Research Article

Machine Learning-Based Secured Intelligent DMA Controller for Video Restoration

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Received 21 January 2022; Revised 20 February 2022; Accepted 26 February 2022; Published 5 April 2022

Academic Editor: Mohammad Farukh Hashmi

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Maximum power point tracking (MPPT) is an optimization algorithm for adjusting maximum power for DC/DC converters. SEPIC (single-ended primary-inductor converter) can allow the voltage to match the impedance between input and output. The perturbation and observation (P&O) method is a state-of-art tracking technique to maintain the voltage in photovoltaic (PV) systems. For this purpose, the adaptation of the P&O technique in economical digital devices can make sure of its efficiency and robustness. This paper was aimed at developing and designing an effective photovoltaic system based on the modified P&O algorithm with improved accuracy and power efficiency, thereby increasing the stability of a solar system. The performance of the proposed solar regulator system with two MPPT algorithms is verified using MATLAB simulator along with advanced modified P&O, and a hybrid excellence controller algorithm is also developed. The proposed system uses IoT-based sensors to transmit vital data to the cloud for remote monitoring and control purposes. The IoT platform helps the system to be viewed remotely.

1. Introduction

The renewable energy system can convert the electric power existing in sources, for example, wind, sunlight, water flow, tides, and biomass into a form, such as electricity or heat energy. The Internet of Things (IoT) is about real-life communication and mechanical communication to each other, and PC exchange will be accessible to objects [1]. The wind sources are used in power sailing ships for decades. Chemical energy is converted to electricity using fuel cell through a chemical reaction with oxygen or another oxidizing agent. Solar photovoltaic systems generally specified as solar PV systems can convert sunlight directly into electrical energy [2]. This type of conversion is completely contrasted to solar water heaters. These PV systems will help in reducing the emission of carbon, thereby minimizing the cost of electricity bill by generating sustainable electrical energy from the sunlight rather than the power generated from burning fossil fuels [3].

Boost converters are created by swapping the input and output signals. Boost is an abbreviation for voltage boost, which is what it does solely. Despite the fact that the output is always bigger than the input, the key challenge is obtaining step up and step down voltage from a single device in response to the output voltage [4]. We may utilize two cascaded converters (a buck and a boost) to get the desired
result. However, two different controllers as well as a separate switch are necessary for this. As a result, it is not a good option. Although a buck-boost converter may provide the desired output, the output in this case is inverting [5]. These converters feature higher component stress levels, smaller component sizes, and lower efficiency than other converters. In order to limit the losses caused by high voltages, a circuit with buck-boost conversion characteristics, a minimal energy storage element need, and a small inductor size are all desirable attributes. However, the inductor should not be so small that the ripple current is excessive [6].

As a result, the optimal converter should have low component stresses, low energy storage needs, and size and efficiency performance that are equivalent to either the boost converter or the buck converter, among other characteristics [7]. The SEPIC (single-ended 12 primary-inductor converter) converter is one example of a converter that delivered the desired output. We can control the output of a MOSFET by altering the duty cycle of the gate signal. If the duty cycle is larger than 50%, it will increase the speed of the machine. As a result, it is referred to as a boost converter [8]. The voltage is stepped down and the device operates as a buck converter if the duty cycle is less than 50 percent.

Another feature of this converter is that it produces a positive controlled output voltage from an input voltage that ranges between the output voltage and the voltage above or below it. It may be used as a buck and boost converter at the same time, and it contains just a few active components and a basic controller that allows for low noise operation [9].

Furthermore, the distribution of electricity can be done by a state supplier, a company that produces and/or distributes electricity to the consumers. The various sources of electricity are evenly distributed through the electrical grid which possibly travel at great distance to different areas from source plants [14]. This grid network is unreliable at certain interval, because of factors such as excessive loading, challenging climatic barriers, and other upgrading services.

There are two important reasons while establishing PV power systems. Firstly, we will be able to provide electricity to the entire location, and secondly, we can possibly eradicate issues related to massive utility grids [15]. This total electrical power to be generated is reliant on numerous aspects such as dimension and organization, types of PV modules, daylight accessibility, and effectiveness of the electrical components for the conversion of solar to electrical energy operational at different destinations such as offices and residential places.

