Setting the series resistance of photovoltaic modules

Overview

Determining series resistance of the photovoltaic module Abstract: Procedures for determining the series resistance value of a photovoltaic module, are explained theoretically and mathematically.

Key Takeaways

Series resistance (Rs) in PV modules is a critical parameter affecting efficiency and can be determined through analytical, measurement-based, or modeling approaches.

Understanding Series Resistance

Series resistance in a PV module represents the resistance encountered along the current path, including the internal resistance of cells, contact resistance at interconnections, and wiring resistance within the module. High series resistance reduces the fill factor and overall power output, particularly affecting the slope of the I–V curve near the maximum power point (MPP) and open-circuit voltage (Voc),. It is distinct from shunt resistance, which relates to leakage paths bypassing the cells.

Measurement and Calculation MethodsI–V Curve Analysis: Series resistance can be extracted by fitting the illuminated I–V curve to the single-diode or double-diode model. This involves adjusting Rs along with other diode parameters to match the measured curve. The slope of the I–V curve near Voc can provide an apparent series resistance, but this is not the same as the Rs used in the one-diode model.

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Maximum Power Point (MPP) Method: A practical approach is to measure current and voltage near the MPP, which minimally affects power output. This method allows accurate determination of Rs without significantly reducing module performance. Experimental validation has shown that series resistance determined near MPP can differ by less than 2% from values obtained using the full I–V curve.

Analytical and Correction Methods: Advanced methods involve deriving Rs from the derivative of the I–V curve and applying correction techniques to account for environmental conditions, such as irradiance and temperature. This ensures that series resistance values are comparable across different operating conditions and can be used for long-term health monitoring of PV modules.

Practical Considerations

Environmental Effects: Series resistance varies with temperature and irradiance, so measurements should be corrected to standard conditions for accurate comparison. Impact on Module Performance: Lower Rs results in sharper I–V characteristics at high voltages, improving fill factor and efficiency. Software Modeling: In PV simulation tools like PVsyst, Rs is an adjustable parameter in the one-diode model and is not directly measurable.

Its effect is coupled with the diode's exponential slope, so careful calibration is required.

Summary

To set or determine the series resistance of PV modules effectively: Measure voltage and current under controlled or corrected environmental conditions. Use I–V curve fitting or MPP-based methods for accurate extraction. Apply analytical corrections to ensure comparability across different operating conditions.

Consider Rs in modeling and monitoring to optimize module performance and assess aging or degradation. By following these approaches, series resistance can be accurately quantified, enabling better performance evaluation and long-term monitoring of photovoltaic systems.

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Article Content

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Determining series resistance of the photovoltaic module Abstract: Procedures for determining the series resistance value of a photovoltaic module, are explained theoretically and mathematically.

A series resistance extraction method for health evaluation of ...

In this study, an analytical method for series resistance was derived, and a correction method for I–V curves that differs from the IEC 60891 standard was proposed, based on the

Measurement of Series Resistance

The simplest way to measure series resistance is to fit the illuminated IV curve with either the ideal diode equation or the double diode equation. While this is conceptually very simple there are often

Photovoltaic module series resistance identification at its maximum ...

The series resistance is the most important single-diode model parameter in assessing the condition of PV modules; this paper proposes a novel method for its determination by using

An Evaluation of Series Resistance Extraction Methods of Photovoltaic ...

In this study, five different methods from the literature, comprising both graphical and analytical methods, are used to determine the series resistance of ten different polycrystalline PV

Methods for online identification of photovoltaic module ageing by ...

In this light, the present work brings new scientific value for series resistance -based ageing detection of PV modules and offers guidelines for the selection of an appropriate single-diode

A validation study of photovoltaic module series resistance ...

This paper presents a validation study on series resistance determination of photovoltaic modules on the basis of the IEC 60891 edition 2.0 (2009) normative standard. A selection of different

PpkandRs

A measuring method is presented, which can measure under natural ambient conditions and directly display the results peak-power Ppk and internal series resistance Rs.

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Determining series resistance for equivalent circuit models of a PV

Our purpose is to evaluate methods to determine the series resistance parameter for an equivalent circuit model of a photovoltaic device comprising a diode with parallel and series resistances.

Series resistance determination and further characterization of c-Si PV ...

This paper presents a new algorithm for determination of the series resistance of crystalline-Si PV modules from individual illuminated I–V curves. Th

Determining series resistance for equivalent circuit models of a PV module

Literature describes various methods for determining a series resistance for a photovoltaic device from measured IV curves. We investigate use of these techniques to estimate the

Determining series resistance for equivalent circuit models of a PV module

Sandia National Laboratories, Albuquerque, NM,USA 87185-1033 Abstract — Literature describes various methods for determining a series resistance for a photovoltaic device from measured IV

Photovoltaic module series resistance identification at its maximum ...

The proposed method can be used with any series resistance identification procedure based on current–voltage curve measurements. The proposed method is experimentally validated

An assessment of series resistance estimation techniques for different ...

Abstract The series resistance is a significant electrical parameter of the solar photovoltaic module and is used for outdoor performance modeling, evaluation and degradation studies. There

Analyzing Series Resistance Effects on PV Characteristics and ...

The paper explores the modeling of photovoltaic (PV) generators and the influence of series resistance (Rs) on their electrical characteristics, particularly the I-V and P-V curves. By visualizing the

A series resistance extraction method for health evaluation of ...

Abstract Photovoltaic (PV) modules must be monitored and evaluated in real-time during long-term operations to maintain a high performance, and series resistance is a critical component of

A novel method to extract the series resistances of individual cells in ...

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Abstract Non-disruptive cell-level characterization of a photovoltaic module is presented. Previous works have developed methods to extract the shunt resistances and the short circuit

Methods for online identification of photovoltaic module ageing by ...

Research Paper Methods for online identification of photovoltaic module ageing by series resistance from measured current–voltage curves

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