Chapter 20
An Accurate and Efficient Analytical Method to Extract the Parameters of the Single and Double Diode Photovoltaic Cells Models

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ABSTRACT

For Photovoltaic systems designers and manufacturers, it is very important to develop suitable models to closely emulate the characteristics of PV cells, predict their behavior and evaluate their efficiency. So the main contribution of this chapter is to propose an improved and accurate method for identifying and determining the equivalent circuit elements values of photovoltaic module using only exact analytical equations and four manufacture's data reference, i.e., the open-circuit voltage (V_{OC}), the short-circuit current (I_{SC}), the current and the voltage at the maximum power point (I_M, V_M). In order to extract the five-parameter Single or Double-Diode models of photovoltaic module, the authors try initially to determine analytically all parameters according to R_S (the value of the series resistance). Thus, all these parameters are calculated once R_S is determined. Rapid and iterative algorithm is then designed to solve a strongly nonlinear equation in order to extract the value of R_S in a precise manner and without any mathematical simplification used usually by many other authors.

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INTRODUCTION

The most powerful natural energy resource is the sun and the solar technologies offer clean and sustainable options for generating electrical energy without pollution. Photovoltaic (PV) technologies have distinct environmental advantages for generating electricity over conventional technologies. The operation of photovoltaic systems does not produce any noise, toxic-gas emissions, or greenhouse gases. Photovoltaic electricity generation, regardless of which technology is used, is a zero-emissions process.

The basic unit for converting solar energy into useful electrical energy is the solar cell. Grouped cells form photovoltaic (PV) modules with the aim of increasing energy production and make the process more practical. However, due to the high investment cost on PV modules, optimal utilization of the available solar energy has to be ensured. This necessitates a precise and reliable simulation of the designed PV systems prior to installation.

For Photovoltaic systems designers and manufacturers, it is very important to develop suitable models to closely emulate the characteristics of PV cells, predicting their behavior and evaluating their efficiency (Majdoul et al., 2015). It can be used also to study the interaction between the power converter and the PV arrays. Climate and solar radiation affect both on PV system supply side issues and on system demand side issues. Designers need both solar data and temperature data. The modeling tool must allow the analysis of the behavior of electrical characteristics in accordance with environmental changes such as temperature and irradiance. It is verify that these extrinsic factors influence strongly the photovoltaic efficiency.

In practice, in order to describe the current-voltage (I-V) relationship for PV simulators, the most popular approach is to use the electrical equivalent circuit with both linear and non-linear components (Ishaque et al., 2011). According to what has been said, it is clear that these components have to be adjusted automatically when the operating conditions change. Over the years, many models have been proposed, but two main equivalent circuit models have been widely used: the single diode model also called simple exponential model and the double diode model or double exponential model. These models differ in the accuracy and number of parameters involved in the calculation of PV current-voltage characteristics. To use these models in the simulation and evaluation of PV systems, one needs to determine the models parameters. However, parameter identification of such models is a challenging problem, since the derived equations for the estimation of a PV model parameters are implicit and nonlinear and may not be analytically solved (Hejri et al., 2014).

This chapter aims to give at first a summary overview of many aspects of photovoltaic cells modelling used and the different parameters estimation methods explained and promoted by many researcher authors. In a second phase, the authors proposes and develops an improved and accurate method for identifying and determining the equivalent circuit elements values of photovoltaic module. They use in this approach, only exact analytical equations and four manufacture's data reference, i.e., the data of three remarkable points: the open-circuit voltage (V_{OC}), the short-circuit current (I_{SC}) and the current and the voltage at the maximum power point (I_M, V_M). This approach is presented in a way that it can be easily accessed by the expert and the non-specialist of photovoltaic systems.

This promising alternative would be to compute the parameters PV cells model using the hybrid approach by combining analytical method and numeric computing. Thus, the authors try initially to determine analytically all parameters according to R_S (the value of the series resistance). Thus, all these parameters are calculated once the series resistance R_S is determined. Then a rapid and iterative algorithm is designed to solve a strongly nonlinear equation in order to extract the value of R_S in a precise manner