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**BSI Standards Publication**

## **Photovoltaic devices**

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Part 1: Measurement of photovoltaic current-voltage characteristics

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## National foreword

This British Standard is the UK implementation of EN IEC 60904-1:2020. It is identical to IEC 60904-1:2020. It supersedes BS EN 60904-1:2006, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee GEL/82, Photovoltaic Energy Systems.

A list of organizations represented on this committee can be obtained on request to its committee manager.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2020  
Published by BSI Standards Limited 2020

ISBN 978 0 580 97363 5

ICS 27.160

**Compliance with a British Standard cannot confer immunity from legal obligations.**

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 November 2020.

### Amendments/corrigenda issued since publication

Date	Text affected
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## EUROPÄISCHE NORM

November 2020

ICS 27.160

Supersedes EN 60904-1:2006 and all of its amendments  
and corrigenda (if any)

English Version

Photovoltaic devices - Part 1: Measurement of photovoltaic  
current-voltage characteristics  
(IEC 60904-1:2020)

Dispositifs photovoltaïques - Partie 1: Mesurage des  
caractéristiques courant-tension des dispositifs  
photovoltaïques  
(IEC 60904-1:2020)

Photovoltaische Einrichtungen - Teil 1: Messen der  
photovoltaischen Strom-/Spannungskennlinien  
(IEC 60904-1:2020)

This European Standard was approved by CENELEC on 2020-10-30. 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.

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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

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## European foreword

The text of document 82/1760/FDIS, future edition 3 of IEC 60904-1, prepared by IEC/TC 82 "Solar photovoltaic energy systems" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 60904-1:2020.

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) 2021-07-30
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2023-10-30

This document supersedes EN 60904-1:2006 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 60904-1:2020 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 60904-1-1	NOTE	Harmonized as EN 60904-1-1
IEC 61829	NOTE	Harmonized as EN 61829

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(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](http://www.cenelec.eu).

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60891	-	Photovoltaic devices - Procedures for temperature and irradiance corrections to measured I-V characteristics	EN 60891	-
IEC 60904-2	-	Photovoltaic devices - Part 2: Requirements for photovoltaic reference devices	EN 60904-2	-
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 60904-4	-	Photovoltaic devices - Part 4: Reference solar devices - Procedures for establishing calibration traceability	EN IEC 60904-4	-
IEC 60904-5	-	Photovoltaic devices - Part 5: Determination of the equivalent cell temperature (ECT) of photovoltaic (PV) devices by the open-circuit voltage method	EN 60904-5	-
IEC 60904-7	-	Photovoltaic devices - Part 7: Computation of the spectral mismatch correction for measurements of photovoltaic devices	EN IEC 60904-7	-
IEC 60904-9	-	Photovoltaic devices - Part 9: Classification of solar simulator characteristics	-	-
IEC 60904-10	-	Photovoltaic devices - Part 10: Methods of linear dependence and linearity measurements	-	-

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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 61215	series	Crystalline silicon terrestrial photovoltaic (PV) modules - Design qualification and type approval	-	-
IEC/TS 61836	-	Solar photovoltaic energy systems - Terms, definitions and symbols	CLC/TS 61836	-
IEC 61853-1	-	Photovoltaic (PV) module performance testing and energy rating - Part 1: Irradiance and temperature performance measurements and power rating	EN 61853-1	-
IEC/TR 63228	-	Measurement protocols for photovoltaic devices based on organic, dye-sensitized or perovskite materials	-	-
ISO 9060	-	Solar energy; specification and classification of instruments for measuring hemispherical solar and direct solar radiation	-	-

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<sup>1</sup> Under preparation.

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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

### PHOTOVOLTAIC DEVICES –

#### Part 1: Measurement of photovoltaic current-voltage characteristics

#### FOREWORD

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International Standard IEC 60904-1 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

This third edition cancels and replaces the second edition published in 2006. This edition constitutes a technical revision.

The main changes with respect to the previous edition are as follows:

- Updated scope to include all conditions.
- Added terms and definitions.
- Reorganised document to avoid unnecessary duplication.
- Added data analysis clause.
- Added informative annexes (area measurement, PV devices with capacitance, dark  $I-V$  curves and effect of spatial non-uniformity of irradiance).

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The text of this International Standard is based on the following documents:

FDIS	Report on voting
82/1760/FDIS	82/1786/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 of IEC 60904 series, under the general title *Photovoltaic devices*, can be found on the IEC website.

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.

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## PHOTOVOLTAIC DEVICES –

### Part 1: Measurement of photovoltaic current-voltage characteristics

#### 1 Scope

This part of IEC 60904 describes procedures for the measurement of current-voltage characteristics ( $I$ - $V$  curves) of photovoltaic (PV) devices in natural or simulated sunlight. These procedures are applicable to a single PV solar cell, a sub-assembly of PV solar cells, or a PV module. They are applicable to single-junction mono-facial PV devices. For other device types, reference is made to the respective documents, in particular for multi-junction devices to IEC 60904-1-1 and for bifacial devices to IEC TS 60904-1-2. Additionally informative annexes are provided concerning area measurement of PV devices (Annex A), PV devices with capacitance (Annex B), measurement of dark current-voltage characteristics (dark  $I$ - $V$  curves) (Annex C) and effects of spatial non-uniformity of irradiance (Annex D).

NOTE The methods provided in this document can also be used as guidance for taking  $I$ - $V$  curves of PV arrays. For on-site measurement refer to IEC 61829.

This document is applicable to non-concentrating PV devices for use in terrestrial environments, with reference to (usually but not exclusively) the global reference spectral irradiance AM1.5 defined in IEC 60904-3. It may also be applicable to PV devices for use under concentrated irradiation if the application uses direct sunlight and reference is instead made to the direct reference spectral irradiance AM1.5d in IEC 60904-3.

The purposes of this document are to lay down basic requirements for the measurement of  $I$ - $V$  curves of PV devices, to define procedures for different measuring techniques in use and to show practices for minimising measurement uncertainty. It is applicable to the measurement of  $I$ - $V$  curves in general.  $I$ - $V$  measurements can have various purposes, such as calibration (i.e. traceable measurement with stated uncertainty, usually performed at standard test conditions) of a PV device under test against a reference device, performance measurement under various conditions (e.g. for device temperature and irradiance) such as those required by IEC 60891 (for determination of temperature coefficients or internal series resistance), by IEC 61853-1 (power rating of PV devices) or by IEC 60904-10 (for determination of output's linear dependence and linearity with respect to a particular test parameter).  $I$ - $V$  measurements are also important in industrial environments such as PV module production facilities, and for testing in the field. Further guidance on  $I$ - $V$  measurements in production facilities is provided in IEC TR 60904-14.

The actual requirements (e.g. for the class of solar simulator) depend on the end-use. Other standards referring to IEC 60904-1 can stipulate specific requirements. Where those requirements are in conflict with this document, the specific requirements take precedence.

#### 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 60891, *Photovoltaic devices – Procedures for temperature and irradiance corrections to measured  $I$ - $V$  characteristics*

IEC 60904-2, *Photovoltaic devices – Part 2: Requirements for reference devices*