Integrated RES With Intelligent MPPT For Efficient Power Generation & Wireless Transmission for PV Applications

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Abstract

The increasing global energy demand and the urgent need to shift to sustainable practices have made the integration of renewable energy sources (RESs) into distribution power systems imperative. This project's main objective is to implement rooftop photovoltaic (PV) systems as an essential part of low-voltage (LV) DC networks' building-integrated centralized generation Maximum Power Point Tracking (MPPT) using Artificial Neural Networks (ANNs) is used to maximize power extraction from photovoltaic (PV) panels and boost power generation efficiency, particularly in partially shaded circumstances. After that, the PV system's generated power is sent to a Luo converter, which effectively tracks and optimizes the power production. For wireless power transmission, the Luo converter's output is then fed into a high-frequency converter. This wireless power transmission improves the system's adaptability and scalability by facilitating smooth energy transfer without the requirement for physical connections. An isolation transformer is attached to the high-frequency converter's output in order to guarantee the system's dependability and safety. The high-frequency converter is isolated from the downstream components by the isolation transformer, which also offers protection against electrical risks. Finally, a battery made especially for use in electric vehicle (EV) applications receives the transformer's isolated output, which is also supplied to DC loads. Finally, we will use the MATLAB 2021a / Simulink program to do a number of numerical simulations in order to validate the suggested controls. The output voltage of 130v is stored in the battery if a voltage of 65 v is taken as output from the photovoltaic system.

Keywords

Renewable energy sources, Photovoltaic (PV) systems, Maximum power point Tracking, Electric Vehicles, MATLAB Simulink, Luo Converter

Submission: 1 October 2024; **Acceptance:** 28 October 2024

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Introduction

Current research on photovoltaic (PV) systems has seen a surge in attention during the past ten years [ZhouKe JinRan et al.]. The PV array's highest possible power point tracking (MPPT) output power is required for efficiency enhancement [Aranzazu et al]. Even while artificial intelligence-based solutions outperform classical MPPT techniques in terms of performance, especially in situations where partial shade and quickly changing environmental variables are present, the former offer a more straightforward framework and implementation.

Concerns about the natural resources' diminishing supply and the growing surroundings impact are driving research into renewable energy sources [Xujian Shu et al]. One type of energy is photovoltaic (PV) energy and it is the most interesting renewable energy sources. A strong base of advantages is formed by its direct conversion to electric power capability, low operating costs, and lower pollutants. Consequently, it makes sense that PV-based systems have a significant market share in the energy sector. PV systems have several benefits; however, one of their main drawbacks is their non-linear environmental dependence [Zhu et al].

Partial shading is the condition of the closed parts of the surface of a solar cell from sun exposure. The condition was caused by the presence of an object that is blocking the solar cells. By blocking the solar cells will result in a decrease in the power produced by solar cells. The decrease is affected by solar irradiation received by solar cells, thereby reducing the value of the output current generated.

In the morning and evening, the position of the sun changes by having a declination angle. Declination angle causes the value of solar irradiation received by the earth's surface to be decreased. The value of solar irradiation at intervals of 800-1000W/m2 could be received by the earth's surface at 9 AM & 2 PM. Irradiation values with intervals of 600-800 W/m2 are available at 8AM & 3PM.Irradiation values between 400-600 W/m2 are located at 7AM & 4PM.Solar cells are highly dependent on the amount of solar irradiation. The quantity is proportional to the value of the output current that could be generated from solar cells. At one time, the cost of solar radiation received reached a maximum based on a standard condition test of 1000W/ m2. This value could produce high current value if the value decreased causing the output current value to drop.

A solar PV system contains multiple PV modules in parallel and series. The generated power from the particular PV Array is total of the power produced from each solar module. In present scenario grid-connected PV arrays are placed at facades, roofs, or usually in cities, where partial shading phenomena may be frequent.

To increase the total system efficiency, tracking the highest power point of PV arrays is essential [Qu Liangxi He]. Modern technologies are bringing about major changes to the power generation and distribution systems. These include the integration of distributed large-scale renewable energy sources, improved communication and control methods, and larger capacities for storage [Zhao et al]. Due to its compact size, low maintenance requirements, and robust structure, solar PV (photovoltaic) energy generating devices are among the most widely used renewable resources.Reliability and efficiency of the PV system are affected by the output voltage, which is normally quite low [Wu, L et al]. As such, a high switching frequency device is needed to increase the minimum PV voltage and bring it up to the utility grid voltage. To improve energy extraction and boost the PV voltage, a DC/DC converter is added to the PV panel [Tian, X et al].

