FLORIDA SOLAR ENERGY CENTER®

FSEC STANDARD

Test Method for Photovoltaic Module Power Rating

FSEC Standard 202-10

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3.0 SCOPE AND LIMITATIONS

Testing requirements set forth in this document shall be used for determining the power ratings of terrestrial flat-plate photovoltaic (PV) modules intended for power-generating applications. These requirements are not intended for use in testing and evaluation of PV concentrator modules.

This document covers the requirements for both indoor testing under a solar simulator and outdoor testing under natural sunlight.

This document is applicable to crystalline silicon, amorphous silicon, and thin-film PV technologies.

This document also provides requirements acceptable to the FSEC certification program for rating of PV modules by other laboratories.

4.0 DEFINITIONS

Terms defined in this section are relevant to PV module testing.

Air Mass (AM): A dimensionless quantity equal to the ratio of: (1) the actual path length of solar radiation through the atmosphere to (2) the vertical path length through the atmosphere at sea level. At sea level, for all but very large zenith angles z, AM = sec z

AM 1.5 Standard Reference Spectrum: The solar spectral irradiance distribution (diffuse and direct) incident at sea level on a sun-facing 37 degree tilted surface from horizontal. The atmospheric conditions for AM 1.5 are: precipitable water vapor 14.2 mm, total ozone 3.4 mm, turbidity (base e, λ=0.5 μm) 0.27

I-V Data: The relationship between current and voltage of a photovoltaic device in the power-producing quadrant, as a set of ordered pairs of current and voltage readings in a table, or as a curve plotted in a suitable coordinate system (i.e., Cartesian).

Maximum Power (Pmp): The point on the current-voltage (I-V) curve of a PV module under illumination, where the product of current and voltage is maximum. For the purpose of this document, "rated" power is defined as Pmp at STC.

PV Module (flat-plate): The smallest environmentally protected, essentially planar assembly of solar cells and ancillary parts, such as interconnections, terminals, and protective devices such as bypass diodes where the assembly is intended to generate dc power under unconcentrated sunlight. The structural (load carrying) member of a module can either be the top layer (superstrate), or the back layer (substrate).

Reference Cell (photovoltaic): A photovoltaic cell whose electrical characteristics are calibrated at the specified irradiance of a standard reference spectrum.

Reference Module (photovoltaic): A packaged assembly of one or more photovoltaic cells whose short circuit current is calibrated at the specified irradiance of a standard reference spectrum.

Standard Test Conditions (STC): Conditions under which a module is typically tested in a laboratory: (1) irradiance intensity of 1000 W/ m^2, (2) AM1.5 standard reference spectrum, and (3) cell or module temperature of 25 ± 2 degrees C.

5.0 NOMENCLATURE

Hm = measured irradiance, kW/m^2
Imp = measured current at peak power
Impo = measured peak power current normalized to 1000 W/m^2
I_{PSTC} = peak power point current at standard test conditions
I_{SCSTC} = short circuit current at standard test conditions
Isc = measured short circuit current
Isco = measured short circuit current normalized to 1000 W/m^2
k = Boltzmann's constant, $1.38x10^{-23}$
n = diode constant
Ns = the number of series connected cells in a module
P_{PSTC} = peak power at standard test conditions
$P_{PSTC\#N}$ = peak power at standard test conditions for test #N
STC = standard test conditions, 1000 W/m^2, 25°C average module temperature and AM 1.5 spectral distribution
SOC = standard operating conditions, 1000 W/m, 45°C average module temperature and AM 1.5 spectral distribution
Ta = module absolute temperature, °K
Tc = the average cell temperature measured at the back face of the module and corrected for the cell location in a module
Vmp = measured voltage at peak power
Voc = measured open circuit voltage
V_{PSTC} = peak power point voltage at standard test conditions
Voco = measured open circuit voltage normalized to 1000 W/m2
V_{OCSTC} = open circuit voltage at standard test conditions
Vpo = measured voltage at peak power normalized to 1000 W/m2
α_1 = temperature correction coefficient of short circuit current
α_2 = temperature correction coefficient of peak power current
β_1 = temperature correction coefficient of open circuit voltage
β_2 = temperature correction coefficient of peak power voltage
$*_1$ = empirical first order peak power voltage normalization constant
$*_2$ = empirical second order peak power voltage normalization constant
ζ = open circuit voltage normalization constant: $\zeta = (nkTa/q)(Ns/Vmp)$

7.0 Non-Concentrating Crystalline Silicone Photovoltaic Modules

Non-concentrating crystalline silicone (c-Si) modules shall be certified to UL 1703, the Standard for Safety for Flat-Plate Photovoltaic Modules and Panels by a Nationally Recognized Test Lab (NRTL) for safety and reliability. Modules shall also be tested using the subsections of International Electrotechnical Commission IEC Standard 61215 to adequately assess the electrical performance of the device. Detailed performance data shall be reported for the following clauses:

- Clause 10.1 Visual inspection
- Clause 10.2 Performance at STC
- Clause 10.4 Measurement of temperature coefficients
- Clause 10.5 Measurement of NOCT
- Clause 10.6 Performance at NOCT
- Clause 10.7 Performance at low irradiance

8.0 Non-Concentrating Thin-Film Photovoltaic Modules

Non-concentrating Thin-Film modules shall be certified to UL 1703, the Standard for Safety for Flat-Plate Photovoltaic Modules and Panels by a Nationally Recognized Test Lab (NRTL) for safety and reliability. Modules shall also be tested using the subsections of International Electrotechnical Commission IEC Standard 61646 to adequately assess the electrical performance of the device. Detailed performance data shall be reported for the following clauses after the test module has been subjected to light-soaking according to IEC 61646 10.18:

- Clause 10.1 Visual inspection
- Clause 10.2 Performance at STC
- Clause 10.4 Measurement of temperature coefficients
- Clause 10.5 Measurement of NOCT
- Clause 10.6 Performance at NOCT
- Clause 10.7 Performance at low irradiance

9.0 Non-Concentrating Building Integrated Photovoltaic (BIPV) Modules

Non-concentrating BIPV modules shall be certified to UL 1703, the Standard for Safety for Flat-Plate Photovoltaic Modules and Panels by a Nationally Recognized Test Lab (NRTL) for safety and reliability. Modules shall also be tested using the subsections of International Electrotechnical Commission IEC Standard 61215 or 61646 to adequately assess the electrical performance of the device. Detailed performance data shall be reported for the appropriate clauses in Section 7.0 or 8.0 depending on the module type. Modules submitted for testing shall include a thermocouple embedded between the module and the substrate for accurate cell temperature measurement.