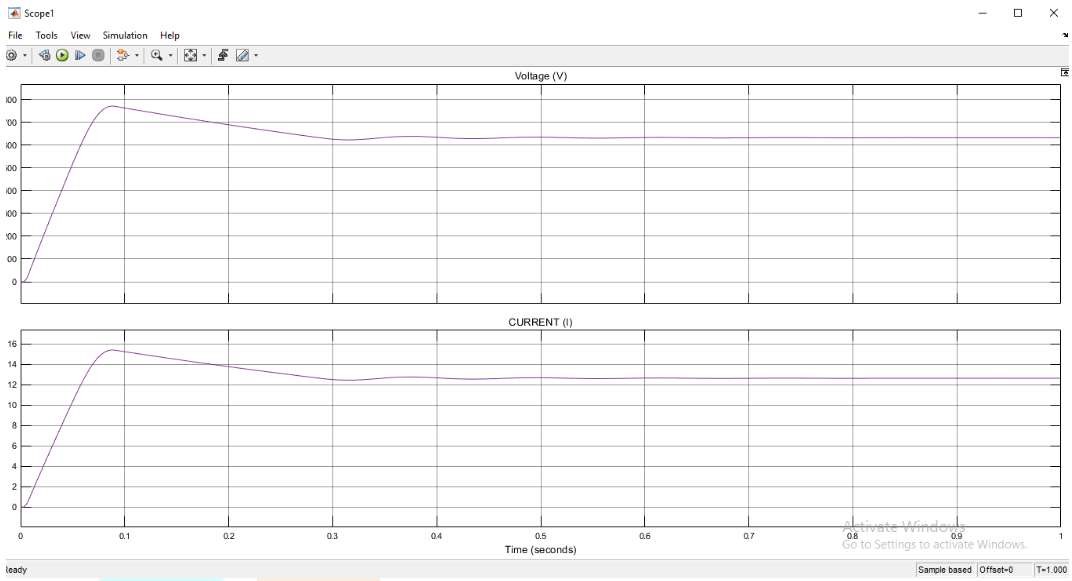



Figure 9. Non-Linear Load based DC output waveform

## 5.2 Linear Load based Results

**Simulation Diagram**

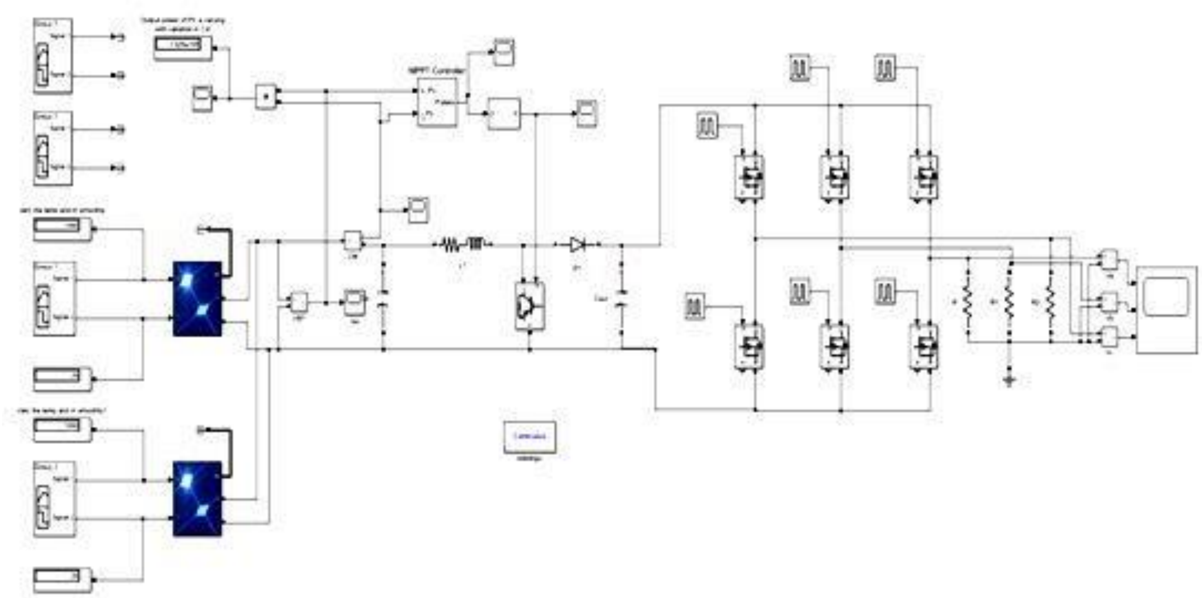


Figure 10. Linear Load based Simulation Diagram

*Output Waveform*

Linear loads are a term for an AC load in which the voltage and pulse rates are sinusoidal. The currents are proportional to the voltage at all times. A Direct Load based output waveform was shown in Figure 11. 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 waveforms can be aided by the synthesis