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Photovoltaic Station Analytical Model

Imad Elzein, Yury N. Petrenko
Lebanese International University
Белорусский национальный технический университет

Before installing a Photovoltaic (PhV) system, a good performance estimation of the adopted PhV generators is necessary since the initial cost of the system is pretty high. The working principle of PhV cells is essentially based on the PhV effect, which refers to the generation of a potential difference at the P-N junction in response to visible or other radiation.

The behavior of a solar cell, as a common approach, is usually modeled by a 1-diode and 2-resistor (1D-2R) electric circuit; this simplest approximation gives satisfactory the nature of the more important physical effects related to the photovoltaic conversion of the sunlight to voltage and current.

Conventional PV models are generally analytical equations based on a physical description formulating photovoltaic generated current (I) with the operating voltage (V), the ambient temperature (T) and the irradiance (G). It is reported that a nonlinear implicit relationship exists between I and V, but normally necessitates using tedious iterative numerical calculations.

In order to facilitate the choice of the most appropriate method for the given particular application, the methods are classified according to their lumped parameter equivalent circuit model: single exponential, double-exponential, multiple-exponential, with and without series and parallel resistances

These numerical and estimation methods significantly increase the computation complexity and thus are not feasible for real-time prediction of I-V characteristics. It seems to be very essential because more recently appears an increasing attention for high-speed performance estimation PhV models are more and more frequently suggested using to execute real-time optimization of the photovoltaic stations.

One solution of this problem (leaving aside any numerical help) appears as a more compact approach may be derived by applying the Lambert W- function, which is defined as $Z=W(z)\exp(W(z))$, where z is any complex number. The general approach to apply the Lambert W-function in solving exponential equation of the PhV cell is to use the following equivalence

$$X=Y(\exp Y) \Leftrightarrow Y=W(X)$$

The Lambert W function is supported in all modern computational platforms, such as MATLAB, Maple, and Mathematica.