Harvesting Maximum PV Power using Artificial Neural Networks

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Abstract:

Photovoltaic (PV) systems have emerged as a key area in renewable energy research, propelled by increasing global energy demand and the necessity for sustainable alternatives. However, the inherent nonlinearity of PV arrays, coupled with their sensitivity to fluctuating environmental conditions such as solar irradiance and temperature, often limits their ability to operate at maximum power output. This paper presents a novel approach for maximizing the power extraction from PV systems through the intelligent integration of Artificial Neural Networks (ANNs) within the MATLAB/Simulink environment. Traditional Maximum Power Point Tracking (MPPT) techniques often struggle with dynamic changes and may exhibit oscillations around the optimal point. Utilizing the learning and adaptive capabilities of ANNs, a robust and efficient MPPT controller is developed. The ANN is trained offline using a comprehensive dataset including various operating conditions, enabling it to accurately predict the maximum power point (MPP) voltage or current. The proposed ANN-based MPPT algorithm is then effectively applied and rigorously evaluated in MATLAB/Simulink, demonstrating superior tracking accuracy, faster convergence, and reduced power losses compared to conventional methods under rapidly changing atmospheric conditions. This research highlights the significant potential of ANNs to enhance the performance and reliability of PV systems, facilitating more efficient and cost-effective solar energy utilization.