Chapter 22
Parameter Optimization of Photovoltaic Solar Cell and Panel Using Genetic Algorithms Strategy

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ABSTRACT

In this chapter, we propose to perform a numerical technique based on genetic algorithms (GAs) to identify the electrical parameters (Is, Iph, Rs, Rsh, and n) of photovoltaic (PV) solar cells and modules. The one diode type approach is used to model the I–V characteristic of the solar cell. To extract electrical parameters, the approach is formulated as optimization problem. The GAs approach was used as a numerical technique in order to overcome problems involved in the local minima in the case optimization criteria. Compared to other methods, we find that the GAs is a very efficient technique to estimate the electrical parameters of photovoltaic solar cells and modules. Compared with other parameter extraction techniques, based on statistical study, results indicate the consistency and uniformity of method in terms of the quality of final solutions. In parallel, the simulated data with the extracted parameters of method base with GAs are in very good agreement with the experimental data in all cases.

INTRODUCTION

Metaheuristic algorithms have become high powerful tools for modeling and optimization. Metaheuristic optimization algorithms are used extensively for solving complex optimization problems. Compared

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to conventional methods based on formal logics or mathematical programming, these metaheuristic algorithms are generally more powerful (Sahab, Toropov & Gandomi, 2013).

Optimization techniques can be divided in two groups, mathematical programming and metaheuristic algorithms. In general, the existing metaheuristic algorithms may be divided into two main categories as follows, Evolutionary algorithm and Evolutionary algorithms (Gandomi, 2014).

An evolutionary algorithm (EA) is a population-based meta-heuristic optimization algorithm inspired by the concepts of biological evolution such as reproduction, mutation, recombination and selection. They are randomized and stochastic techniques which simulate the evolutionary pressure of selection to select high fit individuals and use the evolutionary operators "crossover" and "mutation" to evolve better individuals. EAs generally start with a set (population) of random candidate solutions called individuals or chromosomes. In case of de novo drug design, chromosomes are represented by candidate chemical compounds. Evolutionary algorithms use the scoring function or the fitness function over the current population to determine the quality of the candidate solutions. Various selection methods such as "Roulette wheel", "Tournament", and "Rank" selection are used to populate the right candidates into the mating pool, where they are subjected to crossover and mutation. The crossover operator combines the genetic traits of two individuals (parents) and produces a new off-spring. A mutation event introduces new piece of information into an existing population. Thus, the crossover and mutation operators provide variations among the current population and evolve better and better solutions. The evolution process continues tilluser-specified termination criterion (Surbey, Devia, Sathyaa & Coumarb, 2015). Evolutionary strategy (ES) (Fogell, Owens & Walsh, 1966), genetic algorithm (GA) (Holland, 1975), and differential evolution (DE) (Storn & Price, 1997) are the most well-known paradigms of the evolutionary algorithms which use biological mechanisms such as crossover and mutation. These algorithms have been improved a lot and new variants of them have been introduced (e.g. cellular GA (Canyurt & Hajela, 2010)). Genetic programming (GP) is known as an extension of GAs (Koza, 1992). Several attempts have been made to improve the performance of GP (e.g.multi-stage GP (Gandomi & Alavi, 2011)). The mentioned evolutionary algorithms have been widely used to solve engineering optimization problems (e.g. Yüzgeç, Türker and Hocalar (2009)). Harmony search (HS) algorithm is another evolutionary algorithm proposed by Geemetal (Hedar & Fukushima, 2006). This algorithm simulates the musicians' behavior when they are searching for better harmonies.

Genetic algorithms (GAs) are adaptive heuristic search algorithm based on the evolutionary ideas of natural selection and genetics. As such they represent an intelligent exploitation of a random search used to solve optimization problems (Singh, Agrawal, Tiwari, Al-Helal & Avasthi, 2015). The performance of genetic algorithms depends to a large degree on the parameters which are under the control of the researcher, requiring adjustments to deal with the specific problem at hand. These parameters and namely the fitness function there- fore have to be carefully selected to match the specifics of credit scoring (Kozeny, 2015).

The algorithms that we use to determine parameters of PV generators (solar cells, modules and arrays) must be efficient and sufficiently accurate for process optimization and photovoltaic systems design tasks. These algorithms are of two types: those that use selected parts of the current–voltage (I–V) characteristic (Charles, Abdelkrim, Muoy & Mialhe, 1981; Charles, Ismail & Bordure, 1985; Laplaze & Youm, 1985; Chan & Phang, 1987). Accurate extraction and optimization of solar cells and solar panel parameters are very important in improving the device quality during fabrication and in device modeling and simulation (Gottschalg, Rommel, Infield & Kearney, 1999; Ortiz-Conde, Ma, Thomson, Santos, Garcia, Lei, Finol & Layman, 2000). To simulate and characterized a photovoltaic cell, and