A novel MPPT approach for photovoltaic system using Pelican optimization and high-gain DC–DC converter

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Abstract

Photovoltaic (PV) solar cells are essential in renewable energy generation because they can produce power directly. As one of the most practical and widely used methods for meeting global clean energy demands, PV systems are integral to modern energy strategies. However, these systems face significant challenges in maximizing power output, especially under shading conditions and fluctuating loads. To overcome these issues, a, practical Maximum Power Point Tracking (MPPT) function is crucial for optimizing power extraction in such dynamic environments. Solar panels typically produce electrical outputs that vary in DC voltage, requiring a well-designed DC link interfacing circuit to ensure efficient energy transfer from the PV source to the load. In response to these needs, this study introduces the Pelican Optimization Algorithm (POA), a novel nature-inspired stochastic optimization technique designed to track the Maximum Power Point (MPP) of solar sources with high precision. This innovative MPPT method is coupled with a PV-fed, energy-efficient

high-power DC-to-DC converter, which enhances MPPT operation by providing substantial step-up voltage gain and improved overall efficiency. An ideal PV model technique is employed in this study to accurately approximate the system's mathematical parameters. The performance of the POA is benchmarked against three other Metaheuristics MPPT techniques: Particle Swarm Optimization (PSO), Harris Hawks Optimization (HHO),Gray Wolf Optimization (GWO), and Cuckoo Search (CS). These comparisons are conducted under uniform and partial shading conditions (PSCs) as well as varying load scenarios on a standalone PV system. The results reveal that the proposed MPPT technique excels in tracking the global maximum power point across diverse operating conditions. It offers rapid convergence, minimal MPP oscillation, quick response times (less than 0.2 s), and higher efficiency (99%). MATLAB/Simulink simulations further validate POA's superior performance in MPP stability, tracking time, and effectiveness under PSCs. © The Author(s) 2025.

Author keywords

High gain converter; Maximum power point tracking; Metaheuristics optimization; Pelican optimisation algorithm; Photovoltaic system

Indexed keywords

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algorithm; article; data analysis software; electric potential; energy demand; energy transfer; hawk; mathematical parameters; metaheuristics; oscillation; particle swarm optimization; photovoltaic device; photovoltaics; reaction time; renewable energy; simulation; solar cell; solar panel

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