

Controlling the energy management PV system using AI techniques

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Abstract: In light of the critical need to reduce carbon emissions and address the urgent problem of climate change, renewable energy systems like photovoltaic (PV) systems have grown in importance. Static converters employ reactive energy to alter the current in solar power systems. Energy storage batteries improve power quality by storing voltage and current, and a proportional-integral controller controls reactive and active powers. Batteries also have an effect on steady-state error. Artificial intelligence (AI) is essential for enhancing PV system energy production in different climates, because traditional controllers fail to maximize solar systems' energy output. That being said, changes in the weather may impact how well PV systems work. This research introduces an innovative method for combining solar photovoltaic (PV) systems with efficient input performance by use of adaptive neuro-fuzzy inference systems (ANFIS). A controller based on fuzzy neural inference was developed and tested with respect to energy production and consumption. The relevance of artificial intelligence in energy management is shown by this research, which investigates its role in enabling a battery system to provide continuous power supply to customers. Results in energy control and management were also encouraging, according to the results.

Keywords: ANFIS, photovoltaic (PV) systems, Artificial intelligence (AI).

1. Introduction

Several factors have contributed to the global fascination in renewable energy. To begin, the widespread opposition to the construction of new conventional power plants is a direct result of the high levels of pollution experienced by many industrialized nations. Replacing conventional power plants with renewable ones is, therefore, the only way to solve this issue. Also, the use of nuclear power plants is a reality in several nations.

Unpredictable climatic and meteorological variations may render these energy sources unreliable, even if they can be used in conjunction to mitigate each other's shortcomings [1]. Power producers are looking at hybrid systems that combine renewable energy sources with classic generators to address the issue of dependable autonomous power production systems. A lot of people rely on them to provide power to rural regions [2]. Finding the best combination of off-grid wind and PV systems in terms of component size optimization is a major challenge for hybrid power generating systems [3]. In order to guarantee their efficiency and environmental friendliness, the appropriate number and kind of units were established by lowering the overall cost of the system [4]. The optimal size of hybrid power generating systems has also been the subject of several proposals.

The conventional wisdom is that a power generating system combining wind and solar energy may be either grid-connected or built to operate independently. An ideal mix of solar and wind power, along with a storage battery, was used to meet the yearly demand [5]. A feasibility study was conducted to evaluate the use of renewable energy

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sources, such as wind and solar systems, with the alternative of building a transmission line from the closest substation to deliver electricity to the demand, taking into account various energy consumption scenarios [6]. To find the best configuration, we minimized the overall cost of the system over 20 years while keeping load energy needs to a minimum [7]. Notably, novel techniques decrease the cost function, allowing for nearly optimum or excellent solutions with very simple computations [8].

A particle swarm optimization technique was used for other size optimization algorithms for comparable hybrid power production systems due to its speed and ability to converge to a satisfactory solution. When compared to the standard genetic algorithms mentioned in the literature, it performed better [9]. However, if you're looking to reduce the total cost of your hybrid power generating system, the annealing simulation approach is the way to go. Because of this, our findings were superior to those of the response surface approach [10].

With the help of ANNs, PV systems have been able to control the flow of energy and improve their overall performance [11]. Artificial neural networks (ANNs) are able to adapt the system's output to satisfy energy needs by reviewing and forecasting a number of inputs, including temperature and solar radiation [12]. The fact that these controllers can adjust to new circumstances is another perk.

Energy efficiency and system dependability may be greatly enhanced by integrating ANN-based controllers into PV systems. Two primary components of the performance prediction model are the ANN prediction model and the collector mathematical model. The mathematical model of the solar collector is often based on the instantaneous flow rate of the medium within the collector as well as temperature data, which includes the ambient temperature, intake temperature, radiant illumination, and heat collecting area. The input to an ANN is typically the medium output temperature. Increasing PV output power is possible via Maximum Power Point Tracking (MPPT).

