

Unveiling the Potential of Infrared Thermography in Quantitative Investigation of Potential-Induced Degradation in Crystalline Silicon PV Module

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Abstract

Potential-induced degradation-shunting (PID-s) is a severe degradation mechanism in photovoltaic (PV) cells that significantly impacts module performance. Regular monitoring and quantitative assessment of PID-s are crucial for ensuring long-term reliability of PV systems. Current-voltage (I-V) characteristics and electroluminescence (EL) imaging are commonly used for quantitative performance evaluation of PID-s affected PV modules. However, conducting I-V measurements is time-consuming when performed across large PV installations, while EL imaging has limitations for severely PID-s affected cells with no EL emission. This article proposes the use of inverse infrared (IRINV) thermography as an alternative investigation technique for PID-s in a PV module. IRINV imaging is fast and also effectively maps the severely PID-s affected cells in a PV module. This article unveils the potential of IRINV thermography in quantitative investigation of PID-s in crystalline silicon PV modules. The module level investigations present insights into the correlations between cell temperature and power output under different imaging conditions using Pearson correlation. Results indicate that steady-state operation with medium input current provides the most suitable condition for quantitative PID-s investigation. Furthermore, cell level analysis of temperature distribution and its variation with PID-s progression has been investigated using histogram and kernel density estimation (KDE) statistical tools, revealing distinct patterns as PID-s progresses. A PID-s severity index is proposed based on KDE, providing a quantitative measure of PID-s severity in cells within a PV module. This work provides valuable insights into the use of IRINV thermography as an alternative technique for assessment of PID-s in PV module inspection.

Keywords: Potential-Induced Degradation (PID), Infrared (IR) Imaging, Photovoltaic (PV) Module, Cell Power

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