ANN Based MPPT For Solar Photovoltaic Panels

A sophisticated method for maximizing the power output of solar photovoltaic (PV) panels is a Maximum Power Point Tracking (MPPT) system based on Artificial Neural Networks (ANN). Because it enables a solar PV system to function at its maximum power point (MPP) in the face of changing environmental factors like temperature, shade, and irradiance, MPPT is essential. In situations that change quickly, traditional MPPT algorithms such as Hill Climbing, Incremental Conductance (IC), and Perturb and Observe (P&O) can occasionally malfunction. However, by learning from historical data and adjusting to novel circumstances, ANN-based MPPT can get over these restrictions.

Typically, an ANN model has input, hidden, and output layers. The ANN is trained for MPPT in solar PV utilizing historical data gathered under a variety of circumstances, such as: Temperature, irradiance, and possibly the voltage and current of the PV panel are input parameters. The ideal duty cycle or reference voltage/current that will enable the PV system to run at its peak power is known as the output parameter. The ANN is trained to reduce inaccuracies between the actual value that generates the greatest power output and the projected duty cycle/reference voltage using supervised learning.

The production of electricity through the use of rooftop photovoltaic (PV) systems. Direct current (DC) electricity is generated by photovoltaic (PV) panels using sunlight, making it a decentralized and sustainable energy source[Luo, J et al].Tracking the Maximum Electricity Point (MPPT) technique, which is based on Artificial Neural Networks (ANNs), is used to maximize the extraction of electricity from the PV panels.

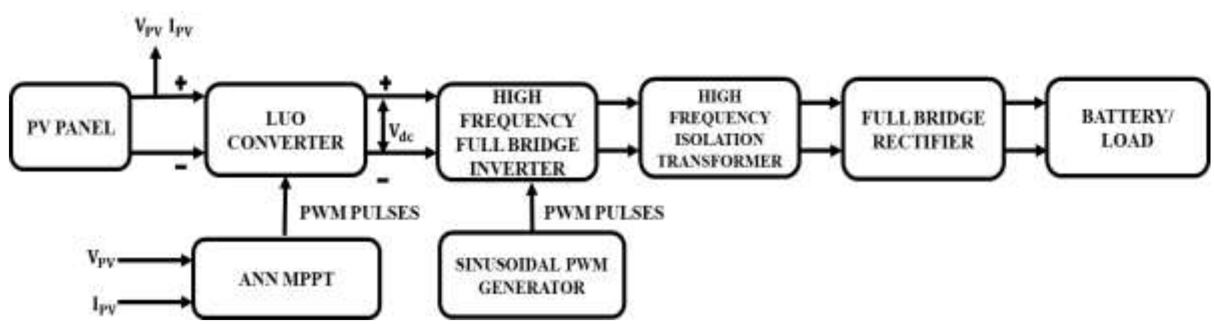

Figure 1 Battery/Load using ANN Based Maximum power point tracking

The Figure 1 depicts the proposed system Schematic diagram. The Luo converter effectively tracks and maximizes the power output from the PV panels, enhancing the overall effectiveness and efficiency of the energy conversion process. Next, the output from the Luo converter is fed into a high-frequency converter[Jiang, Y et al]. This ANN MPPT algorithm adjusts to changing environmental conditions, specifically addressing challenges posed by partial shading to ensure the PV system operates at its maximum efficiency. This part makes wireless power transmission possible, allowing energy to be transferred seamlessly without requiring physical connections. This wireless function increases the system's scalability and flexibility making it appropriate for a range of applications.

The high-frequency converter's output is coupled to an isolation transformer for dependability and safety. In addition to protecting against electrical risks, this transformer isolates the high-frequency converter from downstream components, preserving the integrity of the entire system. The transformer's isolated output is then directed toward a battery made especially for use in electric vehicle (EV) applications. By preserving the excess energy generated by the photovoltaic system, this battery serves as an energy storage device. Furthermore, DC loads can receive the stored energy, offering a constant power source for a range of uses.

Power converters, including inverters and DC-DC converters, as well as several series and parallel configurations of PV modules comprise the PV system used for power conversion, along with the tracking controller. It is therefore possible to enhance the DC voltage produced using a DC-DC converter and to convert the DC power to AC using an inverter. The load rating should be taken into consideration when selecting the PV panel.

