

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE



**Photovoltaic devices –  
Part 9: Classification of solar simulator characteristics**

**Dispositifs photovoltaïques –  
Partie 9: Classification des caractéristiques des simulateurs solaires**





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International Standard IEC 60904-9 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

This third edition cancels and replaces the second edition issued in 2007. It constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- Changed title;
- Added spectral match classification in an extended wavelength range;
- Introduction of new A+ class;
- Definition of additional parameters for spectral irradiance evaluation;
- Added apparatus sections for spectral irradiance measurement and spatial uniformity measurement;

- Revised procedure for spectral match classification (minimum 4 measurement locations);
- Revised measurement procedure for spatial uniformity of irradiance;
- Added informative Annex A for sensitivity analysis of spectral mismatch error related to solar simulator spectral irradiance.

The text of this standard is based on the following documents:

FDIS	Report on voting
82/1756/FDIS	82/1775/RVD

Full information on the voting for the approval of this International Standard can be found in the report on voting indicated in the above table.

This document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 60904 series, published under the general title *Photovoltaic devices*, can be found on the IEC web site.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

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## PHOTOVOLTAIC DEVICES –

### Part 9: Classification of solar simulator characteristics

#### 1 Scope

IEC standards for photovoltaic devices require the use of specific classes of solar simulators deemed appropriate for specific tests. Solar simulators can be either used for performance measurements of PV devices or endurance irradiation tests. This part of IEC 60904 provides the definitions of and means for determining simulator classifications at the required irradiance levels used for electrical stabilization and characterisation of PV devices.

This document is applicable for solar simulators used in PV test and calibration laboratories and in manufacturing lines of solar cells and PV modules. The A+ category is primarily intended for calibration laboratories and is not considered necessary for power measurements in PV manufacturing and in qualification testing. Class A+ has been introduced because it allows for reduction in the uncertainty of secondary reference device calibration, which is usually performed in a calibration laboratory. Measurement uncertainty in PV production lines will directly benefit from a lower uncertainty of calibration, because production line measurements are performed using secondary reference devices.

In the case of PV performance measurements, using a solar simulator of a particular class does not eliminate the need to quantify the influence of the simulator on the measurement by making spectral mismatch corrections and analysing the influences of spatial non-uniformity of irradiance in the test plane and temporal stability of irradiance on that measurement. Test reports for PV devices tested with the simulator report the class of simulator used for the measurement and the method used to quantify the simulator's effect on the results.

The purpose of this document is to define classifications of solar simulators for use in indoor measurements of terrestrial photovoltaic devices. Solar simulators are classified as A+, A, B or C based on criteria of spectral distribution match, irradiance non-uniformity in the test plane and temporal instability of irradiance. This document provides the required methodologies for determining the classification of solar simulators in each of the categories. A solar simulator which does not meet the minimum requirements of class C cannot be classified according to this document.

For spectral match classification a new procedure has been added. This procedure addresses the actual need for an extended wavelength range, which is arising from advances in solar cell technology (such as increased spectral responsivity below 400 nm) as well as solar simulator technology (use of component LEDs). The procedure of the second edition of this standard is still valid, but is only applied if backward compatibility of classification for solar simulators already in use and for solar simulators in production/sale is required. This document is referred to by other IEC standards, in which class requirements are laid down for the use of solar simulators. The solar simulator characteristics described in this document are not used in isolation to imply any level of measurement confidence or measurement uncertainty for a solar simulator application (for example, PV module power measurement). Measurement uncertainties in each application depend on many factors, several of which are outside the scope of this document:

- Characteristics of the solar simulator, possibly including characteristics not covered by this document;
- Methods used to calibrate and operate the solar simulator;
- Characteristics of the device(s) under test (for example, size and spectral responsivity);
- Quantities measured from the device(s) under test, including equipment and methods used for measurement;

- Possible corrections applied to measured quantities.

When applications require a certain solar simulator characteristic, it is preferable to specify a numerical value rather than a letter classification (for example, “≤ 5 % non-uniformity of irradiance” rather than “Class B non-uniformity of irradiance”). If not obvious from the application, it should also be indicated how the required simulator characteristic correlates to relevant measured quantities. Since PV module power measurement is one of the most common applications for solar simulators, brief guidance on this application is given in informative notes for each solar simulator characteristic described in this document. This document is used in combination with IEC TR 60904-14, which deals with best practice recommendations for production line measurements of single-junction PV module maximum power output and reporting at standard test conditions. For output power characterization of PV devices, IEC TR 60904-14 addresses the relevance of the letter grades (A+, A, B, C) for measurement uncertainty.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60904-1, *Photovoltaic devices – Part 1: Measurement of photovoltaic current-voltage characteristics*

IEC 60904-3, *Photovoltaic devices – Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data*

IEC TR 60904-14:<sup>1</sup> *Photovoltaic devices – Part 14: Guidelines for production line measurements of single junction PV module maximum power output and reporting at standard test conditions*

IEC TS 61836, *Solar photovoltaic energy systems – Terms, definitions and symbols*

## 3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC TS 61836 together with the following, apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

### 3.1

#### **solar simulator**

equipment employing a light source with a spectral distribution similar to the natural sunlight used to evaluate characteristics of PV devices

Note 1 to entry: Simulators usually consist of three main components:

- a) light source(s) and associated power supply;
- b) any optics and filters required to modify the output beam to meet the classification requirements; and

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<sup>1</sup> Under preparation. Stage at the time of publication: 82/1748/DTR.