Background Statement for SEMI Draft Document 5597
NEW STANDARD: TEST METHOD FOR CURRENT-VOLTAGE (I-V) PERFORMANCE MEASUREMENT OF ORGANIC PHOTOVOLTAIC (OPV) AND DYE-SENSITIZED SOLAR CELL (DSSC)

Notice: This background statement is not part of the balloted item. It is provided solely to assist the recipient in reaching an informed decision based on the rationale of the activity that preceded the creation of this Document.

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Background Statement:
The major difference between DSSC/OPV and P-N junction solar cell is photoelectric conversion mechanism. DSSC/OPV should need specific basis of reference that differ with STC condition (AM 1.5G, 25 °C, 1000 W/m²) used by P-N junction solar cell. DSSC/OPV also needs to make correction for spectral issue and reserves extra time for I-V test due to capacitance effect. This activity shall develop a new performance test method for DSSC/OPV according with its I-V measurement and device qualification.

Review and Adjudication Information

<table>
<thead>
<tr>
<th>Task Force Review</th>
<th>Committee Adjudication</th>
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<tbody>
<tr>
<td>Group:</td>
<td></td>
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<tr>
<td>Organic and Dye Sensitized Solar Cell Task Force</td>
<td>Taiwan PV TC Chapter</td>
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<td>Date:</td>
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</tr>
</tbody>
</table>

This meeting’s details are subject to change, and additional review sessions may be scheduled if necessary. Contact the task force leaders or Standards staff for confirmation.

Telephone and web information will be distributed to interested parties as the meeting date approaches. If you will not be able to attend these meetings in person but would like to participate by telephone/web, please contact Standards staff. Check [www.semi.org/standards](http://www.semi.org/standards) on calendar of event for the latest meeting schedule.

If you need further assistance, or have questions, please do not hesitate to contact the Organic and Dye Sensitized Solar Cell Task Force.
NEW STANDARD: TEST METHOD FOR CURRENT-VOLTAGE (I-V) PERFORMANCE MEASUREMENT OF ORGANIC PHOTOVOLTAIC (OPV) AND DYE-SENSITIZED SOLAR CELL (DSSC)

1 Purpose
1.1 This standard proposes a performance test method for OPV/DSSC according to its I-V measurement and device qualification.
1.2 The major difference between OPV/DSSC and P-N junction solar cell is photoelectric conversion mechanism, such as
  1.2.1 The operation principle of OPV/DSSC is using layers of organic molecules subject to lighting after excitation electronic then pass to the inorganic/organic layer of the wide energy gap nano-layer and voltage.
  1.2.2 OPV/DSSC has different spectrum and absorption range with P-N junction solar cell does.
  1.2.3 OPV/DSSC needs more photoelectric conversion response time caused by specific material properties.
1.3 Therefore, OPV/DSSC shall need specific basis of reference to differ with STC condition (AM 1.5G, 25 °C, 1000 W·m$^{-2}$) used by P-N junction solar cell, and also make correction for spectral issue and reserves extra time for I-V test due to capacitance effect.

2 Scope
2.1 This standard shall develop a performance test method for OPV/DSSC according to its I-V measurement and device qualification. The objective is to focus on OPV/DSSC current-voltage (I-V) performance evaluation either indoors or outdoors, and provides some actions as below.
  2.1.1 Define the specific STC (see ¶ 5.2.12, ¶ 5.2.13) for OPV/DSSC at indoors.
  2.1.2 Provide both statistic method (see §8) and testing procedures (see § 9) for OPV/DSSC to reduce measurement error due to capacitive effect.
  2.1.3 Evaluate the relationship (see Fig. 4) between short-circuit current ($I_{sc}$) and spectral correction factor (MMF)
  2.1.4 Approach specific diffuse lighting application at indoors or outdoors.

