

INTERNATIONAL STANDARD

NORME INTERNATIONALE

Photovoltaic devices –

Part 1-1: Measurement of current-voltage characteristics of multi-junction photovoltaic (PV) devices

Dispositifs photovoltaïques –

Partie 1-1: Mesurage des caractéristiques courant-tension des dispositifs photovoltaïques (PV) multijonctions



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

PHOTOVOLTAIC DEVICES –

**Part 1-1: Measurement of current-voltage characteristics
of multi-junction photovoltaic (PV) devices**

FOREWORD

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

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

FDIS	Report on voting
82/1254/FDIS	82/1272/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 in the 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 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- withdrawn,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.

PHOTOVOLTAIC DEVICES –

Part 1-1: Measurement of current-voltage characteristics of multi-junction photovoltaic (PV) devices

1 Scope

This part of IEC 60904 describes procedures for the measurement of the current-voltage characteristics of multi-junction photovoltaic devices in natural or simulated sunlight. It is applicable to single PV cells, sub-assemblies of such cells or entire PV modules. It is principally intended for non-concentrating devices, but parts may be applicable also to concentrating multi-junction PV devices. An essential prerequisite is the spectral responsivity of the multi-junction devices, whose measurement is covered by IEC 60904-8-1.

The requirements for measurement of current-voltage characteristics of single-junction PV devices are covered by IEC 60904-1 whereas this document describes the additional requirements for the measurement of current-voltage characteristics of multi-junction PV devices.

This document may be applicable to PV devices designed for use under concentrated irradiation if they are measured without the optics for concentration and irradiated using direct normal irradiance and a mismatch correction with respect to a direct normal reference spectral irradiance distribution is performed. The reference spectral irradiance distribution is provided in IEC 60904-3

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

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

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

IEC 60904-4, *Photovoltaic devices – Part 4: Reference solar devices – Procedures for establishing calibration traceability*

IEC 60904-7, *Photovoltaic devices – Part 7: Computation of the spectral mismatch correction for measurements of photovoltaic devices*

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*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC TS 61836 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1

current limiting junction

junction in a multi-junction photovoltaic device in which under given illumination conditions the lowest photovoltaic current is generated

4 General considerations

The procedure for measurement of the current-voltage characteristics of single-junction PV devices is described in detail in IEC 60904-1. The procedure for measurement of the current-voltage characteristics of a multi-junction PV device is based on the same basic principles, but requires some additional elements, which are described herein.

This document describes the additional considerations, requirements and procedures for the measurement of the current-voltage characteristics of multi-junction PV devices based on the measurement principles of single-junction PV devices.

Therefore, the provisions in IEC 60904-1 are also valid for the measurement of multi-junction PV devices except where explicitly amended by this document.

Multi-junction PV devices consist of two or more series-connected junctions. In general it is only possible to determine the current-voltage characteristics of the entire device. However, it may be useful to quantify the photovoltaic current associated with each individual junction and excessive variation of current with voltage in the current-voltage characteristics between the short-circuit and maximum-power point that may indicate shunting of each junction. To understand the performance of a multi-junction device under different spectra it is helpful to characterize each junction within it.

Luminescent coupling may be present and influence the measurements. For example, light emitted from a GaInP cell may be absorbed and generate photovoltaic current in an underlying GaAs junction. Similarly, a photon emitted by a GaAs cell may be absorbed and generate photovoltaic current in an underlying Ge junction. For relatively high efficiency cells, the coupling between the cells in this way can cause non-negligible changes in measured current under some conditions. For details see bibliography.

For multi-junction PV devices which provide separate connections to each junction, the measurement of current-voltage characteristics of each single-junction is possible and follows the procedure for single-junction devices (IEC 60904-1) using the appropriate connections.