Modified Double Diode Based Parameter Assessment of Industrial Solar Cells

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Abstract

Renewable energy systems have become increasingly common due to many factors, such as the price and the possibility of depletion of fossil fuel, the social and environmental problems. The overall finding shows that the use of solar energy to meet demand for power, carbon release obligations and price reduction of photovoltaic modules has risen in developing countries. So, solar power systems are commonly used as large-scale PV modules in electricity generation. Simulation of solar PV systems typically involves two stages, formulation of the mathematical model and selection of parameters.

In order to achieve successful photovoltaic systems control and optimization, scientists developed various PV models based on voltage and power supply for PV systems. These models have been tested to show the physical behaviour of PV models successfully. PV models are widely used in Real World applications in single and double diode literature. The modified double diode model (MDDM) was used due to various drawbacks as the resistivity in the neighbouring grains boundary area was added in series with the second diode because the resistivity in the vicinity of the grain boundaries was higher than in the case of crystallites. In addition, the actual performance of PV models is often influenced by undefined parameters that may be misunderstood and unreliable as ageing, deterioration and volatile operating conditions of the device are faced on a regular basis. Therefore, precise identification of PV parameters in order to further simulate and configure PV systems is a critical step in advance.

There are typically three types of existing methods: empirical methods, numerical methods and metaheuristic methods. The manufacturers usually include in their data sheet the voltage of the maximum power point (VMPP), the maximum power point current (IMPP), the current of the short circuit (ISC) and the voltage of the open circuit (VOC). The accuracy of parameter evaluation by research methods depends heavily on the appropriate location of certain parameters on solar PV output characteristics. A set of transcendent equations is resolved in the analytical process to obtain the parameters of the solar cell. The main benefit of the empirical approach is the calculation speed and fairly reliable performance. The points on the PV characteristic curve suit numerical extraction procedures based on certain algorithms. Like the analysis approach, an objective conclusion can be obtained as all points on the characteristic curve are taken into account in the algorithm. Newton-Raphson is the form used in literature most commonly. In order to determine the I-V function of a single diode PV configuration parameters, the Levenberg Marquardt algorithm was implemented. The key drawbacks of computer techniques such as Newton Raphson are the need for thorough convergency calculations, and as the number of parameters to be computed increases they do not yield accurate results.

Meta-heuristic techniques were developed to address the limitations of empirical and iterative techniques. Their key benefit is that continuity and differentiability in the objective function are not necessary. Over the past decade, meta-heuristics have also been used to estimate the circuit model parameters of solar photovoltaic cells. The meta-heuristic literature methods used for single, double, and three-diodes were moth flame optimisation (MFO), Flower Pollination Algorithm (FPA), Cat Swarm Optimisation (CSO), an improved whale optimization (IWOA). However, less work is being done with the MDDM as per literature records, and no optimizer can find the best global solution to all problems, enabling researchers to use various optimizers to determine the optimum 8 parameters of the MDDM PV system.

In this paper, the Harris Hawk Optimization (HHO) algorithm for optimisation of 8 parameters of the MDDM of industrial solar cell has been implemented. Two or more Harris Hawks' cooperative hunting practices enabled this algorithm to hunt running prey like rabbits. Therefore, their main tactic was the surprise attack as these Hawks cooperated and struck the prey in several ways and almost at the same time, they came together on a discovered running prey. The exploitation and discovery phases of the HHO algorithm therefore were focused upon Hawks' surprise attacks and the running resources of rabbit.

Keywords: Solar cell parameters; industrial solar cell; modified double diode model (MDDM); metaheuristic approach

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