NOTICE: SEMI Standards and Safety Guidelines do not purport to address all safety issues associated with their use. It is the responsibility of the users of the Documents to establish appropriate safety and health practices, and determine the applicability of regulatory or other limitations prior to use.

3 Limitations
3.1 This document does not specify any kind of sample specification for OPV/DSSC, e.g. 1x1 cm$^2$, 1x5 cm$^2$, 2x5 cm$^2$, 1x10 cm$^2$, etc.
3.2 I-V performance measurement method does not provide the specifications of I-V sweep by setting delay time but the test time should be considered.

4 Referenced Standards and Documents
4.1 ASTM Standards

4.2 ISO Standards

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ISO 3534 — Statistics - Vocabulary and symbols
ISO/IEC 17025 — General requirements for the competence of testing and calibration laboratories

4.3 IEC Standards

IEC 60410 — Sampling plans and procedures for inspection by attributes
IEC 60891 — Procedures for temperature and irradiance corrections to measured I-V characteristics of crystalline silicon photovoltaic devices
IEC 60904-1 — Photovoltaic devices – Part 1: Measurements of photovoltaic current-voltage characteristics
IEC 60904-2 — Photovoltaic devices – Part 2: Requirements for reference solar devices
IEC 60904-5 — Photovoltaic devices – Part 5: Determination of the equivalent cell temperature (ECT) of photovoltaic (PV) devices by the open-circuit voltage method
IEC 60904-7 — Photovoltaic devices – Part 7: Computation of spectral mismatch error introduced in the testing of a photovoltaic device
IEC 60904-8 — Photovoltaic devices – Part 8: Measurement of spectral response of a photovoltaic (PV) device
IEC 60904-9 — Photovoltaic devices – Part 9: Solar simulator performance requirements
IEC 60904-10 — Photovoltaic devices – Part 10: Methods of linearity measurement
IEC 61646 — Thin-film terrestrial photovoltaic (PV) modules – Design qualification and type approval
IEC 61853-1 — Photovoltaic (PV) module performance testing and energy rating - Part 1: Irradiance and temperature performance measurements and power rating

NOTICE: Unless otherwise indicated, all documents cited shall be the latest published versions.

5 Terminology

5.1 Abbreviations and Acronyms

5.1.1 A — cell area (m²)
5.1.2 α — temperature coefficient (°C⁻¹)
5.1.3 E — irradiance (W⋅m⁻²)
5.1.4 η — efficiency (%)
5.1.5 FF — fill factor (%)
5.1.6 I — current (A)
5.1.7 Iₘₖₑₜ — short-circuit current (A)
5.1.8 MMF — spectral mismatch parameter (or factor)
5.1.9 Pₘₖₑₜ — maximum power (W)
5.1.10 Rₛ — series resistance (Ω)
5.1.11 Rₕ — shunt resistance (Ω)
5.1.12 T — temperature (°C)
5.1.13 V — voltage (V)
5.1.14 Vₘₖₑₜ — open-circuit voltage (V)
5.1.15 DUT — device under test
5.1.16 RD — reference device

5.1.17 *TM* — temperature monitor
5.1.18 *SMU* — source measurement unit
5.1.19 *ITP* — isothermal test plane
5.1.20 *CI* — control interface
5.1.21 *SS* — solar simulator