A novel ANN-based MPPT method is developed to track the PV module's maximum power under various weather conditions. The recommended input variables are PV cell temperature (T_pv), PV voltage (V_pv), and PV current (I_pv). In the DC-DC switching boost Landsman converter, duty cycle, the output variable, is used to maintain maximum power tracking.

Since trial and error is the basis for modeling the traditional FLC, there is little chance of attaining optimal performance. Consequently, acquiring artificial neural networks offers a different approach to solving nonlinear issues. They are able to deal with incomplete facts and learn from examples. After being trained, they can make quick predictions.

The PV module has a distinct MPP for each measurement of temperature and irradiance; to find this point, The PV module's output needs to be voltage-matched to the MPP Vmp.

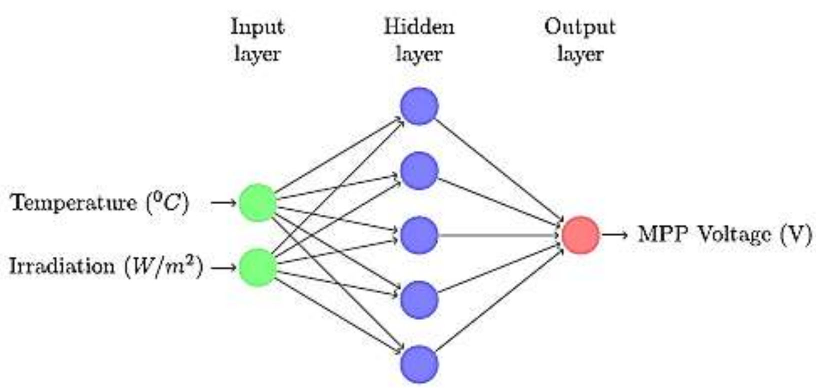

Figure 2 Structure of ANN

The proposed ANN-based Maximum power point tracking controller consists of a two-layer feed-forward network, as shown in Figure 2.The quantity, kind, and interconnections of neurons inside each layer, along with the number of layers and levels, constitute the topology of a neural network [Luo, J. et al].

It should be noted that this topology was chosen following several trials in order to increase the accuracy of the final neural network.

The two input layer neurons convey the temperature and irradiance to the hidden layer. These are the input variables. The activation function of five of the hidden layer's neurons is a hyperbolic tangent function. The hidden output layer's neuron intensities are described by the weight matrix, represented by WH, Wo, and the biases vector, represented by bh, bo, respectively. The vector of the input signal contains the temperature T and the irradiance G. The output layer contains a single neuron with a linear activation function that calculates the MPP voltage Vmp.To improve prediction accuracy, a variety of metrics should be included in the database that the neural network is trained on.

The Levenberg-Marquardt back propagation approach, which uses the approximate Hessian matrix to minimize the mean square error (MSE), is used to train the neural network off-line. Because of this algorithm's strong performance and demonstrated processing efficiency, it was selected as the optimization tool.

The training and validation MSE curves are very similar, proving that the ANN learning was effective. Once the training method is completed, the ANN-based MPPT controller must be able to supply the MPP voltage in all weather. This controller has the benefit of not requiring a large number of iterations for finding the MPP. As a result, this lowers oscillations at the MPP and raises this controller's efficiency. When a calculator is added, we discover that this method needs temperature and irradiance sensors.

Solar photovoltaic (PV)-powered wireless charging for EVs provides a smooth and environmentally responsible alternative for EV charging infrastructure. This method does away with the necessity for physical plug-in connections by combining wireless power transfer (WPT) with sustainable solar energy.

Results And Discussions

The simulation results are examined using software MATLAB/ SIMULINK.The voltage waveform of a solar panel in partially shadowed conditions is depicted in Figure 3.The output voltage waveform under typical conditions is shown in Figure 4. The temperature of the PV board is maintained at 25 °C for the initial 0.3 seconds. The heat is then quickly raised and maintained at 35 °C after 0.3s . This is comparable to holding the solar irradiation at 800 W/sqm for 0.3 seconds, then quickly rising to 1000 W/sqm and staying endless thereafter

The LUO converter receives an input voltage of 64V when it is partially shaded. The voltage that is output might be approximately 350V. It tracks the PV panel's maximum power using the ANN MPPT algorithm. The suggested converter produces and maintains a constant output voltage which is best suited for EV applications.

