Solar System Improvement With Maximum Power Point Tracking

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ABSTRACT
Similar to the majority of renewable energy sources, solar power is not a reliable source of energy. It can only be used or stored during the day. The PV array's MPP is hunted after by the user before it's distributed to the grid. The Maximum Power Point Tracking algorithm technique (MPPT) and the Perturb and Observe (P&O) method are two separate methods to track the MPP. The MPPT algorithm is employed in the undertaking to track the MPP. A method of controlling the improvement of the grid-connected hybrid system's power quality. A significant portion of the overall quantity of energy produced by alternative energy sources is made up of electricity provided by solar systems. This hybrid system is grid-tied and consists of batteries, fuel-cell-powered devices, and solar panels. Using this technique, electrochemical reactions and fuzzy gain tuners control the system's power flow. This technique can regulate reactive power, regulate voltage, and enhance power quality.

Keywords: Maximum Power Point Tracking (MPPT), Photovoltaic (PV), Fuzzy logic Controller and Artificial Neural Network.

1. INTRODUCTION

1.1 The challenge of this Project:

Based on the information congregated during the initial stage of the detection algorithm, a methodology for the identification of partial shadowing circumstances in Photovoltaic (PV) arrays is established. To identify the periodic Partial Shading Condition (PSC) and ascertain the ideal number of MPPT algorithm execution points during PSC, the frequent partial shading detection (PSD) issue is first addressed. To get the most power possible out of the PV array at the execution point, the second stage of the PSD issue addresses the Maximum Power Point Tracking (MPPT) problem. Determine the global maximum operating point under various partial shading situations to address the PSD issues.

*1.2 Objectives***:**

Applying the power generated by a PV array effectively is difficult due to its non-linear properties and dependence of its output power on the array terminal voltage for the same environmental conditions. Users get a PV array that is useful for achieving larger power output when many such PV modules are joined in series and parallel configurations. The need to enhance the materials and technologies used to capture this power source is driven by the growing number of uses for PV energy. The effectiveness of the PV collecting process is primarily influenced by storage methods, radiation intensity at the source, and PV efficiency. The materials used in PV manufacture have an upper limit on efficiency. The performance of the cell, which governs the effectiveness of the total collecting process, is extremely difficult to significantly enhance.

However, filter circuits are responsible for instability problems. As a result, using a Voltage Source Inverter (VSI) is difficult. When controlling a grid-connected, the current controller has an unplanned and inconsistent effect. The grid-connected systems' conventional single-loop control has been replaced with performance-based dual-loop control, also referred to as voltage and current control loops. The power loop determines whether a grid-tied system can accept the quality of electricity delivered to the grid. To connect the solar array to a shared DC bus while building the proposed system, a high-gain, and extremely efficient DC/DC converter should be employed. This type of converter improves voltage levels as well as productivity over prior types while decreasing switching and loading losses. However, the sun-based PV module's productivity is low. A most extreme power point tracker is anticipated to work the PV category at its highest power point due to the staggering cost of sun-based cells. The PV generator then produces the most power depending on three factors: insolation, load profile (load impedance), and cell temperature (environmental temperature).

When the area of the individual cells is increased, the current rating of the modules also increases, and vice versa. Over the past ten years, the production of renewable energy has increased due to rising global energy demand and environmental concerns. Because they have no emissions and are infinite, renewable energy sources like solar, wind, and hydro are becoming more and more popular. The development of PV energy dates back to its initial usage as a power source for space satellites which are making it a renewable energy source with a more rapidly rising market share. Commercial PV cells emerged as a result of expanded efforts in semiconductor material technology, making PVs a significant alternative to electrical power.

1.3 Need for Renewable Energy:

PV cells transform light energy into electricity, another type of energy. The conversion process halts or slows down when light energy is diminished or interrupted, such as when the sun sets in the evening or a cloud blocks the sun. The conversion process continues as soon as the sunlight appears again, and it does so without the need for moving components, noise pollution, radiation, or regular upkeep. Additionally, the influence of the integrated chokes' weak coupling and weak residual coupling on the filter's performance is investigated, as well as the electromagnetic decoupling model of the transformer-based filter design. To overcome the issues that emerge with traditional converters, micro-grid systems employ high-gain, high-efficiency power processing machines. In this study, a brand-new design for expensive-gain, more efficient power processing units is presented.