5.2 Definitions
5.2.1 *cell temperature* — the temperature (°C) of solar cell
5.2.2 *DSSC* — dye-sensitized solar cell
5.2.3 *IPCE* — incident photon-electron conversion efficiency
5.2.4 *isothermal test plane* — the isothermal plane intended to contain DUT at the reference irradiance level
5.2.5 *I-V* — current-voltage
5.2.6 *light source* — a source of radiant energy to simulate natural sunlight and used for cell performance measurement
5.2.7 *OPV* — organic photovoltaic
5.2.8 *performance data* — *P*<sub>max</sub>, *V*<sub>oc</sub>, *I*<sub>sc</sub>, FF, η
5.2.9 *RSD* — relative standard deviation
5.2.10 *SR* — spectral response
5.2.11 *STC* — standard test conditions for solar cell. Cell temperature: 25 °C, AM 1.5G, Irradiance: 1000 W·m<sup>-2</sup>
5.2.12 *sweep direction* — defined in direction either from *I*<sub>sc</sub> to *V*<sub>oc</sub> (forward) or *V*<sub>oc</sub> to *I*<sub>sc</sub> (backward)
5.2.13 *test sample* — test device of OPV/DSSC
5.2.14 *ULIC* — ultra low irradiance condition for OPV/DSSC. Cell temperature: 25 °C, AM 1.5G, Irradiance: 1 W·m<sup>-2</sup>
5.2.15 *VLIC* — very low irradiance condition for OPV/DSSC. Cell temperature: 25 °C, AM 1.5G, Irradiance: 60 W·m<sup>-2</sup>

6 Apparatus

Apparatus includes reference device (RD), temperature monitor (TM), source measurement unit (SMU), isothermal test plane (ITP), solar simulator (SS) (see Fig. 1).

![Testing setup Equipment Diagrammatic Sketch](image)

**Figure 1**

*Testing setup Equipment Diagrammatic Sketch*

6.1 *Reference device (RD)*
6.1.1 Reference device is calibrated indoors using simulated sunlight or outdoors in natural sunlight by reference to the same desired reference spectral irradiance distribution.
6.1.2 Report need to commit traceability including measurement of I-V, SR and IPCE, which are determined in accordance with IEC 60904-2.

6.2 *Temperature monitor (TM)*
6.2.1 Temperature monitor shall record both the cell temperature and test plane temperature simultaneously while I-V is measured, and its accuracy need keep within ±0.5 °C.

6.3 Source measurement unit (SMU)

6.3.1 Source measurement unit is used to measure current and voltage through DUT by using a voltage sweep with numerous steps (see ¶ 9.6) to build I-V curve.

6.4 Isothermal test plane (ITP)

6.4.1 Isothermal test plane intended to contain DUT at the reference irradiance level (see ¶ 9.6), and control test cell keep temperature within (25 ± 1) °C.

6.5 Solar simulator (SS)

6.5.1 Solar simulator may be one of three classes (A, B, or C) for each of the three categories includes spectral match, spatial non-uniformity and temporal instability. Each simulator is rated with three letters in order of spectral match, non-uniformity of irradiance in the test plane and temporal instability (e.g. CBA). Solar simulators for irradiance exposure should at least fulfill class BBA requirements, and class AAA is better for long term instability issue.

6.5.2 Test plane should be intended to fully contain all the area of test device.

6.5.3 Report need to commit traceability include measurement of spectral match, uniformity and temporal instability.

7 Preconditioning and Conditioning

7.1 DSSC and OPV samples (see Fig. 2, Fig. 3)
7.1.1 Five test samples, which are made by same raw materials and process, are required at least. General test sample assembled should be including seal, package and four well-attached wires (or terminal wires). Terminal wires are used multiply set designed for the safety of the rated current and length is 5 cm.

7.1.2 Relative performance data is defined as Eq. (1) for test samples, and shall keep 90% at least in one month after pre-test.

\[
Relative\ Performance\ data(\%) \equiv \frac{(Final - Initial)}{Initial} \times 100\%
\]  

(1)

7.2 Reference device

7.2.1 Calibration for the secondary photovoltaic reference cell should consists of short-circuit current \( (I_{sc}) \) under natural or simulated sunlight, by using a primary reference cell to measure the incident irradiance \( (E_i) \).

7.2.2 Reference cell is important during calibration for solar simulator, which is required long-term stability for frequent calibrations. Until now, a test sample matching such requirements has rarely been found. Therefore, a crystalline silicon (c-Si) solar cell with long-term stability is generally used as an alternative. (see Table 1).

