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BIO-INSPIRED OPTIMIZATION FOR ENHANCED MAXIMUM POWER POINT TRACKING IN GRID-CONNECTED PHOTOVOLTAIC SYSTEMS

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Abstract

As the global reliance on fossil fuels diminishes, there is an urgent need to transit towards renewable energy resources (RES). Solar Photovoltaic (PV) systems are emerging as a viable choice for end users to meet their energy demands sustainably. In this research, a modified single-ended primary-inductor converter (SEPIC) powered by solar PV is proposed, to provide a more reliable and efficient energy conversion system. Given the variability in solar irradiance, the Wild Spider Foraging (WSF)-based bio-inspired Maximum Power Point Tracking (MPPT) control technique is utilized to ensure maximum power extraction from the solar PV source. The regulated DC output is then inverted using an inverter controlled by a three-dimensional Space Vector Pulse Width Modulation (SVPWM) technique. This inverter output is fed to the grid through a split-inductor.
The effectiveness of the proposed system simulated using MATLAB environment is validated by constructing a prototype model in the laboratory. Thus, both the results demonstrate that the proposed system achieves a maximum efficiency of 94.83%. Furthermore, the performance of this system compared with state-of-the-art systems, revealing that the WSF based MPPT outperforms both Particle Swarm Optimization (PSO) and Ant Colony Optimization (ACO) techniques in terms of tracking speed and efficiency, making WSF the optimal choice when both optimization speed and solution quality are critical.
The proposed MPPT and converter strategy directly supports environmental sustainability by enhancing the efficiency of solar photovoltaic energy conversion. By maximizing power extraction under varying irradiance conditions and improving grid integration, the system reduces dependence on fossil fuels and promotes the adoption of clean, renewable energy. This contributes to lowering greenhouse gas emissions and supports global efforts toward a more sustainable and resilient energy infrastructure.

Key words: 3D Space Vector Pulse Width Modulation, modified single-ended primary-inductor converter, solar photovoltaic, Wild Spider Foraging

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