One of the main applications of solar PV systems is to cover the inaccessible regions and other remote locations by primary power grid. These PV components can charge the batteries for the period of visible radiation of sunlight by generating electricity [16]. Based on the generation of power from the radiation, power DC can load the AC across the inverter directly or indirectly. Though there are certain limits and drawbacks due to the measurements of battery size while configuring the solar system, it can deliver independent electrical power from the utility grid [17].

In such cases, wherever minimum quantity of electrical power is necessary for systems particularly in UPS and emergency call boxes, the proposed method is efficient and cost-effective; however, the grid is inaccessible. PV systems are considered as the most inexpensive for areas which are located away from existing power lines and best possible alternative for some real-time applications which require large volume of electricity. Solar technologies are widely categorized based on the capturing method, and they are active and passive [18]. These methods can be useful for conversion and distribution of direct sunlight and provide energy to various destinations connected together. Unlike solar energy, there are other renewable energies which can utilize the sunlight directly or indirectly. Ocean thermal energy and geothermal energy are the best illustrations. Lively solar systems use pumps, fans, concentrated solar power, and solar thermal collectors for the conversion of daylight into beneficial productions. Procedures include selecting well-equipped sources such as thermal equipment and natural air design and identifying the shape of the building facing the sun [19].

Figure 1 represents the PV panel of the grid. Active solar technology is called as supply-based technology since it can strengthen the supply of energy. Decreasing solar technology reduces the need for different resources and is often referred to as demand-based technology [20]. Since solar energy is not available at night, conserving it is one of the biggest problems with an uninterrupted supply. Both solar and wind power are intermediate sources of energy, meaning that all available production can be used based on the acquisition or set for future purposes or the transmission of transmission lines to the required areas [21]. Solar energy can be stored as molten salts. Because of the high specific heat capacity, these storages will be efficient and also cost-effective in concentrated solar power plants. They can provide heat at temperatures well-suited for traditional power systems [22]. The maximum power generated differs from temperature and irradiance. For instance, if a solar power station can store 1.44 T\text{J} in 68 m\text{m}^3 storage tank, it is sufficient to deliver complete production for about 38-40 hours with 99% effectiveness [1].

PV module power point tracking (MPPT) is an automated control method that can adjust the power interfaces, resulting in the maximum possible potential power harvest under a variety of variables such as light intensity level, shading, climatic conditions, and the characteristics of PV modules [23]. While this is happening, PV arrays have a poor conversion efficiency, necessitating the need for MPPT control approaches. The primary goal of this article is to get the solar operating voltage as near as possible to the MPP values while running in a controlled environment. This approach has emerged as a critical component in the approximation of PV system design and performance, and it cannot be replaced [24]. Traditional techniques are less difficult to adopt, although there are certain variations at MPP due to its location. As a result of this circumstance, the tracking speed for the fixed perturb step is poor. Over the course of a decade, there has been a growing interest in the future direction of solar energy utilization [25]. Aside from the fact that PV systems used for solar energy harvesting emit no greenhouse gases, the cheap maintenance costs of PV systems are also significant advantages. PV systems, on the other hand, have a poor conversion efficiency when compared to other technologies. As a result, in PV systems, the MPPT for the solar array is critical to their operation. It was difficult to
monitor the system because of its nonlinear performance, as well as changes in MPP with respect to solar irradiation level and temperature [26].

The goal of this research is to evaluate different MPPT systems that can give contextual information, implementation analysis, grid interconnection of PV, and solar microinverter design needs, all of which are briefly illustrated in the literature. In this research, a number of different MPPT algorithms are developed and implemented in real time [27]. On the other hand, using an advanced modified P&O and a hybrid excellence controller algorithm, the suggested work includes the improvement of regulation and the enhancement of performance of an off-grid solar photovoltaic (PV) system [28]. The suggested technique provides controllability and flexibility for a wide range of sunlight conditions while also preventing the system from being blocked. Furthermore, the benefits and drawbacks of MPPT, together with their classifications, which may be used as a starting point for future research in order to optimize solar power production, are reviewed [29].

