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Characterization and Classification of a 5-kW Xenon Lamp Solar Simulator with an Ellipsoidal Reflector

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Solar photovoltaic (PV) modules are generally guaranteed to provide up to 85% of their rated power after 25 years of outdoor exposure. However, a number of factors, be it inherent to the PV technology or due to the environment, can result in premature performance degradation and even electrical failure.
In order to monitor the module's performance, without the influence of the constantly changing outdoor operating conditions, it is necessary to use a solar simulator where the light intensity (100 mW/cm2), module temperature (25°C) and air mass between the light source and the target area (AM 1.5 global spectrum) are constant even after 25 years. These constant conditions constitute the Standard Test Conditions (STC), which are universally accepted for solar simulators.
For this study, a steady state simulator was designed, built, characterized and classified. The 5-kW Xenon lamp simulator with ellipsoidal F2.5 reflector was characterized in terms of (i) the spectral match to the AM 1.5 global spectrum with a 100 nm bandwidth from 300 nm to 1100 nm, (ii) the irradiance spatial uniformity as measured with a class A pyranometer and (iii) the temporal instability over both short- and long-term periods. These three criteria were measured over an effective target area of 1.5 m x 1.5 m (at a grid size of 5 cm x 5 cm), with source-to-target distances varying from 2.0 m to 6.0 m. As per the IEC 60904-9-2007, ASTM and JIS specifications, the designed simulator conforms to an AAA rating. That is, the measured spectra were within 0.75 - 1.25 times the AM 1.5 global spectrum (A), ≤ 2% spatial non-uniformity over the entire target area (A) and < 2% long-term instability (A).
Furthermore, current-voltage (I-V) measurement reproducibility of the simulator was evaluated for various PV modules technologies and the results indicated a confidence level of more than 95%. This paper will detail the design of the simulator, methodology for AAA rating, its results and reproducibility of the I-V measurements of various PV technologies.

Keywords: AAA Solar Simulator, STC, Spectral Match, Irradiance Spatial Uniformity, Temporal Instability, I-V measurements

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