An inexpensive means to meet the high power demand is through solar photovoltaics. The cost of solar PV still has to come down, though, for it to be accessible to everyone. Depending on the area, the weather might vary sometimes. The amount of sunlight that Solar PV could be able to absorb is difficult to predict. This makes it challenging for humans to store energy for later use. Additionally, the peak radiation supply might not coincide with the peak electricity demand. Therefore, a method for efficient energy storage and recovery is needed.

A PV module, a dc/dc boost converter, a maximum power point tracking algorithm, and a load make up a solar PV system. The PV module receives incoming radiation (R). It produces current (I) and voltage (V) that are supplied into the load. Due to changes in atmospheric conditions, the voltage power characteristic of a photovoltaic (PV) array is nonlinear and time-varying. The output power of the PV module also varies with variations in temperature and solar radiation. The PV module must function at the greatest point of the PV characteristic to achieve optimal efficiency.

By using PV systems, the functioning of the power system may be improved, including the voltage profile, energy losses in the distribution feeder, and the load on the tap changer transformer during peak hours. There is a lot of progress taking place in PV technology. However, the system has some negative side effects and issues that limit its widespread use, including inadequate performance, harmonic pollution, over-capacity of the feeding systems, high investment costs, and low reliability. The maximum power point tracking (MPPT) controlling approach is employed to increase PV efficiency. With this technique, a PV panel's produced voltage and current can be used to control system power. In the event of unforeseen weather, there may be a greater chance of system failure.

2. Previous research work

A key component of PV power systems is MPPT. Several applications employ MPPT calculations for incremental conductance and hill-climbing algorithms. The two techniques monitor the PV array and identify progressions or variations in the amount of electricity generated. The irradiance has changed, which is what caused the noticeable difference. If there have been significant irradiance changes, the two approaches are prone to disappointment. Based on the single-diode mode, the extent of the PV system's performance through these methods is studied [1] – [5].

PV modules are connected in series, the string is least likely to flow current while it is shaded, which lowers the amount of electricity generated. Each module's output is coupled to a shunt-connected fly-back DC to DC converter, which has been developed into the new Distributed Maximum Power Point Tracking (DMPPT). On the secondary side, a power MOSFET and an anti-parallel diode are connected. There are two operating modes; the first is known as resonant MPPT mode and the second is typical fly-back mode. The PV source and grid are separated during tracking utilizing an output switch. This scheme's benefits include ease of implementation and appropriate payment [5] – [8].

For MPPT, there are two control strategies: direct maximum power control strategy and power-voltage-based control strategy. The T-S fuzzy model is used to define the two MPPT control plans to achieve maximum output. To implement asymptotic MPPT for PV power systems, the proposed control techniques are used. Gains for the observer and controller are achieved by solving the formulation or equation for the linear matrix inequality [9], [10].

The method offers numerous advantages, including the dependable arrangement of just one parameter and the significantly less complicated MPPT structure. The algorithm is run on a buck-boost converter and its performance is evaluated by contrasting it with a standard Hill Climbing (HC) MPPT method. The results demonstrate that it circumvents the HC strategy's shortcomings in trailing rapidly and precisely under varied partial shade situations. On a cloudy day with rapidly moving clouds and partial shade, a test is conducted. The output power demonstrates that the suggested method outperforms the HC method in terms of global peak tracking speed and accuracy in identifying the peak point under various Pcc [11]-[14].

A DC-DC converter must be connected to the grid to connect a PV-based power source, which raises the cost of operation. A more complex power conversion setup might arise from using these DC-DC and DC-AC combinations. A boosting inverter would be appropriate to lower the configuration. To enhance the PV cell's voltage gain, the power conversion and inversion should be completed in a single step. Due to its capacity to boost and invert on a single stage, a Z source inverter would be appropriate in such a situation [15] – [18].