of many voltage levels but in order to provide 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 renewable energy source.

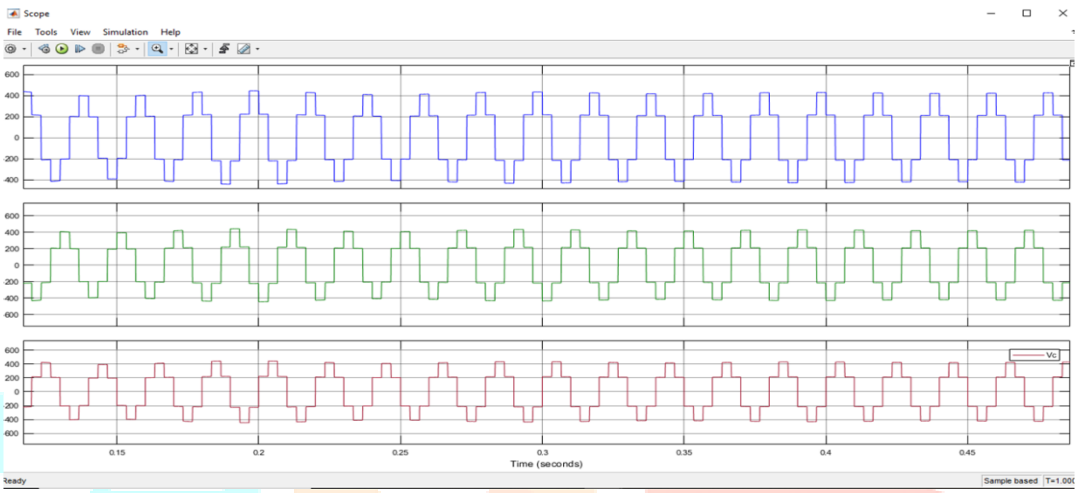



Figure 11. Linear Load based output waveform

*PV Output Waveform*

Models of photovoltaic modules or panels consisting of several basic cells. Any photovoltaic installation made up of a number of basic cells shall now be referred to as an array. For commercial use, the power produced by a single module is rarely sufficient, so modules are connected to form an array to supply the load.