During the MOSFET turn on (positive slope),

$$V_{IV} = V_{L_{Rew}}.$$  \(1\)

During the MOSFET turn off (negative slope),

$$V_{La-N} - V_{Cx} + V_{CUT} - V_{LS},$$  \(2\)
equating the above equations.

For inductor $$L_2$$ during turn on of MOSFET, voltage across inductor $$L_2$$ is $$V_{C_2}$$:

$$\Delta I_{12} \over \frac{T_{an}}{L_2} = \frac{V_o}{L_2}.$$  \(3\)

During MOSFET turn off, voltage across output voltage is equal to voltage across $$L_2$$:

$$\Delta I_{12} \over \frac{T_{an}}{L_2} = \frac{V_{an}}{L_2}.$$  \(4\)

Equating the above equation,

$$T_{av} \cdot V_{L_2_{Rew}} - T_{av} \cdot V_{Laem}.$$  \(5\)

2. Related Work

A number of research studies have been conducted and published in the literature that are connected to the solar renewable energy generating circuit of the system. Using an MPPT strategy test, Galotto revealed that the amount of energy released from a PV panel tracking element is compared to the amount of energy released from a strong, negative component, strong responses via sensors [1]. When used in conjunction with an array simulator for solar analysis and simulation using MATLAB and Simulink, the DC-DC digital-controlled converter performs as shown in [1]. The results of the tests have demonstrated that an upgraded MPPT approach termed IC, which is based on the proportional-integral (PI) and P&O functions, is successful. Additionally, normal daily installation may be used to verify the simulation findings of PV MPPT techniques, which can be utilized to reduce the cost of the system. To monitor photovoltaic applications, Shmilovitz developed a rapid MPPT system with outstanding performance and entirely reliable tracking [2]. By using the MPP algorithm [2], it is possible to obtain excellent tracking performance while applying distribution mode adjustments to optimize strong responses and stability characteristics. The findings demonstrated that the interaction time in response to abrupt radiation changes was within normal limits. A steady connection across the photovoltaic curve is shown in our suggested solution, which leads to a closed circuit and thereby overcomes this problem.

Shukla et al. investigated and discussed the impact of power quality on the performance of photovoltaic inverters. In this example, PSPICE [3] is used to show the modelling and simulation of grid-connected networks. Instead of relying on a grid system for verification of the output of the pulse width modulation (PWM) inverter, the synchronization system contains voltage and frequency comparators for that purpose.
In their paper [4], Hamid et al. discuss the modelling of a grid-connected DC-linked PV/hybrid system. During times when the hybrid system is not getting sunlight, it functions as a main system, with the power grid acting as a backup to remedy any system shortfalls [29]. The energy required is obtained via the use of a photovoltaic (PV) system and a power grid in areas where electricity is scarce during the summer. As a consequence, a hybrid system is able to provide the necessary quantity of energy at all times of the year. A smart grid-connected PV/wind hybrid system model, developed by Meshram et al. [5], incorporating induction generators, wind turbines, solar arrays, controllers, and converters is described. An investigation of the dynamic behavior of the suggested model was carried out under a range of difficult settings. Solar radiation, temperature, and wind speed data are gathered from a system that is coupled to a total of 28.8 kW of solar electricity generation [30].

The MPPT algorithm was utilized to increase the efficiency of the produced power system’s implementation. During the development process, real-time measurable parameters are employed as inputs to the system [4, 5]. The suggested model, as well as its control method, provides a suitable foundation for optimizing the performance of the smart grid [5].

3. Proposed Methodology

Continuous conduction mode is defined as the state of a SEPIC in which the current through the inductor \( L_1 \) never drops below zero volts. A SEPIC operates in steady-state mode when the average voltage across capacitor \( C_s \) (VCs) is equal to the voltage applied to the SEPIC (VIN). Because the capacitor \( C_s \) prevents direct current from flowing across it, the average current across it \( (I_{Cs}) \) is zero, leaving the inductor \( L_1 \) as the sole source of current for the load [31].

As a result, the average current through inductor \( L_1 \) is the same as the average current through the load, and the average current through the load is independent of the input voltage. When average voltages are considered, the following may be written:

\[
VIN = VL_1 + VCs + VL_2. \tag{6}
\]

Because the average voltage of VCs is equal to VIN \( VL_1 = VL_2 \), the average voltage of VCs is equal to VIN \( VL_2 \).

