UNIVERSITI TEKNOLOGI MARA

MAXIMUM POWER POINT TRACKING FOR PHOTOVOLTAIC APPLICATIONS BY USING IMPROVED PSO UNDER PARTIAL SHADING CONDITIONS

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ABSTRACT

Maximum power point tracking (MPPT) for photovoltaic (PV) systems is difficult, especially under partial shadowing. Traditional particle swarm optimisation (PSO) approaches have many drawbacks, such as growing particle populations, which slow the search for the global peak and lower PV system efficiency and stability. High inertia weight values can make particles move aggressively, exceeding the best solution and slowing convergence. Due to particle mobility reduction, low inertia weight values might trap particles in local minima prematurely. Incorrect acceleration coefficients can produce rapid convergence at a local optimum, preventing enticing investigation or slowing optimal solution movement, resulting in poor performance. The challenges can be overcome by developing a new hybrid inertia weight (HIW) for rapid tracking of the maximum power point (MPP) under different irradiance levels and partial shading conditions, enhancing the acceleration coefficient using a cosine method for accurate MPP tracking, and evaluating the improved PSO's accuracy, efficiency, and speed. A comprehensive research overview, PV system modelling under PSC, buck-boost converter design for PV applications, and PSO algorithm refinement by optimising initialisation conditions, population size, acceleration coefficients, and hybrid inertia weight are included. Simulink implements the updated PSO algorithm for rigorous performance evaluation. Results show significant gains using proposed strategies. An optimal population size of 5 has a 96.28% efficiency average. The Naim 1 acceleration coefficient approach had 90.98% efficiency, but the cosine-based method performed better. The HIW method surpassed prior methods with 97.38% efficiency, 100% accuracy, and 1.7899 seconds convergence. Further dynamic condition research showed that the enhanced PSO consistently outperformed conventional, LQR, and ED PSO. The HIW PSO had an average efficiency of 97.1% and accuracy of 100% under constant irradiance, PSC, and a combination of both. For constant irradiance, PSC, and a mix of both, HIW averaged 1.4020 s, 1.3 s, and 1.1196 s for convergence speeds. The proposed HIW improved PSO convergence, accuracy, and efficiency in dynamic situations. These advances are essential for more reliable and efficient PV systems, especially in partial shadow. The improved PSO technique improves PV system power production reliability and efficiency and boosts public acceptance for renewable energy sources by fixing their most fundamental flaws.

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CHAPTER 1
INTRODUCTION

1.1 Research Background

Photovoltaic (PV) arrays are subjected to different irradiance levels caused by nonuniform shading under partial shading conditions (PSC). As a result, a mismatch between the modules will occur, a reduction in the power generated will occur, and the hotspot phenomenon will be observed. Maximum Power point (MPP) Tracking (MPPT) is a technique used in PV systems to maximise a PV array's power output by adjusting the PV array's operating point to match the MPP of the array's voltage-current (V-I) characteristic curve. This is important because the MPP of a PV array can vary depending on factors such as temperature, solar irradiance, and shading. The performance of a solar energy system can be improved by inserting an intelligent power converter with an appropriate MPPT control between the PV source and the load. The smart converter maximises the power extracted from the solar panel by real-time impedance matching and regulates the PV voltage level.

Buck-Boost Converter is a Direct Current to Direct Current (DC-DC) converter that can change the voltage level by either stepping up or down depending on the input and output voltage levels. It is often used in MPPT systems because it can efficiently track the MPP of a PV array regardless of whether the array's voltage is higher or lower than the voltage of the load. To achieve impedance matching, the DC-DC converter must be controlled by a high-performance MPPT algorithm. Many original MPPT algorithms have been used, such as the perturbing and observing algorithm, Incremental Conductance (InC), fractional open and short circuit techniques, neural networks, sliding mode and fuzzy logic.

Particle Swarm Optimization (PSO) is an optimization algorithm that is inspired by the behaviour of flocks of birds or schools of fish. It is often used in MPPT systems because it can efficiently search the V-I characteristic curve of a PV array to find the maximum power point. The algorithm uses a population of "particles" that represent