Even when only a tiny portion of the solar PV panel is shaded, its performance is dramatically decreased. The overall power output of the solar panel is decreased because the power produced in uniform shadow is different from that produced under partial shade. The effects of partial shadowing and the resulting power loss can be lessened by connecting a bypass diode between the cells. These diodes provide a different path for the current coming from the evenly shaded area. The overall output is more than the power generated, even when a tiny amount of power is lost owing to voltage drop [19] - [20].

3. Materials and Method

As the switching device's voltage rating is only half that of the output voltage, this converter has increased power density, and efficiency, as well as expense decreases. The focal point voltage is Vo/2 because the capacitance of C1 and C2 is equal. Additionally, this lessens the voltage stress across the converters' switching components. Fig 1. In high-power rating PV systems with a high voltage gain, buck conversion with the regulator is required, and it maintains the DC bus voltage constant. Due to smaller input filters and current ripple withdrawal, buck converters with a broader range of voltage levels are more suitable for PV interfaces.

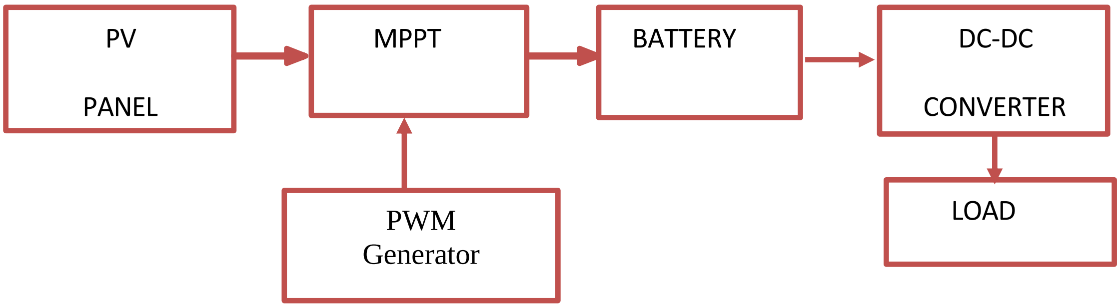

Fig 1. Simulated Block Diagram

3.1 Photovoltaic Cell:

Fig 2 represent the direct conversion of incoming solar energy into electrical energy is the fundamental tenet of solar technology. The two main subcategories of solar technology are photovoltaic (PV) panels and concentrated solar thermal power (CSTP). Mirrors are used by CSTP to collect ultraviolet radiation and focus it onto a receiver plate. A fluid in the receiver plate is heated by the focused power. Applications for CSTP include processing minerals, producing chemicals, and treating food. A PV cell is a device that collects solar energy from PV panels and uses it to generate electricity.

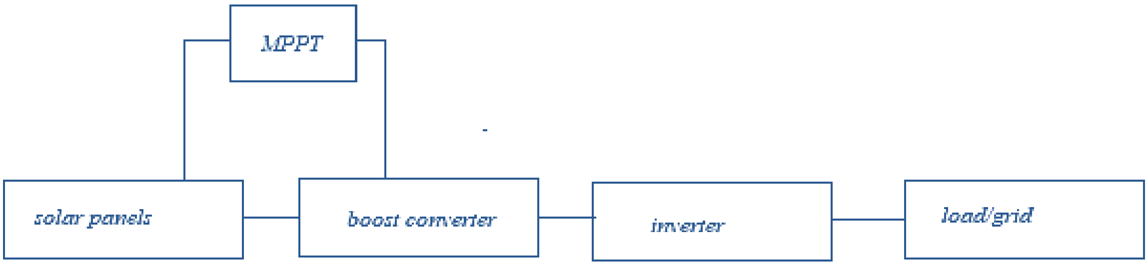

Fig 2. Diagram of Solar Energy Blocks

3.2 Perturb and Observe

In the P&O algorithm, perturbation is used to induce power variation. Periodically, the current and prior measured power values are compared. The process of perturbation continues if the measurement power increases; if not, the process is reversed. The solar PV array voltage is subjected to a disturbance in the suggested model. The system measures the output power by increasing or decreasing the voltage of the solar PV array. Power production increased every time the voltage was raised. This suggests that the solar PV array's functional point is located on the left side of the MPP. More perturbation is necessary to reach MPP. The voltage at which the machine operates is altered for each MPPT cycle.