As a result, the two inductors may be coiled on the same core in this configuration. Due to the fact that the voltages are of similar magnitude, the mutual inductance effect between them will be zero. This section makes the assumption that the coil’s polarity is right. Due to the fact that the voltages are of similar magnitude, the ripple currents of the two inductors will be of same magnitude, as well [32].

The general design of the proposed framework appeared in Figures 2 and 3. The proposed off-grid PV system is sorted out into three primary units to be specific: PV array model, battery, charge controller and cloud storage using internet of things (IoT). Proposed off-grid solar photovoltaic (PV) system designed with advanced modified P&O and hybrid excellence controller.

![Figure 2: Solar panel characteristics curve showing MPP at operating points A and B.](image)

\[ V_O = \frac{D \times V_I}{1 - D}. \tag{7} \]

But, this does not give reason for loss due to parasitic elements; for instance, diode drop \( V_D \) is expressed as

\[ V_O + V_D = \frac{D \times V_I}{1 - D}. \tag{8} \]

From equations (7) and (8), we get

\[ D = \frac{V_O + V_D}{V_O + V_{I_{min}} + V_D}. \tag{9} \]

When the input voltage decreases, the duty cycle will increase. The maximum duty cycle is given by

\[ D_{max} = \frac{V_O + V_D}{V_O + V_{I_{min}} + V_D}. \tag{10} \]

The maximum height of ripple current is measured and is approximately 35–45% of the maximum current input to determine the inductance at the minimum input voltage. The ripple current flowing through two identical inductors \( L_1 \) and \( L_2 \) is denoted as

\[ \Delta I_L = I_i \times 40\% = I_{i0} \times \frac{V_O \times 40\%}{V_{I_{min}}}. \tag{11} \]
The inductor value is calculated by

\[ L_1 = L_2 = L = \frac{V_{i_{\text{min}}}}{\Delta I_{i_{\text{sw}}} f_{i_{\text{sw}}}} \times D_{\text{max}}, \quad (12) \]

where \( f_{i_{\text{sw}}} \) is the switching frequency and \( D_{\text{max}} \) is the duty cycle at \( V_{i_{\text{in}}} \). The peak current in the inductor ensures that the inductor does not saturate.

3.2. Modeling of Photovoltaic Array. The simple circuit diagram of photovoltaic system is depicted in Figure 4. This proposed method provides an equal model of PV system consisting of a resistance connected in series and the parallel, diode, and source. Series resistance means internal power loss and the parallel resistance consistent to leakage current to ground. The diode refers to the p-n junction’s nonlinear impedance, which is shown by the current source. In theory, a diode coupled in series to a current source is the ideal solar cell. The direct current generated that varies linearly with solar radiation when solar radiation falls on cell.

Applying Kirchhoff’s current law, the output current of the cell is expressed by

\[ I = I_{\text{ph}} - I_d - I_{i_{\text{sh}}}, \quad (13) \]

The characteristic equations are formulated with reference to the circuit shown in Figure 4. Mathematical equations describe how the light-produced current or photocurrent changes as a function of irradiance and temperature.

\[ I = I_{\text{ph}} - I_d - I_{i_{\text{sh}}} \left[ \exp \left( \frac{(V + IR_s)q}{akTN_s} \right) - 1 \right] - \frac{V + IR_s}{R_{i_{\text{sh}}}}, \quad (14) \]

\[ I_{\text{ph}} = I_r \frac{I_{i_{\text{sc}}}}{I_{\text{sc}}}. \quad (15) \]

4. Advanced Modified P&O and Hybrid Excellence Controller

4.1. Advanced Modified P&O. The output diode must be selected to handle the peak current and the reverse voltage. In a SEPIC, the diode peak current is the same as the switch peak current \( I_{i_{\text{dt}}} \). The minimum peak reverse voltage that the diode should withstand is the power dissipation in diode equal to the output current multiplied by the forward voltage drop of the diode. The Schottky diode is used to minimize the switching loss: Diode peak current \( = 2.475 \text{ A} \).