<table>
<thead>
<tr>
<th>Windows with Filter Type</th>
<th>Applied type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Si + BK7 or Quartz</td>
<td>Mono-crystalline Si (c-Si)</td>
</tr>
<tr>
<td>Si + BK7 or Quartz</td>
<td>Poly-crystalline Si (mc-Si)</td>
</tr>
<tr>
<td>Si + BK7 or Quartz with KG2</td>
<td>Amorphous Si (a-Si)</td>
</tr>
<tr>
<td>Si + BK7 or Quartz with KG3</td>
<td>DSSC with N749</td>
</tr>
<tr>
<td>Si + BK7 or Quartz with KG5</td>
<td>DSSC with N719, and OPV with polymer</td>
</tr>
</tbody>
</table>

Calibrations for the filtered reference cell should consist of short-circuit current \( (I_{sc}) \) and incident irradiance \( (E_i) \). In addition, the relative spectral response of cell needs be calibrated to determine the relative spectral irradiance of the light source as well. Errors in the short-circuit current, due to both spectral irradiance of light source and spectral
response of primary reference cell, are then corrected by dividing the short-circuit current and the spectral mismatch parameter. Also, if the cell temperature is out of (25 ± 1) °C, then temperature coefficient (α) of short-circuit current (I_{sc}) should be needed.

8 Statistic method
8.1 The objective is to reduce measurement error due to the capacitive effect and find the relationship between I_{sc} and spectral correction factor (see ¶ 9.6, ¶ 9.9).

8.2 This statistic method (see Fig. 4) provides guide lines for test sample to compensate measured data under STC (see ¶ 5.2.11, ¶ 5.2.12, ¶ 5.2.13).

![Diagram](data:image/png;base64,iVBORw0KGgoAAAANSUhEUgAAAIoAAAAHCAIAAADFf4j5AAAABGdBTUEAALGPC/xhB/Q0N'\...)

Figure 4
Corrected I_{sc} in I-V by Mismatch Factor (MMF)

8.3 RSD is defined as Eq. (2).

\[
RSD(\%) \equiv \frac{\text{standard deviation}}{\text{average}} \times 100\%
\]  

(2)

8.4 The non-uniformity is defined as Eq. (3)

\[
Non-uniformity(\%) \equiv \frac{(\text{max} - \text{min})}{(\text{max} + \text{min})} \times 100\%
\]  

(3)

9 Testing Procedures
The measured performance data (see ¶ 5.2.14) of test sample is highly responsive to the external measurement conditions. A reliable evaluation results requires the measurement to be performed under proper conditions and the details of the measurement should be clearly described in the report. Fig. 5 is the testing procedures for test sample performance data evaluation.
9.1 Visual Inspection

9.1.1 Five test samples for qualification testing (plus spares as desired) shall be taken at random from a production batch or batches, in accordance with the procedure given in IEC 60410. Test samples shall have been manufactured from specified materials and components in accordance with the relevant drawings and process sheets, and shall have been subjected to the manufacturer's normal inspection, quality control and production acceptance procedures.

9.1.2 For the purposes of design qualification and type approval, the following items are considered to be major defects.

9.1.2.1 Broken, cracked, or torn external surfaces, including superstrates, substrates and frames;

9.1.2.2 Bent or misaligned external surfaces, including superstrates, substrates and frames to the extent that the installation and/or operation of the module would be impaired;

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Figure 5
Testing Procedures

9.2 Measured active area

9.3 Check I-V/IPCE measurement systems

9.4 Check wire connection

9.5 Light soaking

9.6 Forward/Backward I-V at STC or VLIC or ULIC

9.7 I-V at STC or VLIC or ULIC

9.8 Visual inspection

9.9 Data analysis

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Figure 6
Cell/Module Package Configuration Diagrammatic Sketches

1. Light direction

Front-side
Encapsulant
Cell
Back-side

Substrate configuration

Front-side
Encapsulant
Cell
Back-side

Superstrate configuration
9.1.2.3 Voids in, or visible corrosion of any layers of the active circuitry of test sample, extending over more than 10% of any cell;
9.1.2.4 Bubbles or delamination forming a continuous path between any part of the electrical circuit and the edge of test sample;
9.1.2.5 When test sample have a loss of mechanical integrity, the installation and/or operation would be impaired.