Furthermore, by internally blackboxing the ANN, the voltage inverter may be used as an input to enhance MPPT performance. Renewable energy sources have a lot of potential, and solar power is among the most promising. The unpredictability of weather patterns is one of numerous obstacles to its optimal exploitation. Scientists are using ANN methods to lessen the impact of weather-related problems on solar energy management systems. It is possible to train ANN to anticipate patterns of solar radiation using past data. Solar energy harvesting can be made more efficient using this technique. Following this introduction, the study presents a photovoltaic (PV) energy system. The final portion delves into the topic of PV performance forecasts. An introduction to the Basic Controller Design for Artificial Neural Networks is provided in Section 4.

The fifth portion provides the results and discussion, while the sixth section contains the important conclusions comments.

2. Materials and Methods

Power system that uses photovoltaics

Systems are able to optimize and operate efficiently because to their capacity to forecast energy output and consumption. Machine learning algorithms can sift through weather patterns and past data to predict energy production, allowing for precise system configuration adjustments. Furthermore, PV systems managed by artificial intelligence (AI) can track and respond to fluctuations in energy demand instantly, guaranteeing economical and efficient energy use. In conclusion, enhancing the efficiency and longevity of PV systems via the use of AI in energy management is an encouraging prospect. Several renewable energy firms have taken advantage of this technology's reliability to invest in it and use it as a marketing hub for their goods. A strong engineering system that could disseminate this technology to the surrounding nations and local community made this job possible. The current mild environment is the main factor that allows renewable energy to be effectively used. Because of this, it is well-suited for use with PV systems and renewable energy sources. Maximum performance from photovoltaic (PV) systems is only

possible in Jordan, because to the country's mild yearly average temperature and abundant direct solid sun radiation. All manufacturers are now measuring and testing the performance of their PV goods due to these capabilities, since it allows them to gain accurate feedback on their new equipment and systems. Many industries that do not utilize the electric power grid have found widespread application for the standalone PV system [13]. Parts of the off-grid PV system that are often used include batteries, buck converters, boost converters, maximum power point tracking controllers, PID controllers, and PV panels [14]. This is the setup that interfaces with the power grid directly. Solar panels, an electric load, a distribution panel, a meter, and an electrical grid are the main components.

The SPV cell is able to transform the sun's rays into usable electricity. The movement of electrons is one definition of electricity. Transferring electrons from an atom's nucleus often requires an external source of energy. The most energetic form of an electron that is still bonded to its parent atom is a valence electron. Free electrons have a higher energy level than valence electrons because it takes more energy to remove an electron from an atom. A PV array is made up of many PV modules that are connected in both series and parallel. Figure 1 shows the PV array, a nonlinear system defined by the equivalent cell circuit, $P(V)$, and $I(V)$.

There are a number of mathematical models that attempt to depict the link between semiconductor junctions and their nonlinear behavior. Of them, the "Four-Parameter Model" is by far the most popular. In [15], the effectiveness of PV arrays made of mono-crystalline and polycrystalline materials is thoroughly examined.

The explanation of the maximum energy point tracking method

Keeping tabs on the MPP may be done in a number of ways. Among these methods are neural network, fuzzy logic control, fractional OCV, fractional SCC, and incremental conductance [16].

As an MPPT method, this research took a fuzzy logic controller (FLC) into account. Using a data-knowledge process, the FLC approach keeps the PV system under control. Figure 2 depicts the FLC phases.

where K stands for the sampling time. Figure 3 shows the MFs of the FLC inputs E_r , the FLC output $C E_r$, and the duty cycle (D). There are five fuzzy sets used in each MF: NN, PN, ZR, NP, and PP. In each set, N stands for low and P for high

Fuzzy sets are defined by their membership function (MF). The linearity and ease of use of the triangular MFs make them quite popular. Aside from being superior to other MFs, they are also functioning well. The triangle may undergo changes caused by language modifiers, truth-functional modifiers, compositions, projections, and other operations, yielding additional forms [17].

