# TECHNICAL REPORT – TYPE 2

# IEC TR 61836

First edition
1997-10



## Solar photovoltaic energy systems – Terms and symbols

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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# SOLAR PHOTOVOLTAIC ENERGY SYSTEMS – TERMS AND SYMBOLS

## FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the 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, the IEC publishes International Standards. 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. The 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 the 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 National Committees.

3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical reports or guides and they are accepted by the National Committees in that sense.

4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.

5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.

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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 report of one of the following types:

- type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;
- type 2, when 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;
- type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

Technical reports of types 1 and 2 are subject to review within three years of publication to decide whether they can be transformed into International Standards. Technical reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

IEC 61836, which is a technical report of type 2, has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

The text of this technical report is based on the following documents:

| Committee draft | Report on voting |
|---|---|
| 82/154/CDV | 82/170/RVC |

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

This document is issued in the type 2 technical report series of publications (according to G.3.2.2 of part 1 of the ISO/IEC Directives) as a “prospective standard for provisional application” in the field of photovoltaic energy systems because there is an urgent requirement for a consolidated glossary for everyday use.

This document is not to be regarded as an “International Standard”. It is proposed for provisional application so that information and experience of its use in practice may be gathered. Comments on the content of this document should be sent to the IEC Central Office.

A review of this type 2 technical report will be carried out not later than three years after its publication, with the options of either extension for another three years or conversion into an International Standard or withdrawal.

# INTRODUCTION

Following the development of solar photovoltaic (PV) technology, specific standards have been developed by IEC technical committee 82 since 1987.

The terms and symbols used therein necessitate a systematization in order to have a consolidated glossary for experts' common understanding.

The elaboration of this technical report required a solution to the slight differences which were sometimes found among existing IEC standards.

# SOLAR PHOTOVOLTAIC ENERGY SYSTEMS – TERMS AND SYMBOLS

## 1 Scope and object

This technical report compiles the terms and symbols from the published IEC Standards cited in the normative references.

The object of this technical report is to harmonize the terms and symbols used in the standards within the field of photovoltaic (PV) solar energy systems. It is the intent to update this technical report every three years to incorporate published standards not referenced herein.

A two-step procedure will be followed for the preparation of the glossary. This technical report contains the terms and symbols used in published IEC PV standards. The step 2 document should be incorporated in this technical report as an annex and will deal with the terms and symbols from other national or international PV standards and relevant documents.

NOTE – In order to harmonize slight differences between existing IEC standards some rewording of the definitions was necessary.

## 2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this technical report. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this technical report are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60891:1987, *Procedures for temperature and irradiance corrections to measured I-V characteristics of crystalline silicon photovoltaic devices*
Amendment 1 (1992)

IEC 60904-1:1987, *Photovoltaic devices – Part 1: Measurement of photovoltaic current-voltage characteristics*

IEC 60904-2:1989, *Photovoltaic devices – Part 2: Requirements for reference solar cells*

IEC 60904-3:1989, *Photovoltaic devices – Part 3: Measurement principles for terrestrial photovoltaic (PV) solar devices with reference spectral irradiance data*

IEC 60904-5:1993, *Photovoltaic devices – Part 5: Determination of the equivalent cell temperature (ECT) of photovoltaic (PV) devices by the open-circuit voltage method*

IEC 60904-6:1994, *Photovoltaic devices – Part 6: Requirements for reference solar modules*

IEC 61173:1992, *Overvoltage protection for photovoltaic (PV) power generating systems – Guide*

IEC 61194:1992, *Characteristic parameters of stand-alone photovoltaic (PV) systems*

IEC 61215:1993, *Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval*

IEC 61277:1995, *Terrestrial photovoltaic (PV) power generating systems – General and guide*

IEC 61829:1995, *Crystalline silicon photovoltaic (PV) array – On-site measurement of I-V characteristics*

## 3 Glossary of terms and symbols used in IEC standards

3.1 *acceptance test conditions (ATC):* Reference values of ambient temperature, in-plane irradiance and spectral distribution, specified for power rating of photovoltaic (PV) arrays. (IEC 61829)

3.2 *air mass (AM):* The length of path through the earth's atmosphere traversed by the direct solar beam, expressed as a multiple of the path traversed to a point at sea level with the sun directly overhead.

At any point, the value of the air mass is given by:

$$AM = P/P_0 \times (1/\sin \theta)$$

where

$P$ is the local air pressure (Pa);

$P_0$ = 1,013 × $10^5$ Pa (1,013 bar);

$\theta$ is the solar elevation angle.