9.2 Measured Active Area

The active surface, active area or aperture area of the specimen shall be coplanar within ±2° with the active surface of test sample. (see ¶ 10.3)

9.2.1 Total area: The total projected area of the cell or module. For the case of a cell attached to glass, the total area would be the area of the glass sheet. For a module, it would include the area of frames.

9.2.2 Aperture area: The portion of the total cell or module area that includes all essential components, including active material, bus bars, fingers and interconnects.

9.2.3 Designated illumination area: A portion of the cell or module area from which some cell or module contacting components are excluded.

9.3 Check I-V/IPCE Measurement System

9.3.1 The irradiance measurements shall be made by using a reference device packaged (or a pyranometer) and calibrated in conformance with IEC 60904-2 or IEC 60904-6. PV reference device shall either be spectrally matched to test specimen, or a spectral mismatch correction shall be performed in conformance with IEC 60904-7. Reference device shall be linear in short-circuit current as defined in IEC 60904-10 over the irradiance range of interest. The temperature of reference device and the specimen shall be measured by using instrumentation with accuracy of ±1 °C and repeatability of ±0.5 °C. If the temperature of reference device differs and more than 2 °C from the temperature at which it was calibrated, the calibration value shall be adjusted to the measured temperature. If the reference device is a pyranometer, then temperature measurement and temperature correction are not required for output signal.

9.4 Check Wire Connection

9.4.1 Voltages and currents shall be measured by using instrumentation with an accuracy of ±0.2 % of the open-circuit voltage (V_{oc}) and short-circuit current (I_{sc}), and using independent leads from the terminals of the specimen to keep them as short as possible. The measurement ranges of the data acquisition should be carefully chosen. If the test specimen is a packaged test sample, the four terminal wires connection should start at the cell bus bars. Connect checking by the short-circuit current shall be measured at zero voltage, using a variable bias (preferably electronic) to offset the voltage drop across the external series resistance. Alternatively, short circuit current may be extrapolated from the current-voltage characteristic. The curve is extrapolated to zero voltage provided that voltage drop is not higher than 3 % of test sample open-circuit voltage and that there is a linear relationship between current and voltage.

9.5 Light Soaking

9.5.1 In order to anneal and stabilize the electrical characteristics of test sample by means of simulated solar irradiation approach from 10 min to 30 min, some requirements are written as follows.

9.5.2 Setting reference device the irradiance between 600 W·m^{-2} and 1000 W·m^{-2}, then record the irradiance.

9.5.3 Attach the resistive or SMU loads to test sample and mount them. Subject each test sample to irradiation until its maximum power value stabilizes. Stabilization occurs when measurements from two consecutive periods of at least 43 kWh·m^{-2} each integrated over periods when the temperature is between 40 °C and 60 °C, meet the following check criteria is defined as Eq.(4), having deviations 2 % or less.

\[
\text{check criteria} = \left( \frac{\text{max} - \text{min}}{\text{average}} \right) \times 100\% \tag{4}
\]

All intermediate maximum power measurements shall be performed at any convenient sample temperature reproduced within ±2 °C. Recommend used by the manufacturer in the test plane of simulator.
9.5.4 Ensure temperature of test sample does not vary more than ±2 °C within the range of 40 °C to 50 °C during the test, and record the temperature.

