Chapter 17
Enhancing Photovoltaic System Performance Using PSO for Maximum Power Point Tracking and DC-Bus Voltage Regulation in Grid-Connected PV Systems

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ABSTRACT

This research presents an integrated approach to enhance the performance of grid-connected photovoltaic (PV) systems by combining sensor-based orientation with

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the practical swarm optimization (PSO) algorithm for maximum power point tracking (MPPT) and a proportional-integral (PI) controller for DC voltage regulation. Solar positioning and infrared sensors provide real-time data, guiding the dynamic movement of the solar panel. The PSO algorithm optimizes motor movements for efficient MPPT, ensuring the panel aligns with the optimal sun position throughout the day. Simultaneously, the PI controller regulates the DC bus voltage, contributing to system stability and grid compliance. Experimental results reveal increased power output, demonstrating the synergistic impact of the integrated system. This approach not only maximizes energy capture but also improves system reliability.

INTRODUCTION

Grid-connected photovoltaic (PV) systems are gaining popularity as a feasible and long-term alternative for generating clean energy (Pragadish et al., 2023). As the demand for renewable energy sources increases, it is critical to optimise the performance of grid-connected PV systems in order to maximise efficiency and production (Niveditha VR. & Rajakumar PS., 2020). In recent years, sensor-based orientation and intelligent control algorithms have emerged as viable approaches to improving system performance (Natrayan & Merneedi, 2020). The purpose of this literature review is to investigate and analyse existing research on the optimisation of grid-connected PV systems through sensor-based orientation and intelligent control algorithms (Natrayan, Senthil Kumar, et al., 2018; Natrayan, Sivaprakash, et al., 2018). Sensor-based orientation is crucial for increasing the energy capture of PV systems. Several sensors, including sun trackers and inclination sensors, have been used to precisely align the PV panels with the incident solar energy (Natrayan & Kumar, 2020; Sathish et al., 2021). Sensor-based orientation ensures that the panels receive optimal solar irradiance throughout the day by constantly tracking the sun's location and altering the panel orientation accordingly (Palaniyappan et al., 2022; Vaishali et al., 2021). This increases the overall energy generation of the system and maximises the use of the available solar resource (Chehelgerdi et al., 2023).

Furthermore, intelligent control solutions have demonstrated promising results in improving the operation and performance of grid-connected PV systems (Ramesh et al., 2022; Sathish et al., 2022; Sendrayaperumal et al., 2021). These strategies combine advanced control algorithms, machine learning techniques, and data-driven approaches. Intelligent control systems can use real-time data from sensors and other sources to dynamically modify system characteristics such as power output, voltage regulation, and reactive power control (Hemalatha et al., 2020; Sureshkumar et al., 2022; Venkatesh et al., 2022). This allows the PV system to perform at its full capability despite changing environmental conditions and load demands. Furthermore,

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