First Solar

Module Characterization Light Response of FS Series 4 PV Modules

PURPOSE

This document provides supplemental information about the response of First Solar FS Series 4 (S4), Series 4V2 (S4V2) and Series 4V3 (S4V3) PV modules in varying light conditions. The data is intended to support the proper design of systems using these modules as well as the development of more accurate models for energy prediction. All data reported in this document is the result of consolidation of multiple characterization studies made on individual samples from the FS Series 4 product family.

SCOPE

All data reported in this document is based on measurements of a population of modules which represents the range of First Solar Series 4 products. This data will be updated periodically and without notice to best represent the current module production as First Solar continues on a roadmap to higher efficiencies.

RESULTS

The power output performance of multiple modules in the FS Series 4 family is characterized at varying irradiance levels. When these results are normalized relative to Standard Test Conditions (1000W/m^2 total irradiance with AM1.5 global spectrum and 25°C module temperature), the relative power output as a function of irradiance (referred to here as the "efficiency-irradiance response" or **EIR**) can be determined as shown in Figure 1-3.

Data used to generate the consolidated performance results described in this report was obtained in the laboratory with a long-pulse type solar simulator for S4 modules. The S4 EIR response sufficiently characterizes the S4V2 and S4V3 EIR response, and the data shown in Figure 2 reflects this with a correction made to reflect the updated temperature coefficient present in S4V2 modules (-0.34%/°C), and the data shown in Figure 3 reflects the module response of a S4V3 module with the updated temperature coefficient present (-0.28%/°C). The simulator used to obtain the laboratory measurements allows adjustment of the total irradiance level at the module's surface. However, adjustment of this total (broadband) irradiance level results in small changes in the spectral irradiance produced by the simulator. All data has been corrected for measurement error due to spectral mismatch, which occurs as the total irradiance level of the simulator is varied.

Figures 1-3 also depict the **EIR** performance characteristic at higher module temperatures. Such conditions are more common in actual module operation than Standard Test Conditions. Ratings at these more common conditions provide a good characterization of typical module behavior observed in the field. The negative temperature coefficient of P_{MAX} is evident as the relative performance is lower at higher module temperatures.

Evaluation of FS Series 4V2 and Series 4V3 PV modules across all rated power bins has shown strong performance consistency for the entire series with minor variation from module to module. Limited variation from module to module is normal and is to be expected when comparing measured results to actual field performance.

Figure 1. Dependence of maximum power (P_{MAX}) on total irradiance and module temperature for S4 modules. All values are calculated with respect to P_{MAX} at standard test conditions. Error bars indicate +/- two standard deviations about the mean of response of the sample population.

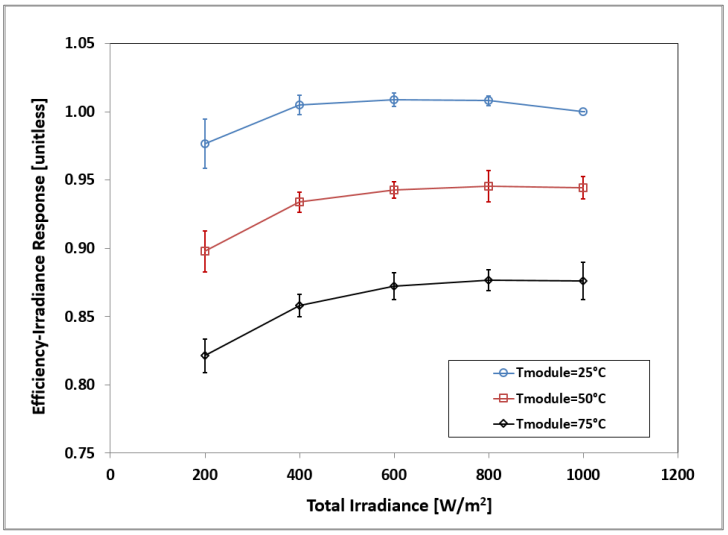

Figure 2. Dependence of P_{MAX} on total irradiance and module temperature for S4V2 modules. This is a representation of the response of S4V2 modules with an 110W nameplate power.

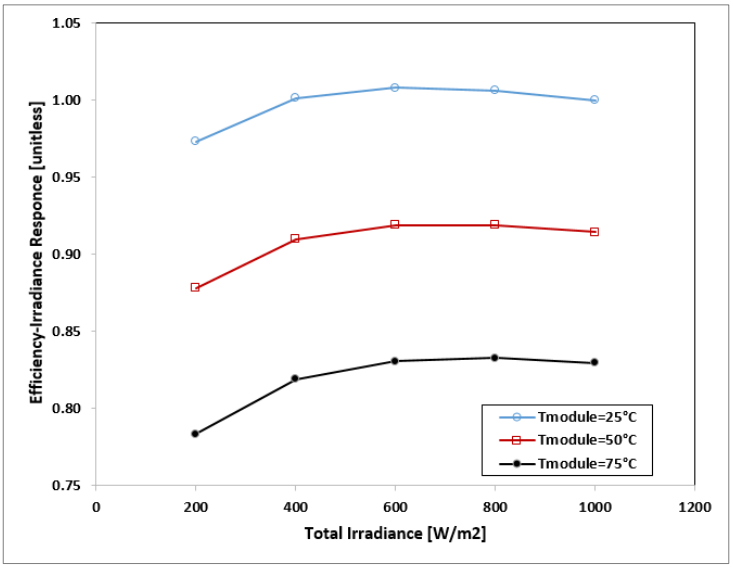

Figure 3. Dependence of P_{MAX} on total irradiance and module temperature for S4V3 modules. This is a representation of the response of S4V3 modules with an 117.5W nameplate power.