An Efficient Photovoltaic Modeling using an Adaptive Fractional-order Archimedes Optimization Algorithm: Validation with partial shading Conditions

Abstract

Detecting the maximum power point in the photovoltaic (PV) system under normal and shaded weather conditions with high accuracy is vital to save the harvested power. Providing a robust model that emulates the physical behavior of a combination of particular solar modules is the core of designing a reliable PV system. As the PV models' parameters are not provided in the manufacturing datasheets, there is a persistent need to introduce an efficient and competent tool that provides the optimal parameters of the PV models. Therefore, this paper presents a novel strategy depending on a novel fractional calculus-based optimization technique to detect the optimal parameters of the PV models. The identified parameters globally fulfilled all tested shading conditions of different types and configurations of PV modules, strings, and arrays to verify the optimizer reliability and efficiency. A novel optimization algorithm called an Adaptive Fractional-order Archimedes Optimization Algorithm (A-FAOA) is proposed to identify the single and double diode model parameters for several PV solar cells/modules under various environmental conditions. The proposed algorithm uses a fractional-calculus memory perspective to enhance the exploration stage of the basic Archimedes Optimization Algorithm. In addition, the two-dimensional-Henon map is adopted in the algorithm to tune its parameters adaptively in an attempt to achieve a smooth transition between the exploration and exploitation phases. The developed technique is tested on several experimental datasets for several PV cells/modules under diverse environmental conditions. The proposed algorithm is compared with the recent literature based on statistical analysis and non-parametric tests. Moreover, the fitting curves and the values of error at the maximum power points are provided to demonstrate the superiority of the proposed method. For further evaluation of the reliability of the identified parameters, several PV systems based on the studied modules are implemented under uniform and partial shading conditions to affirm the accuracy of the identified parameters in representing a complete connected system under several environmental phenomena. The considered PV systems include three different strings (3x1, 6x1, 9x1) and three different arrays (3 × 2, 6 × 3, 9 × 9). High accuracy, robust performance, and minor deviation between the experimental and estimated curves are evident in the results.