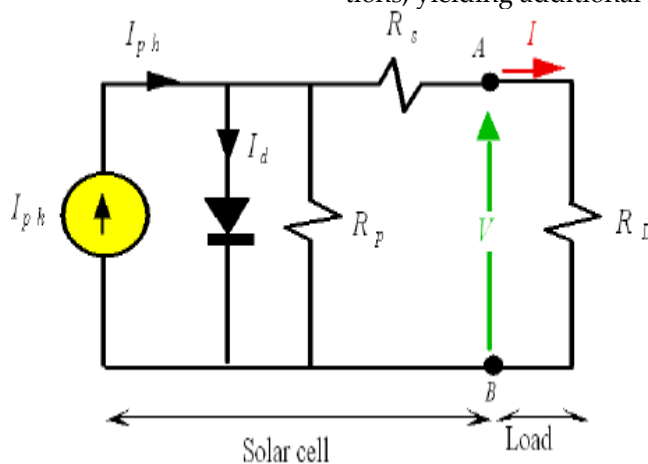


Fig. 1 Power conversion similar circuit for photovoltaic solar batteries.

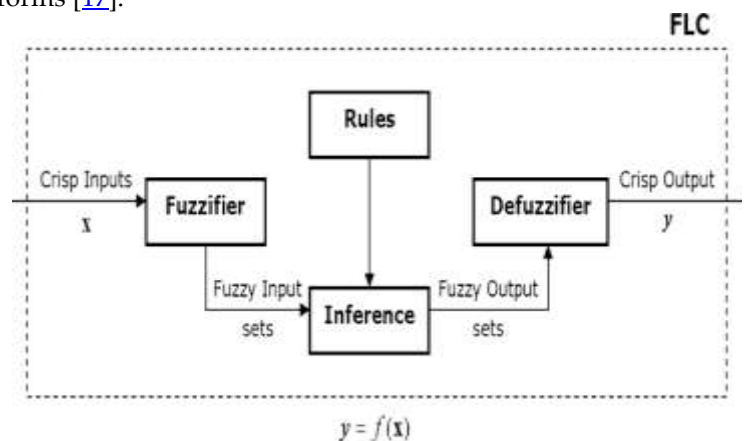


Fig. 2 The FLC technique's block diagram.

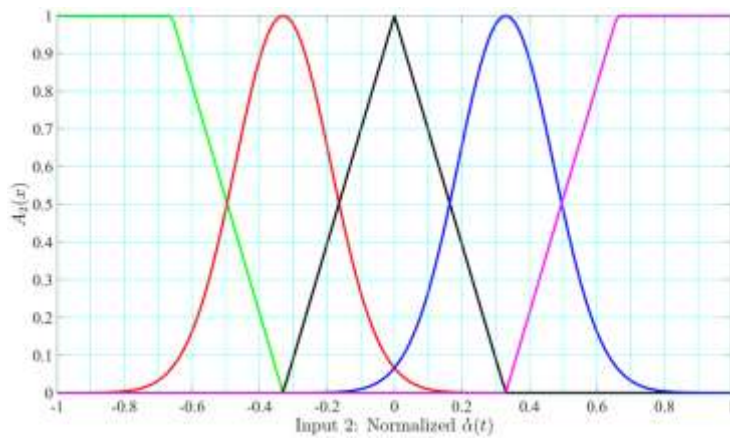


Fig. 3 Power conversion similar circuit for photovoltaic solar batteries.

