Chapter 6
Intelligent MPPT Control for PV Systems:
A Comparative Study of Conventional and Fuzzy Logic Approaches

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ABSTRACT

This chapter presents a comparative analysis of four popular MPPT algorithms—Fuzzy Logic Control (FLC), Perturb and Observe (PNO), Incremental Conductance (INC), and Hill Climb (HC)—implemented in a MATLAB/Simulink-based PV system. The objective is to evaluate their performance under rapidly changing irradiance conditions, focusing on key metrics such as tracking speed, stability, and power extraction efficiency. Simulation results show that INC and PNO offer the most stable and efficient tracking with minimal oscillations, while FLC demonstrates superior adaptability but with slightly slower settling. The HC method exhibits slower convergence and higher ripple, making it the least effective. Overall, INC and PNO are recommended for robust MPPT control, with FLC showing potential for further development.

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INTRODUCTION

The increasing attention to clean and sustainable energy worldwide mirrors our shared dedication to a greener planet, and solar PV applications have become an important fugitive in this attempt (Alaas et al., 2023). Although these systems are extremely promising, they still present some challenges that could limit their applications. Variation in the solar irradiance and temperature can play an important role on our capability to make use of the available solar power, which may be frustrating for someone who uses such systems for delivering electric power (Badea et al., 2025).

In order to overcome these challenges, Maximum Power Point Tracking (MPPT) techniques have been crucial. These are all designed to maximize the energy output of PV systems, because they work effectively during varying weather conditions (Alik et al., 2018).

MPPT algorithms operate by dynamically varying the operating point of a solar PV system, in such a way that the system operates at or near its maximum power. It is important to know that the I-V and P-V characteristics of PV panels are non-linear, and this makes so that a unique value—the Maximum Power Point (MPP)—exists for every combination of irradiance and temperature that maximizes the power generation (Sulthan et al., 2023; Rezk et al., 2019). In the same way that the sun itself waxes and wanes daily in the sky (metaphorically) casting its light upon us one moment and hiding it the next, the MPP per se ebbs and flows as well, and so in order to maximize our extraction of solar energy, we need to chase the MPP in real time, trying to make the most of the full spectrum of sunlight.

In the last decades, several efforts have been devoted by researchers for achieving an efficient range of MPPT techniques, going from traditional like perturb and observe to advanced techniques based on intelligent and adaptive methods (Alik et al., 2017, Manna et al., 2024). Their current progress is not only hoping to achieve a much higher tracking accuracy and faster response speed, but also attempting to reduce the complexity and make them more robust, especially under challenging conditions such as partial shading and fast changing irradiance (Raj et al., 2020; Yang et al., 2023). Their work is a demonstration of our common commitment to achieving as much renewable energy capacity as possible for a greener, cleaner future.

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