Minimum peak reverse voltage the diode must withstand is \(-V_{\text{RDI}}:\)

\[-V_{i_{\text{max}}} + V_{i_{\text{u(m)}}} - 26 \text{ V}. \quad (16)\]

The P&O algorithm provides these two scenarios where the performance of the PV panel is interrupted by a small increase. If the change in power conversion \( \Delta P \) is correct in result, the output power is disturbed according to the MPP, and the disturbance continues in the same manner. When \( \Delta P \) is negative, it deviates from the MPP direction, and the signal interference needs to be changed. The graph
of module output power versus module voltage for a solar panel at a given irradiation is shown in Figure 2.

As shown in Figure 2, the point marked as MPP is maximum power point, the highest theoretic output attained from the PV panel. Let A and B be the two functional points such as point A to the left of the MPP. After that, the disturbance is moved alongside the MPP given a positive disturbance to the power supply. Figure 5 represents the P&O flowchart.

Once we get a positive disturbance, the value of $\Delta P$ becomes negative, and it is necessary to change the deviation indicator to reach the maximum MPP. In contrast, point B is in the right side of the MPP with negative abuse. The design flow for the P&O algorithm is obtained in Figure 3.

4.2. Hybrid Excellence Controller. The proposed HEC control framework essentially in view of a fuzzy supervisory-based rationale rectifies the simple qualities to coherent twofold yield somewhere around 0 and 1. The proposed control framework has MOSFET switch for triggering the boost control plan can manage the rearranged capacities that happen to be it is possible that some esteem. Its fundamental qualities are as follows.

(a) The execution is simple
(b) The learning is quick and precise
(c) It has solid speculation abilities
(d) The fuzzy principles make simpler its comprehension
(e) It is anything but difficult to join both semantic and numeric learning for critical thinking

A typical design of a HEC-based supervisory appeared in Figure 6, in which a hover with X demonstrates an input hub, while others show rule-based hubs for tuning. It exhibits a multilayered encourage forward system, in which every layer has a specific capacity on the information signals. In this basic case, HEC has variable information sources and one yield $(X_n, Y)$ with five layers. Figure 6 represents the architecture of control system.

Table 1 illustrates the HEC rule table used in the proposed work. The battery SOC has five MFs: zero (Z), negative (N), negative small (NS), and negative medium (NM).
The hybrid source gives three MFs: small (S), medium (M), and high (H). Eventually, the mean power is applicable to four MF: positive (P), negative (N), negative big (NB), and positive big (PB).

5. Simulation, Results, and Discussion

The proposed SEPIC for off-grid solar photovoltaic (PV) system with advanced modified P&O controller is analyzed and simulated using MATLAB and Simulink. These control circuits for the distinctive control-based framework are shown in Figure 4.

Figures 7 and 5 give the output of the solar panel. Table 2 gives the advanced level comparison. Figure 8 gives the switch control. The figure has the simulated results of PV voltage and current with power. In that, Figure 9
explained the power output of the PV panel as stated by the irradiance values; according to temperature, there will be a change in voltage and current. The power deviation will vary from 0 to 3 seconds, and there will be a constant power.

5.1. Performance Comparison. From the investigation, switching losses, maximum output power (p.u), and the efficiency of the converters were calculated based on the reproductive results of the different parameters recorded in Table 2. The fuzzy converter, ANFIS, HEC, and advanced modified P&O have efficiency rates of 83.41%, 85.37%, 86.84%, and 89.94% correspondingly.

The comparison of the proposed method with other control algorithms, as shown in table, clearly shows the performance of the suggested under a different level of control index. The proposed conversion system with maximum power tracking efficiency is compared for various converters shown in Figure 10.

Table 3 illustrates a comparison of simulation and hardware results for a variety of input voltages under consideration. Table 4 shows the output voltage and current under a variety of load conditions.

Even if the PV system is designed with flawless components, the output of the system will be lowered in real-world situations owing to partial shade and polluting emissions. This work presents a DC/DC SEPIC at the module level that is only active when there is a discrepancy between the substrings or when a difference between the modules output power exists. By incorporating such converters into a PV system, the running time of the converter is reduced, and the system's dependability is increased. A low-cost, low-efficiency converter may be used to reduce the impacts of partial shadowing in PV systems since the power differential is all that is supplied to the converter at the same time. The simulated result of the converter is compared to the results obtained on the hardware.