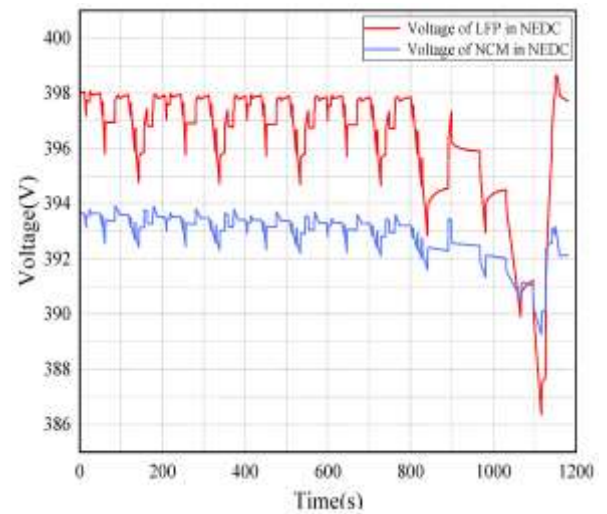


Fig. 4 The FLC technique's block diagram.

3. Results

Two 200Ah lead-acid batteries linked in series have idealized discharge characteristics of 16.667A, 20.833A, and 25A for 400 W, 500 W, and 600 W loads, respectively, as shown in Figure 4. A real-time system collects the data. When the state of charge (SOC) of the battery rises over 70% with a voltage drop of around 20 V, the inverter draws electricity from the grid to bring the SOC back up to 100%. Predictions are made for the values of the simulated data up to a voltage of zero. Under these operating circumstances, the voltage levels that may be used to train the ANN are limited to up to 20 V. If your initial state of charge is low and your load is large, the voltage decrease rate is critical.

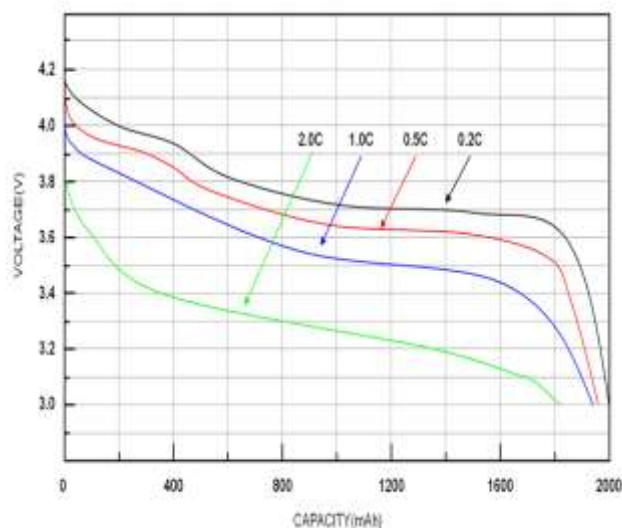


Fig. 5 Conduct by use of an efficient method.

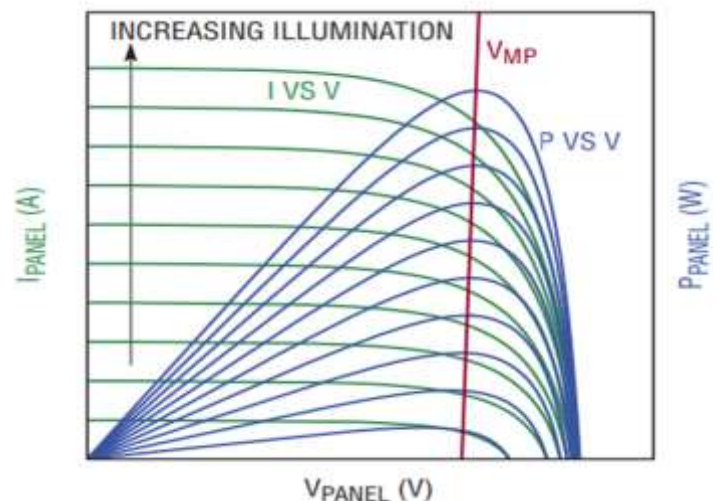


Fig. 6 Power conservation and battery status in solar

Figure 5 shows that, in comparison to the conventional way, the SOC with the intelligent technology guarantees highly smooth and stable operation in all kinds of power and extended duration of operation.

