BS EN IEC 60904-10:2020

BSI Standards Publication

Photovoltaic devices

Part 10: Methods of linear dependence and linearity measurements

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National foreword

This British Standard is the UK implementation of EN IEC 60904-10:2020. It is identical to IEC 60904-10:2020. It supersedes BS EN 60904-10:2010, which is withdrawn.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.

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English Version

Photovoltaic devices - Part 10: Methods of linear dependence and linearity measurements (IEC 60904-10:2020)

Dispositifs photovoltaïques - Partie 10: Méthodes de mesure de la dépendance linéaire et de la linéarité (IEC 60904-10:2020)

Photovoltaische Einrichtungen - Teil 10: Methoden zur Messung der linearen Abhängigkeit und Linearität (IEC 60904-10:2020)

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European foreword

The text of document 82/1759/FDIS, future edition 3 of IEC 60904-10, prepared by IEC/TC 82 "Solar photovoltaic energy systems" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 60904-10:2020.

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- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2023-10-23

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

IEC 61829	NOTE	Harmonized as EN 61829
IEC 61853-1	NOTE	Harmonized as EN 61853-1

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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.

Publication	Year	Title	EN/HD	Year
IEC 60891	-	Photovoltaic devices - Procedures for temperature and irradiance corrections to measured I-V characteristics	EN 60891	-
IEC 60904-1	-	Photovoltaic devices - Part 1: Measurement of photovoltaic current-voltage characteristics	EN IEC 60904-1	-
IEC 60904-1-1	-	Photovoltaic devices - Part 1-1: Measurement of current-voltage characteristics of multi-junction photovoltaic (PV) devices	EN 60904-1-1	-
IEC/TS 60904-1-2	-	Photovoltaic devices - Part 1-2: Measurement of current-voltage characteristics of bifacial photovoltaic (PV) devices	-	-
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 60904-7	-	Photovoltaic devices - Part 7: Computation of the spectral mismatch correction for measurements of photovoltaic devices	EN IEC 60904-7	-
IEC 60904-8	-	Photovoltaic devices - Part 8: Measurement of spectral responsivity of a photovoltaic (PV) device	EN 60904-8	-
IEC 60904-8-1	-	Photovoltaic devices - Part 8-1: Measurement of spectral responsivity of multi-junction photovoltaic (PV) devices	EN 60904-8-1	-

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Publication	Year	Title	EN/HD	Year
IEC 60904-9	-	Photovoltaic devices - Part 9: Classification of solar simulator characteristics	EN IEC 60904-9	-
IEC 61215	series	Crystalline silicon terrestrial photovoltaic (PV) modules - Design qualification and type approval	EN 61215	series
IEC 61724-1	-	Photovoltaic system performance - Part 1: Monitoring	-	-
IEC/TS 61836	-	Solar photovoltaic energy systems - Terms, definitions and symbols	-	-
ISO/TS 28037	-	Determination and use of straight-line calibration functions	-	-

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

PHOTOVOLTAIC DEVICES –

Part 10: Methods of linear dependence and linearity measurements

FOREWORD

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International Standard IEC 60904-10 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

This third edition cancels and replaces the second edition published in 2009. This edition constitutes a technical revision.

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

a) Modification of title.
b) Inclusion of an Introduction explanatory of the changes and the reasoning behind them.
c) Inclusion of a new Clause Terms and Definitions (Clause 3), with distinction between generic linear dependence and linear dependence of short-circuit current versus irradiance (linearity).
d) Explicit definition of equivalent sample (Clause 4).

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e) Technical revision of the apparatus (Clause 5), of the measurement procedures (Clause 6 to Clause 8) and of the data analysis (Clause 9), with separation of the data analysis for a generic linear dependence from the data analysis specific to linearity (i.e. short-circuit current dependence on irradiance) assessment. Additionally, inclusion of impact of spectral effects on both linearity and linear dependence assessment.

f) Introduction of specific data analysis for two-lamp method, making it fully quantitative. Addition of extended version called N-lamp method.

g) Modification of the linearity assessment criterion with inclusion of a formula that can be used to correct the irradiance reading of a PV reference device for non-linearity of its short-circuit current versus irradiance. A linearity factor is specifically newly defined for this purpose.

h) Revision of the requirements for the report (Clause 10) in order to improve clearness about what information is always necessary and what is dependent on the procedure actually followed to measure the linear dependence, including the type of dependence measured (generic or linearity).

