Management and Optimization a Stand-alone PV and Battery System Based on Intelligent MPPT

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ABSTRACT

The paper proposes an intelligent MPPT technique based on Artificial Neural Network (ANN) to optimize the output power of a stand-alone PV system, which includes a photovoltaic array, a battery bank, and an electric DC load. The system is equipped with an Energy Management System (EMS) to regulate the power flow between the PV system and the battery bank. The MPPT-ANN controller achieves higher efficiency compared to the conventional P&O algorithm, and the EMS effectively manages the power flow to ensure reliable and efficient operation of the stand-alone PV and battery system.

Keywords: MPPT, ANN, Stand-alone system

1 Introduction

The passage underscores the significance of solar energy, emphasizing its vast untapped potential to meet global power demands. Despite this, solar energy's current contribution to the global energy supply remains minimal. The development of innovative solar technologies is seen as crucial to enhancing energy production. Factors like weather conditions hinder photovoltaic system efficiency, leading to potential energy loss. The importance of Maximum Power Point Tracking (MPPT) techniques, especially advanced approaches like Artificial Neural Network (ANN) MPPT, is highlighted for precise and swift power tracking. The passage also addresses standalone photovoltaic systems and the role of battery banks in storing excess energy, emphasizing the necessity of strategic Energy Management Systems (EMS) for efficient power flow and system performance.

2 Methodology

The paper implements an intelligent maximum power point tracking (MPPT) technique based on Artificial Neural Network (ANN) using MATLAB/Simulink for optimization of the output power of the stand-alone PV system. The control algorithm is implemented using MATLAB/Simulink and the simulation of the proposed system is carried out using the Homer Pro software. [1] The backpropagation (BP) algorithm, a widely used method for training artificial neural networks (ANNs), is employed in this study. [2] Consists of many interconnected computing processors, called nodes or neurons, existent into input, hidden, and output layers. Each neuron (n) in an ANN, takes values from its inputs (ai), multiply them by the corresponding weights (wij) and sums up all the results plus a constant bias (bj) value. The summation then passes a transfer function (F) and produces the output of the node [3]. This process is shown in the equation (1)

$$Y = F(X) = F\left[\sum_{i=1}^{n}\left(w_{ij}a_i + b_j\right)\right] \tag{1}$$

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The back propagation (BP) algorithm is the most usually employed ANNs training method. therefore, the BP algorithm is adopted in this study [4]. The activation function which is widely used is called as sigmoid function it is nonlinear function whose output lies between 0 and 1 is given by equation (2)

$$F(X) = \frac{1}{1 + e^{-x}} \qquad (2)$$

3 Results and Discussion

The proposed intelligent MPPT-ANN controller is more efficient than the conventional P&O algorithm. The Energy Management System (EMS) effectively manages the power flow between the PV system and the battery bank, ensuring reliable and efficient operation of the stand-alone PV and battery system. The simulation of the proposed system using the Homer Pro software provides insights into optimizing the system design. Figure 1 shows successful energy management with the MPPT-ANN technique, maintaining a stable 500 W load supply. Figure 2 indicates faster and more efficient battery charging with ANN compared to P&O under varying conditions. In Figure 3, MPPT-ANN ensures superior system stability and faster response, minimizing overshoot and oscillation compared to P&O.

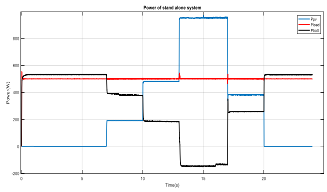

Figure 1: *Photovoltaic, Load and Battery power waveforms stand-alone system with MPPT-ANN in 24 h.in 24h*

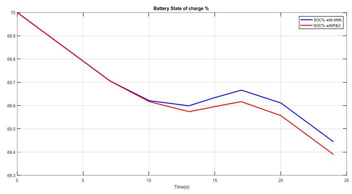

Figure 2: *Battery state of charge waveform of the Two MPPT techniques in 24h*

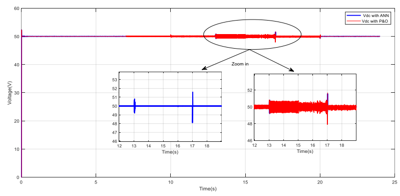

Figure 3: *Voltage in DC bus waveform of a the Two MPPT techniques in 24h*

4 Conclusion

This article discusses the feasibility of a stand-alone photovoltaic system with batteries and its management and control strategy. The two maximum power point tracking methods, P&O and ANN, are compared. The results indicate that the MPPT-ANN method offers several advantages and has an impact on the management control strategy. With the intelligent MPPT charge controller, the load can quickly charge the battery, maintaining Vdc = 50 V throughout the day. The studied system was optimally designed using photovoltaic arrays and lithium-ion batteries with a focus on reliability and cost-effectiveness. This system could be a viable alternative to other methods for obtaining continuous energy charging.

How to Cite

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