3.3 DC-DC Converters

DC power is produced by renewable energy sources like PV panels, however, the output power is not constant because of the environment, irradiance, load, etc. In this case, a DC-DC converter comes in helpful and provides continuous output power by adjusting the PV panel's voltage level. Initial PV panels to employ DC-DC converters date back to the s, but in recent years, the rising popularity of PV panels has drawn researchers from all over the world to design, evaluate and create new, effective architectures and control strategies for DC-DC converters. Power converter innovations have accelerated several improvements in the electric field. The majority of DC-DC converter research focuses on increasing converter productivity, and lowering the number of fields.

3.4 Battery

The battery serves as the primary energy storage device, while the charger uses power from the mains to charge the battery. A DC voltage level is used to run the motor, and an electronic power converter inverts the current to provide a switch-decision signal. Using a DC-DC converter, and lowering the voltage from the rechargeable battery, other electronic components in a car can be operated. To get the most out of the lithium-ion battery, a charger is required. A charging cable's efficiency and dependability, weight and price, charging time, and power density are all noteworthy features. The Battery Management System (BMS) is a vital part of electric and hybrid vehicles. The BMS's responsibility is to guarantee the battery's dependable and safe operation. To guarantee the stability and security of the battery features such as state monitoring and assessment, charge control, and cell balancing have all been included in the Battery system. As an electrochemical-in-nature product, a battery responds differently to various operational and environmental conditions. These capabilities are challenging to implement due to a battery's inconsistent performance. In this study, concerns concerning modern BMSs are addressed. Reviewing the most recent methods for battery status evaluation and expected solutions, the issues facing BMSs in the future are described.

3.5 PWM Generator:

Similar to a typical battery charger, the solar charge controller (also referred to as a regulator) regulates the current coming from the solar panel to the battery bank to prevent overcharging the batteries. It can handle several battery types, much like a typical battery charger. The float voltage may be chosen by the absorption voltage, and it frequently also controls the time and tail current. They work best with lithium-iron-phosphate batteries because, after fully charged, the control unit maintains a voltage of around 13.6V (3.4V per cell) for the rest of the day. The most common charging profile follows the same straightforward procedure as a high-quality mains adapter: bulk mode - intake.

3.6 Fuzzy Controller

Maximum Power Point Trackers, often known as MPPTs, are far more sophisticated than PWM charge controllers and allow solar panels to function at their maximum power points, or more specifically, at the ideal voltage and current for maximum power production. Depending on the battery and operational voltage (Vmp) of the solar panel, MPPT solar charge controllers can be up to 30% more efficient with this innovative technique. Below are detailed explanations of the causes of the improved efficiency as well as how to properly size an MPPT charge controller, In general, greater power systems should all employ MPPT charge controllers.

3.7 Artificial Neural Network

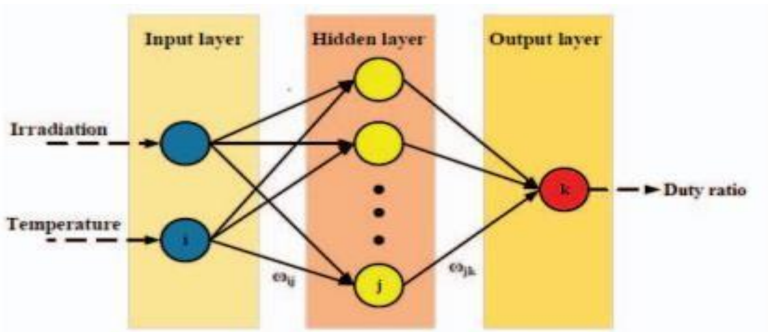

Fig 3. Structure of an ANN in MPPT

Figure 3 represent the MPPT based on artificial neural networks (ANN) A type of artificial intelligence technique is the artificial neural network (ANN). The use of artificial intelligence provides more benefits than traditional approaches. The drawbacks of conventional methods include delayed reactions to unexpected changes in solar temperature and irradiance conditions, failure to monitor maximum power points sometimes, and a lack of understanding of ANN in MPPT. Solar temperature and irradiance are the inputs. The duty ratio to the DC-DC converter is the neural network's intended target. A specific value of duty ratio will be provided by the neural network for each variation in solar temperature and irradiance to get the greatest PowerPoint.

