

Measuring and estimating the temperature of photovoltaic modules

Abstract

The temperature of a photovoltaic module is a key parameter for the accurate assessment of its performance. In cases where actual measurements are not available, a number of different models can be used to estimate the temperature of the module. Seven such relations are applied and evaluated against experimental data. Comparisons show that the residuals can be described by a Gaussian distribution with the minimum half width at half maximum of $\sim 2.2^\circ\text{C}$. Implementation of a simple heat transfer model also results in similar uncertainties ($\sim 2.1\text{-}2.2^\circ\text{C}$). Considering the simplicity of the relations, the complexity of the physics involved (uncertainties in the heat transfer coefficients, transient phenomena) this accuracy is usually considered to be satisfactory.

A more reliable way to determine module temperature is to use the open circuit voltage method where this single value ideally provides knowledge of the average temperature of all cells. It is shown that this method that utilizes the EN 60904-5 standard is not easy to apply and the accuracy is limited by the uncertainties of the various parameters. In particular, the experimental uncertainty in the determination of the thermal voltage becomes a significant source of uncertainty in determining the parameters that characterize module performance if the diode quality factor is not precisely known. An analysis of the accuracy of the required parameters such as the open circuit voltage at reference conditions, its rate of change with temperature, and the diode quality factor indicate that a series of measurements in a temperature controlled environment could be used to reach the goal of determining the cell temperature with an uncertainty of 1°C or less.