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# INTERNATIONAL STANDARD

# NORME INTERNATIONALE

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## Photovoltaic devices – Part 7: Computation of the spectral mismatch correction for measurements of photovoltaic devices

## Dispositifs photovoltaïques – Partie 7: Calcul de la correction de désadaptation des réponses spectrales dans les mesures de dispositifs photovoltaïques

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

# PHOTOVOLTAIC DEVICES –

## Part 7: Computation of the spectral mismatch correction for measurements of photovoltaic devices

## FOREWORD

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International Standard IEC 60904-7 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

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

| FDIS | Report on voting |
|---|---|
| 82/540/FDIS | 82/547/RVD |

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

This third edition cancels and replaces the second edition published in 1998. It constitutes a technical revision. The main changes with respect to the previous edition are listed below:

- the title has been modified in order to better reflect the purpose of the standard (changed from "mismatch error" to "mismatch correction");

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- formulae are now accompanied by explanatory text;
- Clause 3 “Description of method” now describes when it is necessary to use the method and when it may not be needed. It describes what data must be collected before the mismatch correction can be calculated;
- Clauses 4, 5 and 6 have added;
- the formula for the mismatch correction has been corrected.

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

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

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn,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

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# PHOTOVOLTAIC DEVICES –

## Part 7: Computation of the spectral mismatch correction for measurements of photovoltaic devices

## 1 Scope and object

This part of IEC 60904 describes the procedure for correcting the bias error introduced in the testing of a photovoltaic device, caused by the mismatch between the test spectrum and the reference spectrum and by the mismatch between the spectral responses (SR) of the reference cell and of the test specimen. The procedure applies only to photovoltaic devices linear in SR as defined in IEC 60904-10. This procedure is valid for single junction devices but the principle may be extended to cover multijunction devices.

The purpose of this standard is to give guidelines for the correction of measurement bias, should there be a mismatch between both the test spectrum and the reference spectrum and between the reference device SR and the test specimen SR.

Since a PV device has a wavelength-dependent response, its performance is significantly affected by the spectral distribution of the incident radiation, which in natural sunlight varies with several factors such as location, weather, time of year, time of day, orientation of the receiving surface, etc., and with a simulator varies with its type and conditions. If the irradiance is measured with a thermopile-type radiometer (that is not spectrally selective) or with a reference solar cell, the spectral irradiance distribution of the incoming light must be known to make the necessary corrections to obtain the performance of the PV device under the reference solar spectral distribution defined in IEC 60904-3.

If a reference PV device or a thermopile type detector is used to measure the irradiance then, following the procedure given in this standard, it is possible to calculate the spectral mismatch correction necessary to obtain the short-circuit current of the test PV device under the reference solar spectral irradiance distribution included in Table 1 of IEC 60904-3 or any other reference spectrum. If the reference PV device has the same relative spectral response as the test PV device then the reference device automatically takes into account deviations of the real light spectral distribution from the standard spectral distribution, and no further correction of spectral bias errors is necessary. In this case, location and weather conditions are not critical when the reference device method is used for outdoor performance measurements provided both reference cell and test PV device have the same relative spectral response. Also, for identical relative SR's, the spectral classification of the simulator is not critical for indoor measurements.

If the performance of a PV device is measured using a known spectral irradiance distribution, its short-circuit current at any other spectral irradiance distribution can be computed using the spectral response of the PV test device.

## 2 Normative references

The following referenced documents are indispensable for the application 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, *Procedures for temperature and irradiance corrections to measured I-V characteristics of crystalline silicon photovoltaic devices*

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

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

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

IEC 60904-8, *Photovoltaic devices – Part 8: Measurement of spectral response of a photovoltaic (PV) device*

IEC 60904-9, *Photovoltaic devices – Part 9: Solar simulator performance requirements*

IEC 60904-10, *Photovoltaic devices – Part 10 Methods of linearity measurement*

IEC 61215, *Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval*

IEC 61646, *Thin film terrestrial photovoltaic (PV) modules – Design qualification and type approval*

## 3 Description of method

For many PV devices, the shape of the I-V characteristic depends on the short-circuit current and the device temperature, but not on the spectrum used to generate the short-circuit current. For these devices, the correction of spectrum mismatch or spectral response mismatch is possible using the following procedure. For other devices, a measurement of the I-V characteristic shall be done using a light source with the appropriate spectrum.

A correction is not necessary if either the test spectrum is identical to the reference spectrum (see IEC 60904-3) or if the test specimen's relative spectral response is identical to the reference cell relative spectral response. In this case, the reading as obtained from the reference cell specifies which intensity at the reference spectrum will generate the same short-circuit current in the test device as the test spectrum.

If there is a mismatch between both spectra and spectral responses then a mismatch correction should be calculated.

Due to the mismatch in spectra and spectral responses, the reading of the reference cell (see IEC 60904-2) does not give the intensity of the reference spectrum that generates the short-circuit current as measured for the test device. One must determine the effective irradiance of the reference spectrum that generates the same short-circuit current in the test device as generated by the test spectrum at the measured irradiance $G_{\text{meas}}$.

$$G_{\text{eff at ref spectrum}} = MM \times G_{\text{meas}} \qquad (1)$$

where $G_{\text{meas}}$ is the irradiance as measured by the reference device with its specific spectral response $S_{\text{ref}}(\lambda)$ and $MM$ is the spectral mismatch factor as determined in Clause 7.

For a measurement to be referred to the reference spectral irradiance, two correction methods are possible:

a) If possible, adjust the simulator intensity so that the effective irradiance as determined by equation (1) equals the reference irradiance $G_{\text{ref}}$ (e.g. 1 000 W/m$^2$ for STC, as defined in IEC 61215 and IEC 61646). That is to say that the simulator intensity as measured by the reference cell using its calibration value given for the reference spectrum has to be set to

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