IEC 60904-10

Edition 3.0 2020-09

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Photovoltaic devices –
Part 10: Methods of linear dependence and linearity measurements

Dispositifs photovoltaïques –
Partie 10: Méthodes de mesure de la dépendance linéaire et de la linéarité

IEC 60904-10:2020-09(en-fr)

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CONTENTS

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PHOTOVOLTAIC DEVICES –

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FOREWORD

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).

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.

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.

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.