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Parameters Extraction of Single Diode Model

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ABSTRACT:

A single-diode-model circuit with the five parameters for a given environmental condition represents the performance of a photovoltaic (PV) module. However, the implicit model characteristic equation makes parameter extraction computationally difficult. Furthermore, only four equations can be used to calculate the five parameters from the Harris Hawks optimization (HHO) algorithm. To complete the solution, the fifth equation's formulation is extremely difficult. As a result, the researchers attempted several approximations to complete the problem formulation, but the obtained results were often inaccurate. This paper focuses on the parameters extraction of single diode model which considers an exact area under the current-voltage (I-V) curve of a PV cell/module without any approximation. The method is used for different cells as case study-I and for experimental data from a silicon cell and a module that is widely available in the literature as case study-II. In comparison to existing methods, the numerical results are extremely accurate.

KEYWORDS: *Photovoltaic cell, Resistance, Optimization method, Renewable energy sources, Parameters.*

INTRODUCTION:

Solar PV energy is a major source of renewable energy that can be used for rural, domestic, power plants, space shuttles, and transportation due to features such as clean and green source, noiseless, flexible sizes and capacity, and low maintenance. Furthermore, due to cost competition among manufacturers, the degradation of fossil fuels, and volatile costs, PV investment is skyrocketing. The solar cell is the fundamental component of a photovoltaic system. To simulate the behaviour of a solar cell, single and double diode equivalent circuit models are commonly used. The use of diode models allows for the performance evaluation, design, and control of more complex power systems incorporating solar cell panels. However, solar cell manufacturers do not provide the necessary parameter knowledge for modelling. As a result, extracting parameters from manufacturer data is a critical step in developing a reliable simulation model for a solar cell, a solar panel, or even a complex photovoltaic system. The single-diode equivalent circuit of a solar cell is shown below figure (1).

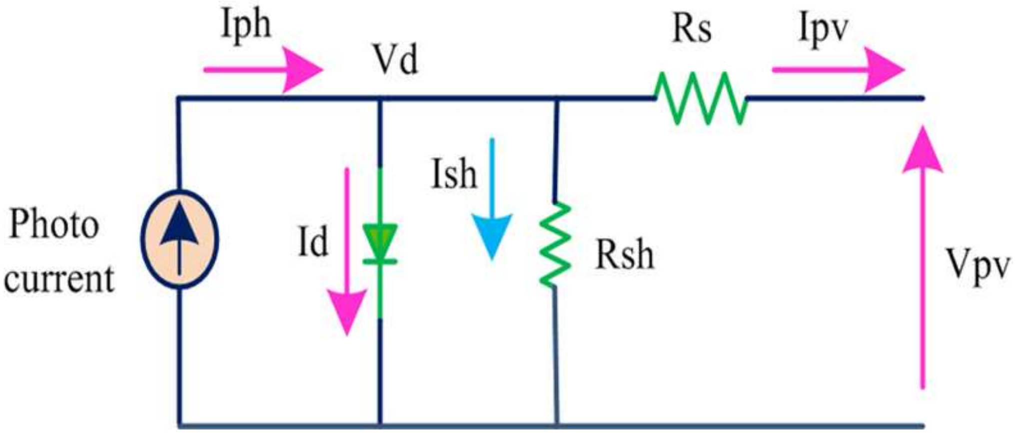

Fig .1 The single diode equivalent circuit of a solor cell

The solar cell I-V relationship is given by

$$I_{pv} = I_{photo} - I_d \left(\exp\left(\frac{V_{pv} + I_{pv}R_s}{aV_t} \right) - 1 \right) - \frac{V_{pv} + I_{pv}R_s}{R_p} \qquad \text{Equation (1)}$$

where Iph is the photocurrent generated by the cell, Io is the diode's reverse saturation current, n is the diode ideality factor, Rs is the series resistance, and Rsh is the shunt resistance The extraction of the five parameters is critical for determining the I-V characteristic of a solar cell under real-world conditions such as irradiance and temperature. In general, extensive testing results are required for experimental characteristics of the I-V curve, from which the parameters are identified. However, in most cases, manufacturers do not provide the testing results or I-V curve, and setting up a complicated measurement system is either too expensive or takes too long. The only information available to adjust the circuit model is limited to three points on the I-V curve on the datasheet (short circuit, open circuit, and maximum power point). Five boundary conditions are required to calculate the five parameters, but with only three points, only four boundary conditions can be derived, and identifying five parameters is a difficult task due to the transcendental and implicit formulations. Current extraction methods are broadly classified as follows.

EXPLINATION:

Harris Hawks optimization (HHO) algorithm:

The HHO algorithm is a metaheuristic method inspired by the natural behaviour and chasing strategy of Harris hawks. Several hawks work together to attack the prey from different directions so that they all converge on the prey they have identified. Harris hawks use a variety of chasing strategies based on the dynamic nature of the prey's situations and evasion patterns. At each stage of the HHO algorithm, Harris hawks are considered candidate solutions, and the prey is considered the best candidate solution (or optimal solution). Initially, hawks are distributed at random across the search space. They then identify the prey's position using one of two strategies: in the first, the hawks determine their new position based on the position of other group members (other hawks) and the position of the prey; in the second, the hawks randomly determine their new position within the range in which the group members move.

$$\vec{X}(t+1) = \begin{cases} X_{rand}(t) - r_1\,|X_{rand} - 2r_2X(t)| & q \geq 0.5 \\ (X_{prey}(t) - X_m(t)) - r_3(LB + r_4(UB - LB)) & q < 0.5 \end{cases}$$

$\vec{X}(t+1)$ where is the hawks' position vector in the next iteration ; X_{prey} (t)is the prey's position in the current iteration; the coefficients r1, r2, r3, r4, and q are randomly generated numbers in the range (0,1), which are updated in each iteration; and LB and UB show the lower and upper limits of the variables, respectively. X_{rand} (t) is the position of a hawk randomly selected from the current population, and X_m(t) is the average position of the current population of the hawks, which can be obtained from the following equation:

X_m(t) $=\frac{1}{W}\sum_{i=1}^{W} X$(t)

where W stands for the total number of hawks

Harris hawks hunt in such a way that the prey becomes tired and its energy levels drop. The hawks then exhibit various chasing behaviours based on the residual energy of the prey. The residual energy of the prey is calculated using the equation below.

E=$2E_o\left(1-\frac{t}{T}\right)$

where T is the maximum number of algorithm iterations; and the value of E o in each iteration is chosen at random from the range (-1,+1).

ADVANTAGES AND APPLICATIONS

ADVANTAGES:

- Single diode model is simple and easy to improvement then the double diode model
- SDM uses the better accuracy which acquiesces for more precise forecast of system performance

APPLICATIONS:

- Rectifiers
- Clipper circuits
- Clamping circuits
- Reverse current protection circuits
- In logic gates
- Voltage multipliers

CONCLUSION

To improve the performance of the original HHO algorithm, a new optimization algorithm called whippy Harris Hawks Optimization (WHHO) was proposed. The proposed algorithm has several notable characteristics, including fast convergence,

global exploration, and high robustness. To assess the performance of the proposed algorithm, the model parameters of PV cells and PV modules for the Single diode model were identified, and the results were compared to some other well-known and powerful methods used in the relevant literature. Using various experiments, we discovered that the computed results were very close to the experimental data of the modules, confirming the proposed algorithm's high performance and accuracy.

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