When the system's maximum performance is discovered, it does not matter how the system's physical state changes.

An artificial neural network is built of three parameters: dataset size, dataset quality, and CNN type. The sections of the input layer that are processed by the multiple receptive layers are called out. It is possible to construct these networks in such a manner that overlapping of the input may be formed, resulting in the output of a high-resolution version of the original picture. For feature detection, CNNs use processes such as pooling and convolutions. Following feature extraction, all fully linked layers perform the function of a classifier. It is less likely that convolutional layers

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**Table 2: Comparison of proposed method with other control algorithms.**

| Controller types                  | Switching losses (%) | Maximum output power (per unit) | Efficiency (%) |
|----------------------------------|----------------------|---------------------------------|---------------|
| Fuzzy                            | 19.13                | 0.84                            | 83.41         |
| ANFIS                            | 16.24                | 0.85                            | 85.37         |
| Hybrid excellence controller     | 13.17                | 0.9                             | 86.84         |
| Advanced modified P&O            | 10.83                | 0.9                             | 89.94         |

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**Figure 7: Power output from PV panel.**
will be coupled with pooling layers since it is not necessary for the CNN to be completely linked. It is regarded as the nerve center of CNN. Convolution is used in the combination of two mathematical functions, the outcome of which is itself a mathematical function, to produce a function. Sliding the filter allows the convolution to be executed across the input data stream. Every location is subjected to matrix multiplication, with the results being shown on the feature map as a summing up of the results. A $p \times p \times s$ input image is used in this layer. $p$ denotes the height and width of the picture, and $s$ denotes the width and height of each channel with variable filters, with the size of each channel being $q \times q \times t$. $q$ is less than the picture dimension, and $t$ might be the same as channel $s$ in terms of size. It is necessary to include an additional pooling layer in between the CNN and the convolution layer in order to get the best possible results. The primary purpose of this layer is to reduce dimensionality in order to obtain reduced calculation times.

![Figure 8: Control signal to the switch.](image1)

![Figure 9: Converter output, voltage, current, and power at the load side.](image2)
Max pooling is the most essential kind of pooling. It is used to choose the highest possible value from each window. In order to categorize input pictures, the fully connected layer is the last layer to be applied after the convolutional and pooling layers have been applied. When neurons in a completely linked layer are coupled to neurons in a preceding layer, activation functions are performed. This section will examine how artificial neural networks or deep learning classifier convolutional neural networks may be used to identify malware assaults on networks like as 5G, IoT, and the healthcare sector, which are all prone to a variety of threats. Along with the identification of malware, it will also offer information security by detecting and classifying dangerous code, as well as the classification of malware. Patients’ lives will be at risk in the healthcare field, despite the fact that every organization includes personal information or data, and that information or data and both are subject to a large number of assaults. As a consequence, many attackers or criminals learn new ways for attacking their targets on a regular basis. Many methods are being employed by security companies to protect against these sorts of assaults, but they are unable to do so due to the billions of pieces of malware that are found on a monthly basis, and it is difficult to reach this goal in the current environment. As a result, technologies such as deep learning are required in order to offer security and privacy.

6. Conclusion

This paper has displayed and assessed off-grid solar photovoltaic (PV) system with advanced modified P&O control framework and IoT. The main benefit of this proposed model is to make power quality improvement in PV systems with IoT. The execution, examination, and control of a proposed off-grid solar PV system with advanced modified P&O were implemented. The proposed PV system includes renewable vitality source, SEPIC, and MPPT controller. The implementation of the proposed control procedures are measured under different temperature and load conditions. The load system is well-managed by the SEPIC. A machine side converter can extract the ideal amount of power. The information collected through the IoT platform can be used in intelligent home programs such as machine learning working out data. From the results obtained, the advanced modified P&O controller achieved and provided the maximum amount of power under challenging conditions.

Data Availability

The data that support the findings of this study are available on request from the corresponding author.
Conflicts of Interest

All authors declared that they do not have any conflict of interest.

Acknowledgments

The authors extend their gratitude to the Deanship of Scientific Research at King Khalid University for funding this work through the research group program under grant number R. G. P. 2/132/42.

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