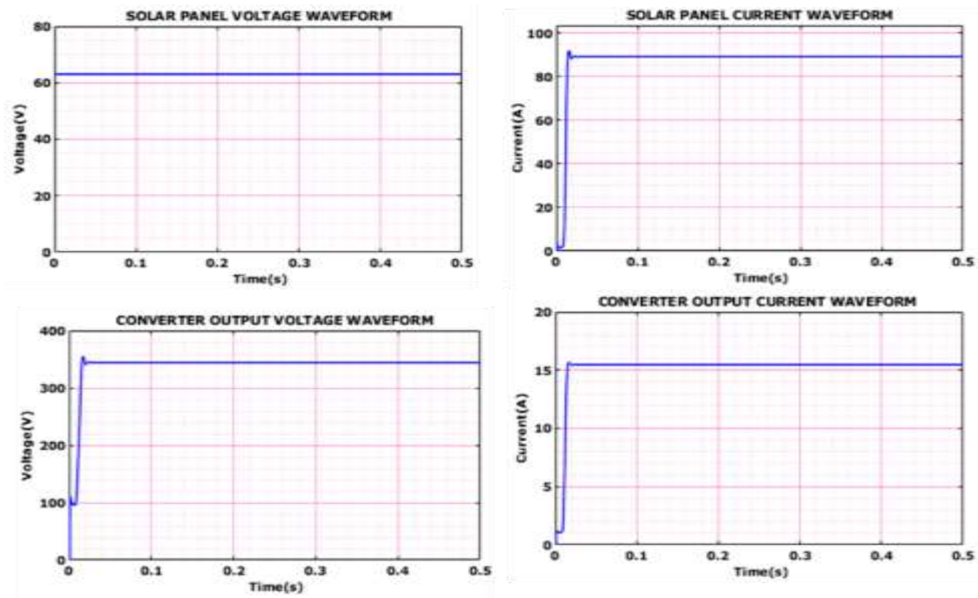

Figure 3 Under Partially shaded condition

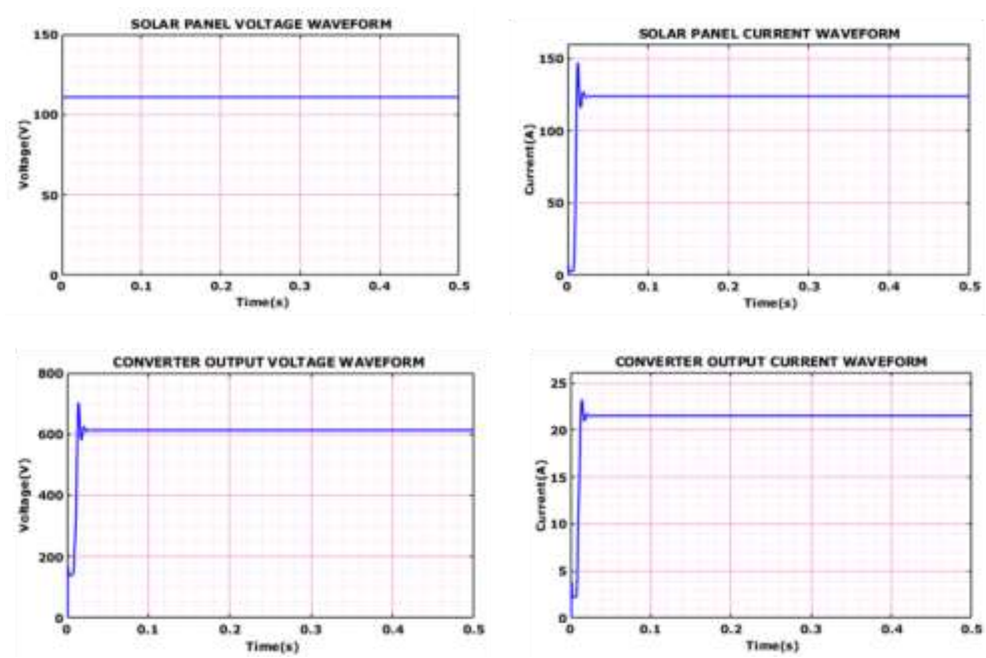

Figure 4 Under Normal operating condition

Reducing the intensity of any two or three of the PV panels around 700 will result in the partially shaded condition. Currently, the LUO Converter is receiving an input voltage of 64V in partially shaded conditions. The potential output voltage is approximately 350V. It monitors the

PV panel's maximum power using the ANN MPPT algorithm. The suggested converter ensures that the output voltage is stable and maintained.