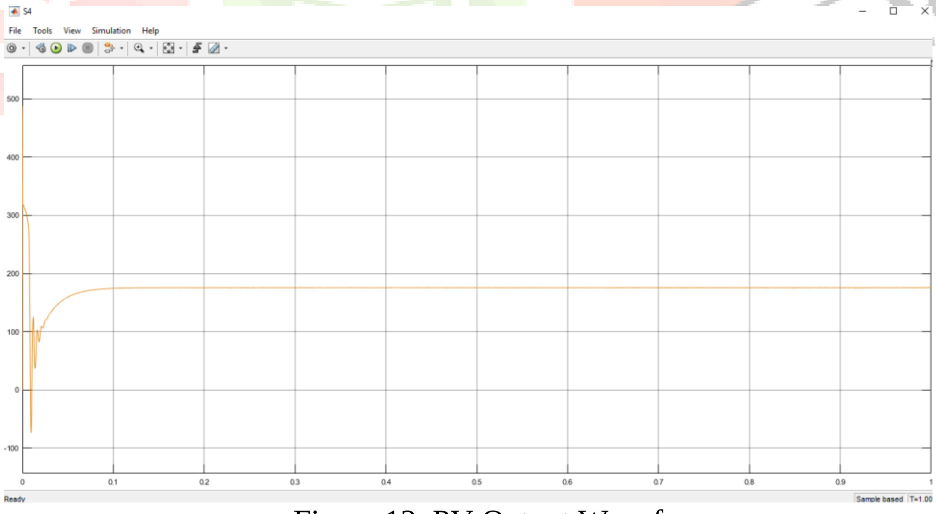



Figure 12. PV Output Waveform

The modules in the array are connected to each other exactly like cells on a module. To obtain higher voltage or at the same time to achieve high current, modules may be connected in series.

*5.3 Output of THD (Total Harmonic Distortion)*

*THD on Proposed Method-I (Back Propagation Neural Network (BPNN-PSO))*

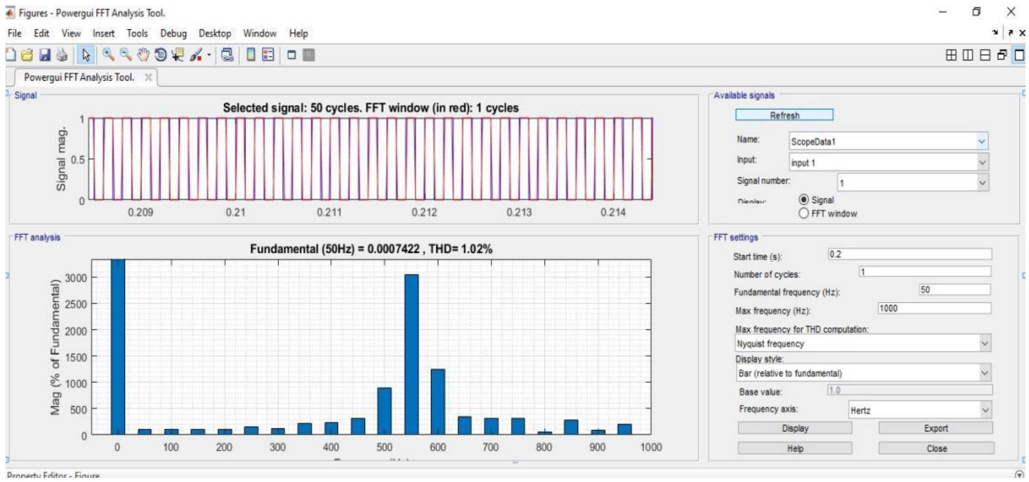



Figure 13. Output of Proposed method-I THD

In this proposed method-I has the gain level of the THD is 1.02%. The outputof proposed method-I was shown in figure 13.

*THD on Proposed Method- II (Artificial Neural Network (ANN))*


Figure 14. Output of Proposed method-II THD

In this proposed method-II has the gain level of THD is 0.75%. The output of proposed method-II was shown in figure 14. This proposed THD is improved when compared to proposed method-I.

## 6. CONCLUSION:

The incremental conductance algorithm for the MPPT method and Artificial Neural Network are evaluated in the recommended work. Such outcomes from every instance observed during testing demonstrate that Incremental conductance algorithm techniques effectively enable the practical swarm optimization algorithm in attaining MPP (Maximum Power Tracking) when photovoltaic method is undergoing 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 Artificial 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 Artificial Neural Network layer remains then utilized to process the photovoltaic method fault data to classify the faults. This simulation outcomes appearance of suggested approach improves continuity and improved accurateness.

### 6.1 Future Scope

- Protecting the environment, especially with regard to reducing carbon dioxide emissions.
- The current study forecast models in order 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.
- On the basis of the user's natural local potential, the possibility to combine two or more renewable energy sources.

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