4. RESULT AND DISCUSSION

In Fig. 4, the PV and Wind energy systems are modelled using Simulink blocks in the Mat-Lab/Simulink programmers. The Mat-lab/Simulink software program is released first of all earlier than starting with a Simulink version. A new Simulink document is opened and saved. These blocks are delivered to the document the use of the block units from the library, and then the blocks are connected, the blocks are commenced through including values, and a version is eventually produced. The version has began receiving extra modifications. The version is then simulated. Viewed is the simulation`s output.

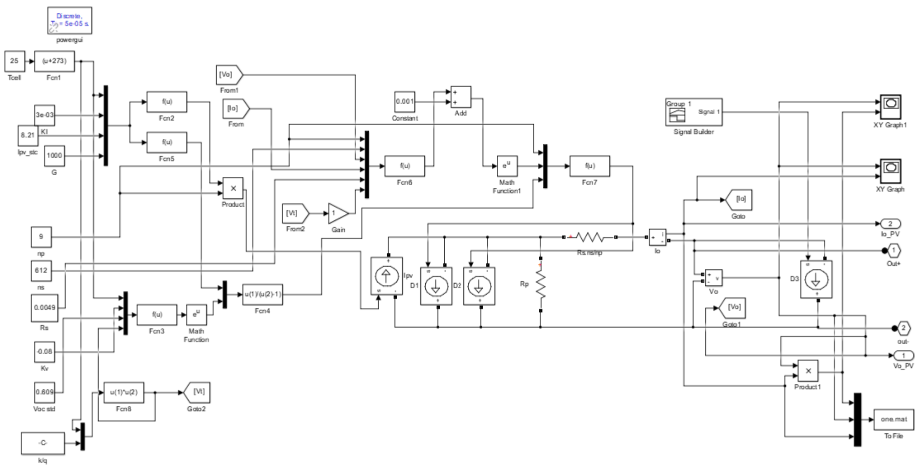

Fig 4. PV Simulink Model

The local controller, sometimes referred to as the primary control level, makes use of local data and works to maintain the voltage stability. To prevent power imbalance at a microgrid's lowest level, it also makes an effort to ensure adequate current distribution. To correct for voltage variation brought on by the main level, a secondary controller with a reaction time slower than the primary is employed as the second-highest level regulator. Last but not least, the tertiary level controller is the top-level control employed to ensure optimal functioning between the utility grid and microgrid and vice versa. It is also in charge of managing power flow and scheduling fuel. Depending on the degree of control and microgrid structure, these various levels of control can be implemented in a concentrated, autonomous, or distributed manner.

4.1 Maximum PowerPoint Tracking

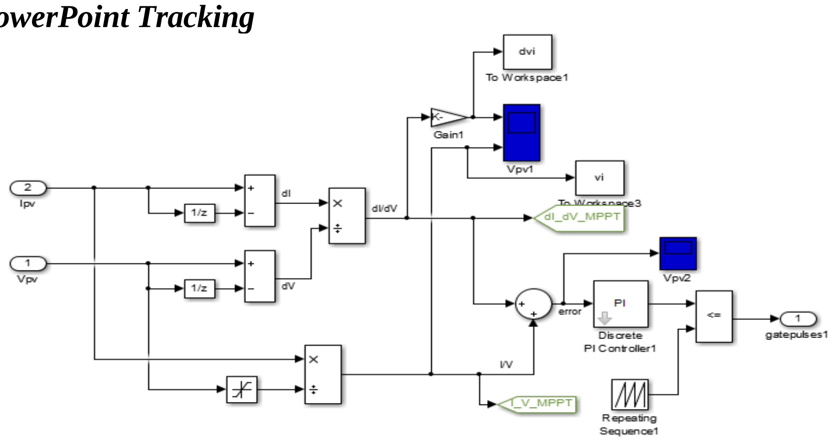

Fig 5. Model of (P&O) MPPT in Simulink to simulate

The above Fig 5 shows the MPPT serves to transfer the maximum amount of electricity possible from the solar PV module to the load. A dc/dc converter, also known as a boost converter, is used to transmit the maximum amount of power from the solar PV module to the load. The interface between the load and the module is a dc/dc converter. Depicts the load and a DC/DC converter with a maximum power point tracking method. To transmit the most power, the duty cycle must be adjusted to match the source's perception of the resistance of the load at the time of peak power.

