

# TECHNICAL SPECIFICATION



---

**Photovoltaic devices –  
Part 1-2: Measurement of current-voltage characteristics of bifacial photovoltaic  
(PV) devices**





## THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2019 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, 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 either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland

Tel.: +41 22 919 02 11  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://www.iec.ch)

### About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

### About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

#### IEC publications search - [webstore.iec.ch/advsearchform](http://webstore.iec.ch/advsearchform)

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

#### IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

#### IEC Customer Service Centre - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: [sales@iec.ch](mailto:sales@iec.ch).

#### Electropedia - [www.electropedia.org](http://www.electropedia.org)

The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

#### IEC Glossary - [std.iec.ch/glossary](http://std.iec.ch/glossary)

67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

# TECHNICAL SPECIFICATION



---

**Photovoltaic devices –  
Part 1-2: Measurement of current-voltage characteristics of bifacial photovoltaic  
(PV) devices**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

---

ICS 27.160

ISBN 978-2-8322-6409-6

**Warning! Make sure that you obtained this publication from an authorized distributor.**

## CONTENTS

FOREWORD.....	4
1 Scope.....	6
2 Normative references .....	6
3 Terms and definitions .....	7
3.1 Bifacial PV device.....	7
3.2 Bifaciality.....	7
3.3 Rear irradiance driven power gain yield .....	7
4 General considerations.....	7
5 Apparatus.....	8
5.1 General.....	8
5.2 Solar simulator with adjustable irradiance levels for single-side illumination.....	8
5.3 Solar simulator with adjustable irradiance levels for double-side illumination .....	8
5.4 Natural sunlight.....	8
5.5 Non-irradiated background and background compensation .....	8
6 Additional <i>I-V</i> characterisations for bifacial devices .....	9
6.1 General.....	9
6.2 Determination of bifacialities .....	10
6.3 Determination of the rear irradiance driven power gain yield .....	11
6.3.1 General .....	11
6.3.2 Outdoor rear irradiance driven power gain yield measurement.....	12
6.3.3 Indoor rear irradiance driven power gain yield measurement with single-side illumination.....	13
6.3.4 Indoor rear irradiance driven power gain yield measurement with double-side illumination .....	14
7 <i>I-V</i> characterisation of bifacial PV devices in practice .....	15
7.1 General.....	15
7.2 <i>I-V</i> measurement of reference bifacial PV devices .....	15
7.3 <i>I-V</i> measurement of bifacial PV devices using a reference bifacial device .....	16
8 Report .....	17
Figure 1 – Scheme of a bifacial PV module and the required non-irradiated background and aperture .....	9
Figure 2 – Front- and rear-side characterization for bifaciality.....	10
Figure 3 – Outdoor measurement.....	12
Figure 4 – Examples of $P_{\max}$ as a function of irradiance level on the rear side $G_r$ (for outdoor or double-side illumination) or its 1-side equivalent irradiance $G_f$ for a device of bifaciality $\varphi = 80\%$ .....	14
Figure 5 – Transmittances of the device ( $T_{\text{DUT}}$ ) and its encapsulant ( $T_{\text{ENC}}$ ).....	15
Figure 6 – Example of $P_{\max, \text{BiFi100}}$ and $P_{\max, \text{BiFi200}}$ derived from the measurement of $P_{\max}$ at STC conditions, $P_{\max, \text{STC}}$ and the BiFi coefficient of the reference used in formulae (8) and (9) .....	17

Table 1 – Maximum peak power, $P_{max}$ , measured at different rear irradiances, $G_r$ , (double-side with $G_f = 1\,000$ ) or alternatively equivalent front irradiances, $G_E$ , and the rear irradiance driven power gain yield, $BiFi$ , derived from the slope of the linear fit on $P_{max}(G_r)$ . Also calculated values $P_{max,BiFi100}$ and $P_{max,BiFi200}$ . .....	14
Table 2 – Example of $P_{max,BiFi100}$ and $P_{max,BiFi200}$ derived from the measurement at STC conditions ( $G_r = 0$ and $G_f = 1\,000$ ) and the rear irradiance driven power gain obtained from the bifacial reference device, $BiFi,ref$ . .....	17

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

## PHOTOVOLTAIC DEVICES –

**Part 1-2: Measurement of current-voltage characteristics of bifacial photovoltaic (PV) devices**

## 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 itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 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.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a Technical Specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical Specification are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC TS 60904-1-2, which is a Technical Specification, has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

The text of this Technical Specification is based on the following documents:

Draft TS	Report on voting
82/1403/DTS	82/1508/RVDTS

Full information on the voting for the approval of this Technical Specification 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.

A bilingual version of this publication may be issued at a later date.

**IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.**