

INTERNATIONAL STANDARD

IEC 60904-1

Second edition
2006-09

Photovoltaic devices –

**Part 1:
Measurement of photovoltaic
current-voltage characteristics**

*This **English-language** version is derived from the original **bilingual** publication by leaving out all French-language pages. Missing page numbers correspond to the French-language pages.*



Reference number
IEC 60904-1:2006(E)

INTERNATIONAL STANDARD

IEC 60904-1

Second edition
2006-09

Photovoltaic devices –

Part 1: Measurement of photovoltaic current-voltage characteristics

© IEC 2006 Copyright - all rights reserved

No part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from the publisher.

International Electrotechnical Commission, 3, rue de Varembe, PO Box 131, CH-1211 Geneva 20, Switzerland
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: inmail@iec.ch Web: www.iec.ch



Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

PRICE CODE

L

For price, see current catalogue

CONTENTS

| | |
|---|----|
| FOREWORD..... | 5 |
| 1 Scope and object..... | 9 |
| 2 Normative references | 9 |
| 3 General measurement requirements..... | 11 |
| 4 Apparatus..... | 13 |
| 4.1 For measurements in natural sunlight..... | 13 |
| 4.2 For measurements in simulated sunlight..... | 13 |
| 5 Measurements in natural sunlight | 13 |
| 6 Measurement in steady-state simulated sunlight..... | 15 |
| 7 Measurement in pulsed simulated sunlight | 19 |
| 8 Test report..... | 23 |

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PHOTOVOLTAIC DEVICES –

Part 1: Measurement of photovoltaic current-voltage characteristics

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

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

This second edition cancels and replaces the first edition published in 1987. This edition constitutes a technical revision.

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

- Added object.
- Added normative references.
- Updated original Clause 2 (General Measurement Requirements), removing Figure 1 as it is obsolete.
- Provided more detail and guidance on how to measure in sunlight or simulated sunlight.
- Expanded original Clause 6 (Test Report) with requirements based on ISO 17025.

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

| FDIS | Report on voting |
|-------------|------------------|
| 82/433/FDIS | 82/450/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 publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of 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 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.

PHOTOVOLTAIC DEVICES –

Part 1: Measurement of photovoltaic current-voltage characteristics

1 Scope and object

This part of IEC 60904 describes procedures for the measurement of current-voltage characteristics of photovoltaic devices in natural or simulated sunlight. These procedures are applicable to a single photovoltaic solar cell, a sub-assembly of photovoltaic solar cells, or a PV module.

NOTE 1 This standard may be applicable to multi-junction test specimens, if each sub-junction generates the same amount of current as it would under the reference AM1,5 spectrum in IEC 60904-3.

NOTE 2 This standard may be applicable to PV devices designed for use under concentrated irradiation if they are irradiated using direct normal irradiance and a mismatch correction with respect to a direct normal reference spectrum is performed.

The purpose of this standard is to lay down basic requirements for the measurement of current-voltage characteristics of photovoltaic devices, to define procedures for different measuring techniques in use and to show practices for minimising measurement uncertainty.

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 (PV) devices*

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

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

IEC 60904-5: *Photovoltaic devices – Part 5: Determination of equivalent cell temperature (ECT) of photovoltaic (PV) devices by the open-circuit voltage method*

IEC 60904-6: *Photovoltaic devices – Part 6: Requirements for reference solar modules*

IEC 60904-7: *Photovoltaic devices – Part 7: Computation of spectral mismatch error introduced in the testing of a photovoltaic device*

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

IEC 60904-10: *Photovoltaic devices – Part 10: Methods for linearity measurements*

ISO/IEC 17025: *General requirements for competence of testing and calibration laboratories*