IEC 60904-7

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colour inside

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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

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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.

This fourth edition cancels and replaces the third edition published in 2008. It constitutes a technical revision.

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

- For better compatibility and less redundancy, the clause “Determination of test spectrum” refers to IEC 60904-9.
- The spectral mismatch factor is called SMM instead of MM to enable differentiation to the angular mismatch factor AMM and spectral angular mismatch factor $SAMM$.
- Formulae for the derivation and application of the spectral mismatch factor SMM are added.
- Links to new standards are given, e.g. concerning multi-junction devices.
- Corrected wording (responsivity instead of response and irradiance instead of intensity).

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

FDIS	Report on voting
82/1590/FDIS	82/1605/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, published under the general title *Photovoltaic devices,* can be found on the IEC website.

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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~~ spectral mismatch error introduced in the testing of a photovoltaic device, caused by the mismatch between the test spectrum and the reference spectrum (e.g. AM1.5 spectrum) and by the mismatch between the spectral ~~responses~~ responsivities (SR) of the reference ~~cell~~ device and of the device under test ~~specimen~~ and therewith reduce the systematic uncertainty. ~~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 multi-junction devices.

The purpose of this document is to give guidelines for the correction of ~~measurement bias~~ the spectral mismatch error, should there be a spectral mismatch betweenthe test spectrum and the reference spectrum as well as between the reference device SR and the device under test ~~specimen~~ SR. The calculated spectral mismatch correction is only valid for the specific combination of test and reference devices measured with a particular test spectrum.

Since a PV device has a wavelength-dependent ~~response~~ spectral responsivity, 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 solar 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 PV reference ~~solar cell~~ device (IEC 60904-2), 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 irradiance 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 document, it is possible to calculate the spectral mismatch correction necessary to obtain the short-circuit current of the ~~test PV~~ device under test under the reference ~~solar~~ spectral irradiance distribution in IEC 60904-3 or any other reference spectrum. If the reference PV device has the same relative spectral ~~response~~ responsivity as the ~~test PV~~ device under test then the reference device automatically takes into account deviations of the ~~real light~~ measured spectral irradiance distribution from the ~~standard~~ reference spectral irradiance distribution, and no further correction of spectral ~~bias~~ mismatch 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~~ under natural sunlight. Also, for identical relative SRs, the spectral classification of the simulator is not critical for ~~indoor~~ measurements with solar simulators.

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~~ responsivity of the PV ~~test~~ device under test.

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 ~~of crystalline silicon photovoltaic devices~~*

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

IEC 60904-1-1, *Photovoltaic devices – Part 1-1: Measurement of current-voltage characteristics of multi-junction photovoltaic (PV) devices*

IEC 60904-2, *Photovoltaic devices – Part 2: Requirements for photovoltaic 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~~ responsivity of a photovoltaic (PV) device*

IEC 60904-8-1, *Photovoltaic devices – Part 8-1: Measurement of spectral responsivity of multi-junction photovoltaic (PV) devices*

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*~~

IEC TS 61836, *Solar photovoltaic energy systems – Terms, definitions and symbols*

ISO 9288:1989, *Thermal insulation – Heat transfer by radiation – Physical quantities and definitions*

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

IEC 60904-7:2019-08(en-fr)

CONTENTS

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PHOTOVOLTAIC DEVICES –

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

1 Scope

This part of IEC 60904 describes the procedure for correcting the spectral mismatch error introduced in the testing of a photovoltaic device, caused by the mismatch between the test spectrum and the reference spectrum (e.g. AM1.5 spectrum) and by the mismatch between the spectral responsivities (SR) of the reference device and of the device under test and therewith reduce the systematic uncertainty. This procedure is valid for single-junction devices but the principle may be extended to cover multi-junction devices.

The purpose of this document is to give guidelines for the correction of the spectral mismatch error, should there be a spectral mismatch between the test spectrum and the reference spectrum as well as between the reference device SR and the device under test SR. The calculated spectral mismatch correction is only valid for the specific combination of test and reference devices measured with a particular test spectrum.

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If a reference PV device or a thermopile type detector is used to measure the irradiance, then, following the procedure given in this document, it is possible to calculate the spectral mismatch correction necessary to obtain the short-circuit current of the device under test under the reference spectral irradiance distribution in IEC 60904-3 or any other reference spectrum. If the reference PV device has the same relative spectral responsivity as the device under test then the reference device automatically takes into account deviations of the measured spectral irradiance distribution from the reference spectral irradiance distribution, and no further correction of spectral mismatch errors is necessary. In this case, location and weather conditions are not critical when the reference device method is used for performance measurements under natural sunlight. Also, for identical relative SRs, the spectral classification of the simulator is not critical for measurements with solar simulators.

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 responsivity of the PV device under test.

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

IEC 60904-8-1, *Photovoltaic devices – Part 8-1: Measurement of spectral responsivity of multi-junction photovoltaic (PV) devices*

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

IEC TS 61836, *Solar photovoltaic energy systems – Terms, definitions and symbols*

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SOMMAIRE

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DISPOSITIFS PHOTOVOLTAÏQUES –

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

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La Norme internationale IEC 60904-7 a été établie par le comité d'études 82 de l'IEC: Systèmes de conversion photovoltaïque de l'énergie solaire.

Cette quatrième édition annule et remplace la troisième édition parue en 2008. Cette édition constitue une révision technique.