9.6 Forward/Backward I-V at STC or VLIC or ULIC

9.6.1 Set up sweep range, sweep direction and record measuring point above 100. Record the current-voltage characteristic and temperature of the specimen concurrently with recording the output and temperature (if required) of the reference device at the desired temperatures. If necessary, make the measurements immediately after removing the shade. Below are two approaches (see ¶ 10.7) to decide I-V measurement of test sample.

9.6.2 I-V sweep by setting delay time: The delay time should be longer than 20 ms for measuring OPV, longer than 40 ms for measuring DSSC with organic solvent electrolyte, and be longer than 1,000 ms for measuring DSSC with ionic liquid electrolyte.

9.6.3 I-V sweep including real-time removing capacity effect: This method need to read simultaneously multi-point forming step after taking the optimization stabilizing area as a point on the I-V curve.

9.6.4 I-V measurements of both scan directions are necessary to estimate the related measurement error, as the temporal response is expected to be dependent on the device structure of test sample and the I-V curves measured at the different sweep directions tend. The final performance data shall having deviations 0.2 % or less.

9.7 I-V at STC or VLIC or ULIC

9.7.1 Each sweep direction (forward or backward) need test at least five times

9.7.2 RSD (see Eq (2)) of performance data measured at each sweep direction shall be less than 1.5 %.

9.7.3 The non-uniformity (see Eq. (3)) of performance data measured at each sweep direction shall be less than 1.5 %.

9.8 Visual Inspection: see ¶ 9.1

9.9 Data Analysis

9.9.1 Provide calculation method of performance data

9.9.2 Test sample need to correct $I_{sc}$ with reference cell (see ¶ 8.2, Fig. 4)

9.9.3 This clause describes a procedure for calibrating test sample in natural or simulated sunlight against a reference cell whose calibration is traceable to SI units. The spectral response match between the reference cell and test sample under the illumination used for the calibration shall be determined by the procedure given in IEC 60904-7 (see Fig. 4). If the spectral mismatch correction is less than 1 %, the mismatch correction may be omitted. The procedure can be applied using both natural and simulated sunlight according to IEC 60904-1 with the following restrictions.

10 Related Documents


10.6 Teng-Chun Wu, Shu-Tsung Hsu and Yean-San Long, PVSEC-23 (2013).

10.7 Teng-Chun Wu, Shu-Tsung Hsu and Yean-San Long, JEPE (2014), Accepted.

10.8 BRIAN O'REGAN and MICHAEL GRÄTZEL, Nature 353, 737 – 740 (1991)


11 Reporting Results

The test report shall include, at minimum, the following:

11.1 A title.

11.2 Name and address of the test laboratory and location where the tests were carried out.

11.3 Unique identification of the certification or report and of each page.
11.4 Name and address of client, where appropriate.
11.5 Description and identification of the item tested.
11.6 Characterization and condition of the test item.
11.7 Date of receipt of test item and date(s) of test, where appropriate.
11.8 Identification of test method used.
11.9 Reference to sampling procedure, where relevant.
11.10 Any deviations from, additions to or exclusions from the test method, and any other information relevant to specific tests, such as environmental conditions.
11.11 Measurements, examinations and derived results supported by tables, graphs, sketches and photographs as appropriate including temperature coefficients of short circuit current, open circuit voltage and peak power, power at STC, STC and low irradiance and any failures observed. If the maximum power loss observed after each of the tests has been measured it should also be reported.
11.12 A statement of the estimated uncertainty of the test results (where relevant).
11.13 A signature and title, or equivalent identification of the person(s) accepting responsibility for the content of the certificate or report, and the date of issue.
11.14 Where relevant, a statement to the effect that the results relate only to the items tested.
11.15 A statement that the certificate or report shall not be reproduced except in full, without the written approval of the laboratory.
APPENDIX 1 REPORTING FORM (DEMO)

NOTICE: The material in this Appendix is an official part of SEMI document 5597 and was approved by full letter ballot procedures on [A&R approval date].