Based on Cases 1 and 2, we deduce that the converter efficiency is almost 90% in both scenarios. The suggested converter keeps the output voltage constant, and the proposed ANN controller tracks the maximum power.

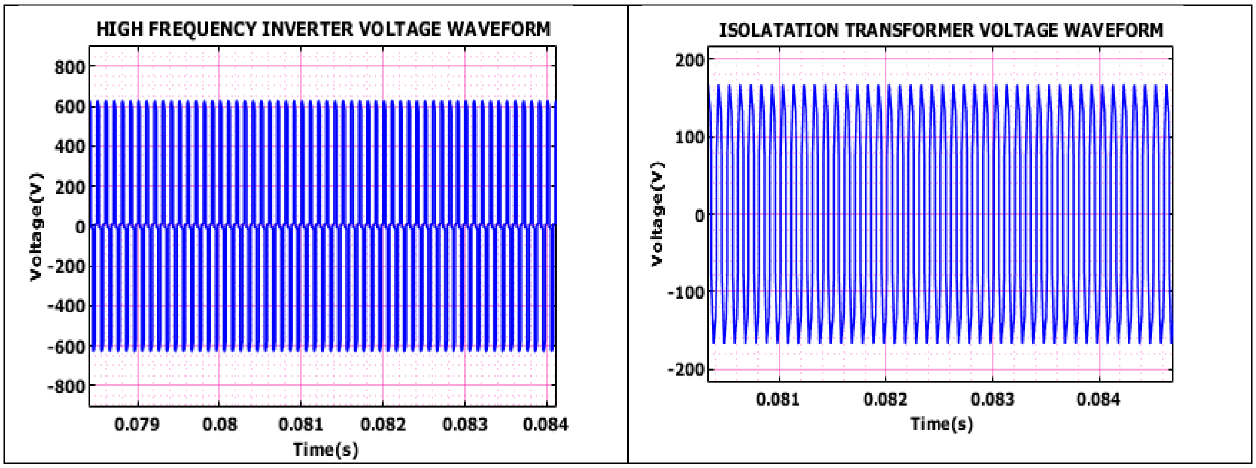

Figure 5 High frequency inverter and Isolation Transformer voltage waveform

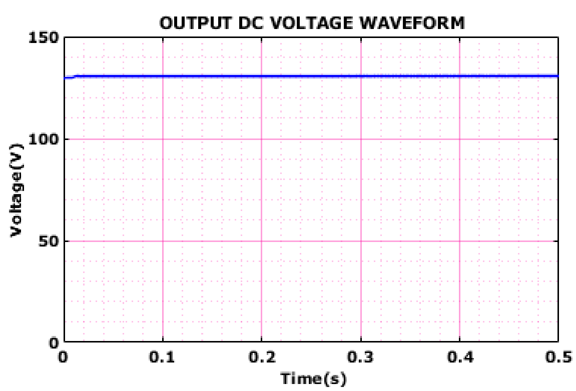

Figure 6 Rectifier output voltage waveform

The Figure 6 Forward Converter represent the waveform for dc load which provide galvanic isolation in figure 5 for protection. The 130V produced from the converter is given to DC load as battery.

Conclusion

In conclusion, this article introduces an innovative approach to harnessing rooftop photovoltaic (PV) systems for Centralized generation integrated with buildings within reduced-voltage (LV) DC grids. The implementation of an ANN MPPT algorithm ensures optimal power extraction from the PV panels, especially in partially shaded conditions, thereby enhancing overall power generation efficiency. Subsequently, the energy is channelled into a high-frequency converter for wireless power transmission. This wireless transmission feature not only facilitates seamless energy transfer but also enhances the adaptability and scalability of the system by eliminating the need for physical connections. To fortify the safety and reliability of the system, the output from the high-frequency converter is linked to an isolation transformer. The isolated output from the transformer is then directed towards a battery designed specifically for Electric Vehicle (EV) applications, concurrently supplying power to DC loads. This dual functionality enhances the versatility of the system, catering to the growing demand for sustainable energy solutions in both stationary and mobile applications. Using MATLAB 2021a/Simulink software, a thorough set of numerical simulations will be carried out in order to verify the efficacy of the suggested controls and system arrangement.

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