4.2 Boost Converter

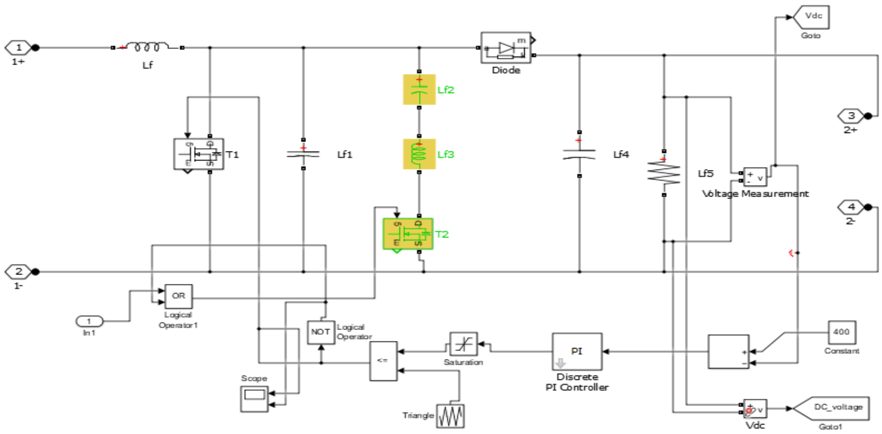

Fig 6. Simulink Model of Boost Converter

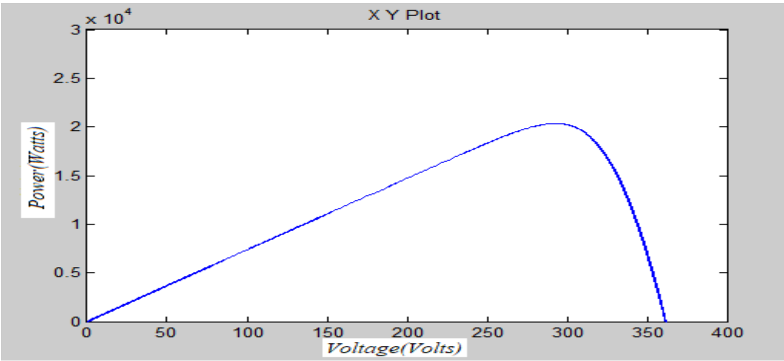

Fig 7. P-V Curve of the PV Module

Below fig 6 and 7 indicates with the provided dc input, a regulated dc output is provided by the dc-dc converter. These are frequently used in photovoltaic generating systems as an interface between the solar panel and the load. To give the most power, the load must be adjusted to match the current and voltage of the solar panel. The power electronic switching systems are referred to as the dc/dc converters. It changes the voltage from one form to another. These might be used to convert between various voltage levels.