Les modifications techniques principales par rapport à l'édition précédente sont les suivantes:

- pour davantage de compatibilité et moins de redondance, l'article "Détermination du spectre pour l'essai" fait référence à l'IEC 60904-9;
- le facteur de désadaptation des réponses spectrales est appelé SMM plutôt que MM afin de permettre la différenciation avec le facteur de désadaptation angulaire AMM et le facteur de désadaptation angulaire spectral $SAMM$;

- les formules correspondant à la dérivée et à l'application du facteur de désadaptation spectral SMM sont ajoutées;
- des références à de nouvelles normes sont données, par exemple concernant les dispositifs multijonctions;
- des formulations ont été corrigées ("sensibilité" remplace "réponse" et "éclairement" remplace "intensité").

Le texte de cette Norme internationale est issu des documents suivants:

FDIS	Rapport de vote
82/1590/FDIS	82/1605/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette norme.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série IEC 60904, publiées sous le titre général *Dispositifs photovoltaïques*, peut être consultée sur le site web de l'IEC.

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DISPOSITIFS PHOTOVOLTAÏQUES –

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

1 Domaine d'application

Cette partie de l'IEC 60904 décrit la procédure pour corriger l'erreur de mesure spectrale introduite dans l'essai d'un dispositif photovoltaïque, due d'une part à la désadaptation du spectre pour l'essai et du spectre de référence (par exemple, spectre AM1.5), et d'autre part à la désadaptation entre les sensibilités spectrales (SS) du dispositif de référence et du dispositif soumis à essai, et ainsi réduire l'incertitude systématique. Cette procédure est valable pour les dispositifs à jonction unique, mais le principe peut être étendu aux dispositifs multijonctions.

Le but du présent document est de donner des lignes directrices pour la correction de l'erreur de mesure spectrale se traduisant par une désadaptation à la fois du spectre pour l'essai et du spectre de référence, ainsi que des sensibilités spectrales (SS) du dispositif de référence et celles du dispositif soumis à essai. La correction calculée de désadaptation des réponses spectrales n'est valable que pour la combinaison spécifique des dispositifs d'essai et de référence mesurés à l'aide d'un spectre d'essai particulier.

Comme la sensibilité spectrale d'un dispositif PV est liée à la longueur d'onde, ses performances sont influencées de manière significative par la distribution spectrale du rayonnement incident, qui, dans le cas d'un éclairement solaire naturel, varie selon plusieurs facteurs tels que l'emplacement, les conditions météorologiques , le moment de l'année ou de la journée, l'orientation de la surface de réception, etc., et qui, avec un simulateur solaire, varie selon son type et les conditions correspondantes. Si l'éclairement est mesuré avec un radiomètre à thermopile (qui n'est pas spectralement sélectif) ou avec un dispositif PV de référence (IEC 60904-2), la distribution spectrale de l'éclairement de la lumière entrante doit être connue de façon à appliquer les corrections nécessaires pour obtenir les performances du dispositif PV avec la distribution spectrale de l'éclairement de référence définie dans l'IEC 60904-3.

Si un dispositif PV de référence ou un détecteur de type thermopile est utilisé pour mesurer l'éclairement, alors, en suivant la procédure donnée dans le présent document, il est possible de calculer la correction de désadaptation des sensibilités spectrales nécessaire à la détermination du courant de court-circuit du dispositif soumis à essai avec une distribution spectrale de l'éclairement de référence donnée dans l'IEC 60904-3 ou avec tout autre spectre de référence. Si le dispositif PV de référence a la même sensibilité spectrale relative que le dispositif soumis à essai alors le dispositif de référence prend automatiquement en compte les écarts de la distribution spectrale de l'éclairement mesurée par rapport à la distribution spectrale de l'éclairement de référence, et aucune correction supplémentaire des erreurs de mesure spectrales n'est nécessaire. Dans ce cas, l'emplacement et les conditions atmosphériques ne sont pas critiques lorsque la méthode employant un dispositif de référence est utilisée pour des mesures de performance sous éclairement solaire naturel. De plus, pour des sensibilités spectrales relatives identiques, la classification spectrale du simulateur n'est pas critique pour des mesures avec des simulateurs solaires.

Si la performance d'un dispositif PV est mesurée en utilisant une distribution spectrale de l'éclairement connue, son courant de court-circuit avec toute autre distribution spectrale de l'éclairement peut être calculé en utilisant la sensibilité spectrale du dispositif PV soumis à essai.

2 Références normatives

Les documents suivants cités dans le texte constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60891, *Dispositifs photovoltaïques – Procédures pour les corrections en fonction de la température et de l'éclairement à appliquer aux caractéristiques I-V mesurées*

IEC 60904-1, *Dispositifs photovoltaïques – Partie 1: Mesure des caractéristiques courant-tension des dispositifs photovoltaïques*

IEC 60904-1-1, *Dispositifs photovoltaïques – Partie 1-1: Mesurage des caractéristiques courant-tension des dispositifs photovoltaïques (PV) multijonctions*

IEC 60904-2, *Dispositifs photovoltaïques – Partie 2: Exigences applicables aux dispositifs photovoltaïques de référence*

IEC 60904-3, *Dispositifs photovoltaïques – Partie 3: Principes de mesure des dispositifs solaires photovoltaïques (PV) à usage terrestre incluant les données de l'éclairement spectral de référence – Dispositifs photovoltaïques*

IEC 60904-8, *Dispositifs photovoltaïques – Partie 8: Mesure de la sensibilité spectrale d'un dispositif photovoltaïque (PV)*

IEC 60904-8-1, *Dispositifs photovoltaïques – Partie 8-1: Mesurage de la sensibilité spectrale des dispositifs photovoltaïques (PV) multijonctions*

IEC 60904-9, *Dispositifs photovoltaïques – Partie 9: Exigences pour le fonctionnement des simulateurs solaires*

IEC TS 61836, *Solar photovoltaic energy systems – Terms, definitions and symbols* (disponible en anglais seulement)

ISO 9288:1989, *Isolation thermique – Transfert de chaleur par rayonnement – Grandeurs physiques et définitions*