

STN	Fotovoltické súčiastky Časť 9: Klasifikácia charakteristík slnečných simulátorov	STN EN IEC 60904-9 36 4604
------------	---	--

Photovoltaic devices - Part 9: Classification of solar simulator characteristics

Táto norma obsahuje anglickú verziu európskej normy.
This standard includes the English version of the European Standard.

Táto norma bola oznámená vo Vestníku ÚNMS SR č. 05/21

Obsahuje: EN IEC 60904-9:2020, IEC 60904-9:2020

Oznámením tejto normy sa od 23.10.2023 ruší
STN EN 60904-9 (36 4604) z júna 2008

132711

EUROPEAN STANDARD

EN IEC 60904-9

NORME EUROPÉENNE

EUROPÄISCHE NORM

November 2020

ICS 27.160

Supersedes EN 60904-9:2007 and all of its amendments
and corrigenda (if any)

English Version

**Photovoltaic devices - Part 9: Classification of solar simulator
characteristics
(IEC 60904-9:2020)**Dispositifs photovoltaïques - Partie 9: Classification des
caractéristiques des simulateurs solaires
(IEC 60904-9:2020)Photovoltaische Einrichtungen - Teil 9: Klassifizierung der
Eigenschaften von Sonnensimulatoren
(IEC 60904-9:2020)

This European Standard was approved by CENELEC on 2020-10-23. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.



European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

EN IEC 60904-9:2020 (E)**European foreword**

The text of document 82/1756/FDIS, future edition 3 of IEC 60904-9, prepared by IEC/TC 82 "Solar photovoltaic energy systems" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 60904-9:2020.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2021-07-23
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2023-10-23

This document supersedes EN 60904-9:2007 and all of its amendments and corrigenda (if any).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 60904-9:2020 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60891	NOTE	Harmonized as EN 60891
IEC 60904-2	NOTE	Harmonized as EN 60904-2
IEC 60904-7:2019	NOTE	Harmonized as EN IEC 60904-7:2019 (not modified)

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

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.

NOTE 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60904-1	-	Photovoltaic devices - Part 1: Measurement of photovoltaic current-voltage characteristics	EN IEC 60904-1	-
IEC 60904-3	-	Photovoltaic devices - Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data	EN IEC 60904-3	-
IEC/TR 60904-14	— ¹	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	-	-

¹ To be published. Stage at the time of publication: 82/1748/DTR.



IEC 60904-9

Edition 3.0 2020-09

INTERNATIONAL STANDARD

NORME INTERNATIONALE



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

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





THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2020 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Recherche de publications IEC -

webstore.iec.ch/advsearchform

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études,...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

Electropedia - www.electropedia.org

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 000 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 16 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

Glossaire IEC - std.iec.ch/glossary

67 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.



IEC 60904-9

Edition 3.0 2020-09

INTERNATIONAL STANDARD

NORME INTERNATIONALE



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

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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 27.160

ISBN 978-2-8322-8765-1

**Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

CONTENTS

FOREWORD	4
1 Scope	6
2 Normative references	7
3 Terms and definitions	7
4 Classification of solar simulator characteristics	12
5 Measurement procedures	13
5.1 Introductory remarks	13
5.2 Spectral match	13
5.2.1 General	13
5.2.2 Apparatus	13
5.2.3 Procedure	14
5.2.4 Measurement uncertainty	15
5.3 Non-uniformity of irradiance in the test plane	16
5.3.1 General	16
5.3.2 Apparatus	16
5.3.3 Procedure	17
5.3.4 Uncertainty of non-uniformity measurement	19
5.4 Temporal instability of irradiance	19
5.4.1 Solar simulators for I-V measurement	19
5.4.2 Solar simulators for irradiance exposure	21
5.4.3 Classification for temporal instability	21
5.4.4 Uncertainty of temporal instability	22
5.5 AM1.5 spectral coverage (SPC)	22
5.6 AM1.5 spectral deviation (SPD)	22
6 Name plate and data sheet	22
Annex A (informative) Assessment of spectral mismatch error: Sensitivity to spectral irradiance	24
A.1 General	24
A.2 Estimation of spectral mismatch-related uncertainty when the spectral responsivities are known	24
A.3 Sensitivity of spectral irradiance for spectral mismatch error when the variation of spectral responsivities is not known	25
A.4 Reporting	28
Bibliography	29
Figure 1 – Locations for spectral irradiance measurement of a rectangular test area (left) and a circular test area (right)	15
Figure 2 – Evaluation of STI for a long pulse solar simulator	20
Figure 3 – Evaluation of STI for a short pulse solar simulator	21
Figure A.1 – Virtual spectral responsivity with its dispersions and the modelling parameters	25
Figure A.2 – Reference SR curves for typical PV technologies	27
Figure A.3 – Robustness of spectral irradiance regarding spectral mismatch error	28

Table 1 – Global reference solar spectral irradiance distribution given in IEC 60904-3 contribution of wavelength intervals to total irradiance in the restricted wavelength range 400 nm to 1 100 nm	9
Table 2 – Global reference solar spectral irradiance distribution given in IEC 60904-3 contribution of wavelength intervals to total irradiance in the extended wavelength range 300 nm to 1 200 nm	10
Table 3 – Definition of solar simulator classifications	12
Table A.1 – Reference SR curves for typical PV technologies	26

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PHOTOVOLTAIC DEVICES –

Part 9: Classification of solar simulator characteristics

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as “IEC Publication(s)”). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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:– 1, *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*

koniec náhľadu – text ďalej pokračuje v platenej verzii STN

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