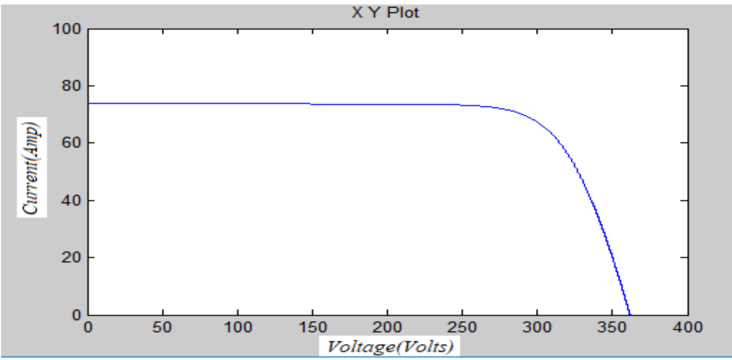

Fig 8. P-V Curve of the PV Module

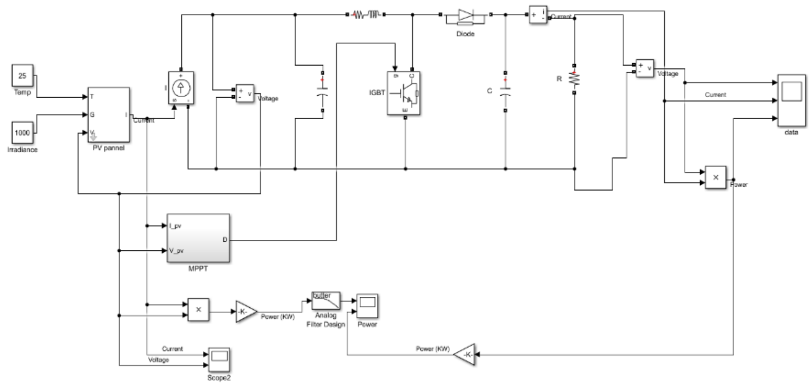

Fig 9. Complete Simulation Design

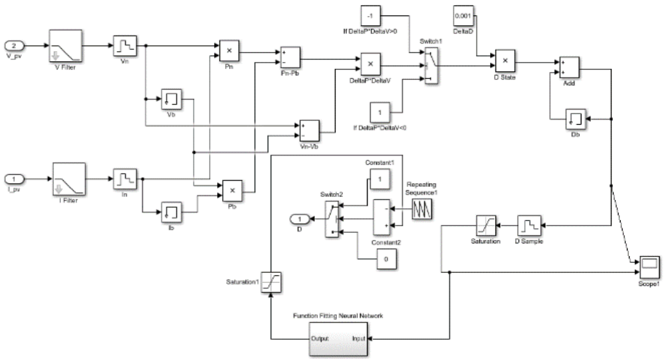

Fig 10. Implementation of ANN controller

Artificial Neural Network for Optimized Solar Maximum Power Point Tracking is one of the tasks in the second phase. Fig 10. Shows the output of the controller, which is more effective than that of other traditional controllers.

4.3 Comparison Results

PHASE	CONTROLLER USED	VOLTAGE	CURRENT	POWER
I	Fuzzy Logic Controller	120V	7.5 AMPS	900 WATTS
II	Artificial Neural Network	120V	8.2 AMPS	1050 WATTS

Result Variation: The addition of the artificial neural network controller improved power efficiency by 16%.

4.4 Scope Result

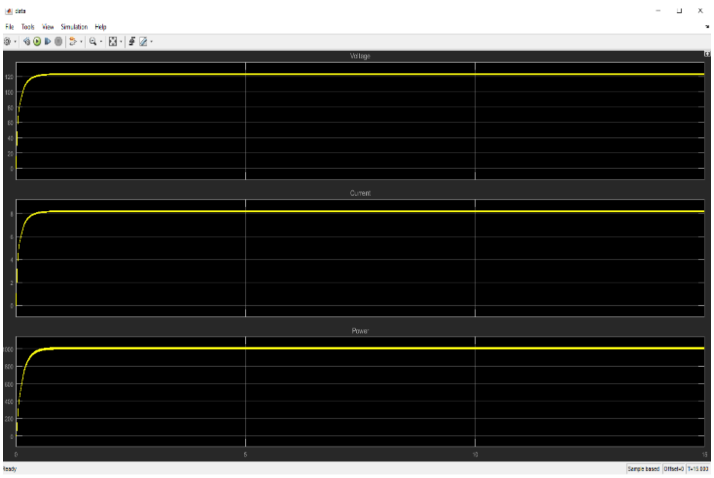

Fig 11. *Scope Result*

5. Conclusion

The PV system is interfaced with the buck converter to maximize power extraction. Numerous maximum power point tracking algorithms are tested in the software, and it is discovered that fuzzy logic exhibits better dynamic response, faster convergence, and a lack of oscillations while tracking. The Fuzzy controller is used to balance the voltage, and the effective performance of the Artificial Neural Network is seen. In this study, an enhanced solar system architecture using MPPT is suggested. Each PV module is made to work at its MPP regardless of the environment using an intelligent controller. Despite the insignificant power improvement, the measured outcomes demonstrate the effectiveness and high efficiency of the suggested architecture. A high-power PV system will experience a noticeable improvement.

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