Figure 6 displays the efficiency of the solar PV system as well as the charging states. A extremely steady and smooth operation yields an efficiency of 91%. As may be seen in

Figure 7, the system parameters' magnitude and phase are shown. Effortless operations are achieved on this diagram. Figure 8 shows the 2RC battery modulated by the adaptive neuro-fuzzy inference system (ANFIS).

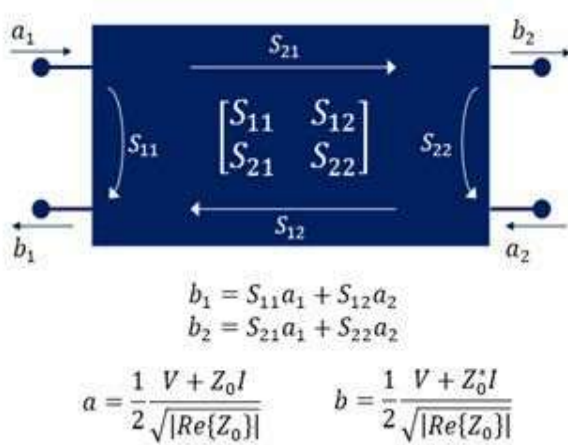


Fig. 7 A structure's amplitude and volume attributes.

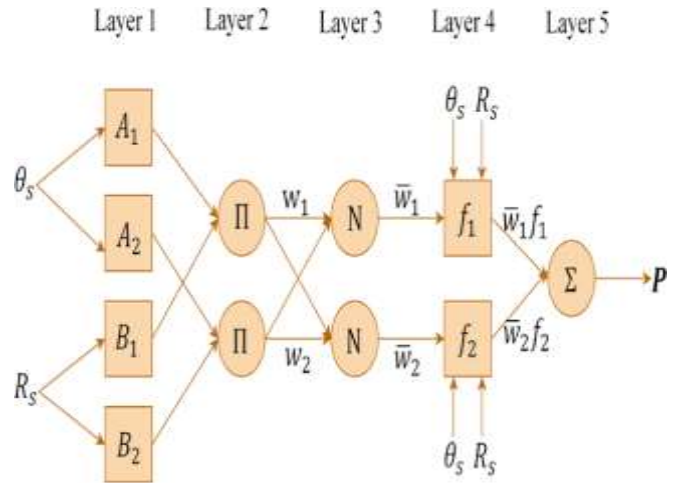


Fig. 8 ANFIS framework and batteries learning inaccuracy

5. Conclusions

The availability of appropriate locations for PV installation is a key factor in the increased number of PV plants connected to the power grid. Using regional coordinates, this approach makes it easier to determine the surface area and battery capacity of photovoltaic (PV) arrays, which is especially helpful in remote areas where global solar radiation data is not easily accessible. Use of this technique includes modeling an improvement in DC-to-AC converters and analyzing the performance of commercial photovoltaic (PV) systems. The results show that the voltage and current outputs of solar converters are highly correlated with those of transducers that operate with continuous direct current (DC) inputs. PV systems have consistently increased their market shares over time, proving to be profitable for several client sectors. Future growth trajectories of photovoltaic (PV) plants are heavily influenced by fluctuations in energy rates. In any scenario where the battery is used to distribute power, the suggested BMS using AI is efficient. The energy management unit's control system enhanced the overall system's functioning, and loads get an adequate supply of energy from storage. Solar photovoltaic (PV) systems for energy management may be designed and tested with the help of the Adaptive Neuro-Fuzzy Inference System (ANFIS), a reliable approach. But there are a number of things holding photovoltaic (PV) systems back from becoming even more widely used. These include people not thinking far enough ahead, not knowing enough about the benefits of PV sources, and the slow process of connecting to the grid. To control the amount of exposure while keeping the temperature constant, a DC-DC boost converter driven by photovoltaics (PV) was developed and put into operation. The new layout makes it easy to see how two photovoltaic (PV) stations are doing and how much better they are at exchanging energy.

Conflicts of Interest: Declare conflicts of interest or state "The authors declare no conflict of interest."

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