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

FDIS	Report on voting
82/1759/FDIS	82/1784/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 the 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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INTRODUCTION

IEC 60904-10 is the reference document for several IEC standards when the linear dependence of one or more electrical parameters of a photovoltaic (PV) device has to be assessed in relation to a test parameter. Test parameters are usually either the device temperature or the irradiance. In order to better reflect the different cases to be handled and the peculiarities of the linear dependence of the short-circuit current of a PV device on the irradiance, IEC 60904-10 has been extensively revised.

To avoid confusion, in this document the word “linearity” will be used only for the dependence of the short-circuit current (I_{SC}) on the irradiance (G), while all the other dependences will be referred to as generic linear dependence (when not explicitly described).

Three major technical changes have been included in this third edition compared to the second edition.

The first main change is the split of the data analysis for the linearity from the one to be used for a generic linear dependence (like for example $V_{OC}(T)$, which gives the open-circuit voltage as function of temperature). The latter keeps the same approach already included in the previous edition, i.e. the least squares fit method, with addition of the recommended use of the measurement uncertainties within the data analysis. The former applies the proportionality function that describes the dependence between I_{SC} and G for an ideal linear PV device. It also makes use of the calibration value of the I_{SC} to establish a reference point towards which the non-linearity is explicitly referred. Also, the impact of test spectra and spectral mismatch on both linearity and generic linear dependence is now considered.

Following this new approach for the linearity assessment, the second major change involves a modification of the definition of non-linearity (referred now explicitly to the calibration value) and the inclusion of a formula to correct the measured irradiance for the non-linearity of the PV device used to measure it. Such a PV device is usually a reference device. However, IEC 61853-1 explicitly considers the case of using the short-circuit current of the PV device itself to measure the irradiance when its linearity has been proved (Note in IEC 61853-1:2011: 8.1). A correction of the actual irradiance measurement to account for deviations of I_{SC} from linearity is therefore relevant when the irradiance is measured by a reference device as well as by the device under test itself. In principle, this can be extended to non-linear devices as well, provided that the non-linearity information is stated in addition to the calibration value of the PV device itself. The irradiance correction for non-linearity is made in this document by means of a multiplication factor, resembling the same approach used in the IEC 60904-7 for the spectral mismatch correction. This formula has been introduced in order to address the explicit reference of the other standards to IEC 60904-10 in terms of handling non-linear devices. However, this formula can be useful to correct deviations from linearity within the acceptance limits even in the case of reference devices classified as linear according to the previous edition of this standard.

The third main change is the revision of the two-lamp method approach. This is achieved first by the introduction of a specific data analysis for the two-lamp method, which was a simple pass/fail test in the second edition and gains now the status of a quantitative method. This change is crucial in order to have results, obtained by any procedure for linearity measurements allowed by this standard, to be fully comparable to each other within their stated measurement uncertainties. Thereby, the irradiance correction formula is also applicable to the results from the two-lamp method. With these additions, the two-lamp method becomes the simplest quantitative method to assess the linearity (i.e. dependence of short-circuit current I_{SC} on irradiance) of PV devices, not even requiring a reference device when devices under test are single PV cells. An extended version called N-lamp method has been included, which overcomes some limitations of the two-lamp method.

A secondary change, which was introduced to improve locating the necessary procedure within the document, is the distinction between the cases of irradiance and of temperature as test parameter, i.e. the parameter being varied and on which the dependence is checked.

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Furthermore, when the linear dependence of a device parameter (e.g. I_{SC}) has to be assessed towards more than a single test parameter, intermediate steps applying the procedures described by this standard can be followed if the device under test is stable according to the criterion given in IEC 61215-1 and its relevant part. For example, the measurement of a power matrix as defined by IEC 61853-1 requires the measurement of the maximum power as a function of both irradiance and temperature. In this case, the most convenient way of performing the power matrix measurement is usually to vary one parameter (e.g. the temperature) while keeping the other (e.g. the irradiance) steady, and then to repeat this procedure at different levels of the second parameter until the full matrix is completed. In this view, the second parameter would be considered as the fixed one, and the first one would be the test parameter towards which the linear dependence is evaluated according to this standard. However, once the full power matrix has been measured, the subsequent data analysis of the maximum power (as well as of any other relevant electrical parameter) of the device under test can be done by considering either parameter as the test parameter as long as the other one is kept constant. Therefore, a linear dependence can be assessed with respect to one or the other parameter, independent of the measurement procedure used to obtain the data.

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