A1-1 Description of Testing Laboratory:

A1-1.1 Measurement of test data (e.g. I-V) need be operated by 3rd party testing lab, e.g. ISO 17025 accredited lab.

Table A1-1 Basic Information of Testing Laboratory

| Basic Information of Testing Laboratory |
|-------------------------------|------------------|
| Laboratory ID/Name            | Address          |

A1-2 Description of Testing Sample

Table A1-2 Description of Testing Sample

<table>
<thead>
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<th>Sample ID</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample Dimension</td>
</tr>
<tr>
<td>Sample Material</td>
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<tr>
<td>Packaged/Window Material</td>
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<tr>
<td>Temperature Sensor</td>
</tr>
</tbody>
</table>

A1-3 Testing Data

A1-3.1 All data measured in each sweep direction (forward or backward) need test at least five times. The average data and standard deviation are listed in the following table.

Table A1-3 Testing Data

<table>
<thead>
<tr>
<th>Sample ID: ____</th>
<th>Basic Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open-Circuit Voltage V&lt;sub&gt;oc&lt;/sub&gt; = ( ± ) V</td>
<td></td>
</tr>
<tr>
<td>Short-Circuit Current I&lt;sub&gt;sc&lt;/sub&gt; = ( ± ) A</td>
<td></td>
</tr>
<tr>
<td>Maximum Power P&lt;sub&gt;max&lt;/sub&gt; = ( ± ) W</td>
<td></td>
</tr>
<tr>
<td>Fill Factor FF = ( ± ) %</td>
<td></td>
</tr>
<tr>
<td>Test Condition STC • VLIC • ULIC • Others,</td>
<td></td>
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Supplementary Information:

<table>
<thead>
<tr>
<th>Mismatch Factor MMF =</th>
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<tbody>
<tr>
<td>Area A = cm&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Efficiency η = ( ± ) %</td>
</tr>
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A1-4 MMF Data

A1-4.1 The Spectral Response Measurement

Table A1-4 MMF Data

<table>
<thead>
<tr>
<th>Sample ID:</th>
<th>SR/IPCE Plot</th>
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A1-4.2 Reference Test Condition Performance

Table A1-5 Reference Test Condition Performance

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<th>Basic Information</th>
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<tbody>
<tr>
<td>Mismatch Factor</td>
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<td>Area</td>
<td>A = cm²</td>
</tr>
<tr>
<td>Efficiency</td>
<td>η = ( ± ) %</td>
</tr>
</tbody>
</table>

Reference Test Condition: ☐STC ☐VLIC ☐ULIC ☐Others,

A1-5 Others Descriptions

A1-5.1 Measured Methods

A1-5.1.1 The testing items and methods listed in this report have been approved by the commissioners and commissioned parties and then been adopted for the calibration.

A1-5.1.2 The measured procedure was carried out according to _____.

A1-5.2 Standard Equipment of System

Table A1-6 Standard Equipment of System

<table>
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<th>Traceability Date</th>
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<td>Reference detector</td>
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<tr>
<td>Solar simulator</td>
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</table>
A1-5.3 Environmental Conditions

A1-5.3.1 The calibration was performed under the following environmental conditions.

- Ambient temperature: (___ ± ___) °C
- Relative humidity: (___ ± ___) %RH

A1-5.4 Relative Expanded Combined Uncertainty

A1-5.4.1 Relative expanded combined uncertainty was performed according to ___.

A1-5.4.2 The relative expanded uncertainty, with a coverage factor $k = 2$ and a confidence level of about 95 %.

A1-6 References


APPENDIX 2 PHOTOS OF TESTING SAMPLES

NOTICE: The material in this Appendix is an official part of SEMI document 5597 and was approved by full letter ballot procedures on [A&R approval date].

A2-1 Photos of testing sample

Table A2-1 Photos of Testing Sample

<table>
<thead>
<tr>
<th>Item</th>
<th>Front-side</th>
<th>Back-side</th>
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