The value of “air mass” is 1 at sea level with cloudless sky when the sun is directly overhead and the air pressure $P$ = 1,013 × $10^5$ Pa (1,013 bar or 760 mm Hg). (IEC 60904-3)

3.3 *ambient temperature ($T_{amb}$):* The temperature of the air surrounding the photovoltaic (PV) generator as measured in a vented enclosure and shielded from solar, sky and ground radiation. (IEC 60904-3) Unit: °C

3.4 *angle of incidence:* The angle between the direct irradiant beam and the normal to the active surface. (IEC 60904-3) Unit: rad

3.5 *array:* A mechanically integrated assembly of modules or panels together with support structure, but exclusive of foundation, tracking apparatus, thermal control and other such components, to form a d.c. power-producing unit. (IEC 61277)

3.6 *array field:* The aggregate of all solar photovoltaic arrays within a given system. (IEC 61277)

3.7 *azimuth ($\alpha$):* The projected angle between a straight line from the apparent position of the sun to the point of observation and due south, measured from south in the northern hemisphere, from north in the southern hemisphere, and negative to the east, positive to the west. (IEC 61194) Unit: rad

3.8 *cell temperature ($T_j$ ):* Temperature measured by a thermal sensor in contact with the cell or derived from $V_{oc}$ measurement or thermal balance calculations. (IEC 60904-3) Unit: °C

3.9 *conversion efficiency:* The ratio of maximum electrical power output to the product of generator area and incident irradiance measured under defined test conditions and expressed as a percentage. (IEC 60904-3)

3.10 *current-temperature coefficient ($\alpha$):* The change of the short-circuit current of a photovoltaic (PV) device per unit change of cell temperature. (IEC 60904-3) Unit: A·°$C^{-1}$

NOTE – This coefficient varies with irradiance and to a lesser extent with temperature.

3.11 *current-voltage characteristic (I = f(V)):* The output current of a photovoltaic (PV) generator as a function of output voltage, at a particular temperature and irradiance. (IEC 60904-3)

3.12 *diffuse irradiance:* The radiant power from the whole of the sky, incident upon unit area except that contributing to the direct solar irradiance. (IEC 60904-3) Unit: $W \cdot m^{-2}$

3.13 *diffuse irradiation:* Diffuse irradiance integrated over a specified time interval. (IEC 60904-3) Unit: $J \cdot m^{-2}$

3.14 *direct irradiance:* The radiant power from the sun's disk and from the circumsolar region of the sky within a subtended angle of $8{,}7 \times 10^{-2}$ rad (5°) incident upon unit area. (IEC 60904-3) Unit: $W \cdot m^{-2}$

3.15 *direct irradiation:* Direct irradiance integrated over a specified time interval. (IEC 60904-3) Unit: $J \cdot m^{-2}$

3.16 *electric utility:* Generally, an organization responsible for the installation, operation and maintenance of major electric supply and distribution systems. (IEC 61277)

3.17 *equivalent cell temperature (ECT):* The junction temperature at which the measured electrical output of a photovoltaic (PV) device (cells, modules, arrays of one type of module) would be produced if the entire device were operating uniformly at this junction temperature. (IEC 60904-5) Unit: °C

3.18 *fill factor (FF):* The ratio of maximum power to the product of open-circuit voltage and short-circuit current:

$$FF = P_{max} / ( V_{oc} I_{sc} )$$ (IEC 60904-3)

3.19 *global irradiance*. Total radiant power incident upon unit area of a horizontal surface = direct irradiance (horizontal) + diffuse irradiance (horizontal). (IEC 60904-3) Unit: $W \cdot m^{-2}$

3.20 *global irradiation:* Global irradiance integrated over a specified time interval. (IEC 60904-3) Unit: $J \cdot m^{-2}$

3.21 *inverter:* A device which changes d.c. input into an a.c. output. (IEC 61277)

3.22 *inverter efficiency:* The ratio of the useful a.c. electrical output power of the inverter to the d.c. power input. (IEC 61277)

3.23 *irradiance (G):* Radiant power incident upon unit area of surface. (IEC 60904-3) Unit: $W \cdot m^{-2}$

3.24 *irradiation (H):* Irradiance integrated over a specified time interval. (IEC 60904-3) Unit: $J \cdot m^{-2}$

3.25 *load current ($I_L$ ):* The current supplied by the photovoltaic (PV) generator, at a particular temperature and irradiance, into a load connected across its terminals. (IEC 60904-3) Unit: A

3.26 *load power ($P_L$):* The power supplied to a load connected to the terminals of the photovoltaic (PV) generator at a particular temperature and irradiance. $P_L = V_L \cdot I_L$ (IEC 60904-3) Unit: W

3.27 *load voltage ($V_L$ ):* The voltage appearing across the terminals of a load connected to the terminals of the photovoltaic (PV) generator at a particular temperature and irradiance. (IEC 60904-3) Unit: V

3.28 *maximum power ($P_{max}$):* The power at the point on the current-voltage characteristic where the product of current and voltage is a maximum. (IEC 60904-3) Unit: W

3.29 *maximum power current ($I_{Pmax}$):* The current corresponding to maximum power. (IEC 60904-3) Unit: A

3.30 *maximum power voltage ($V_{Pmax}$):* The voltage corresponding to maximum power. (IEC 60904-3) Unit: V

3.31 *module:* The smallest complete environmentally protected assembly of interconnected solar cells. (IEC 60904-3; IEC 61277)

3.32 *module surface temperature*: The mean temperature of the back surface of the module. (IEC 60904-3) Unit: °C

3.33 *monitor and control subsystem:* Logic and control circuitry that supervises the overall operation of the system by controlling the interaction between all subsystems. (IEC 61277)

3.34 *nominal operating cell temperature (NOCT):* The equilibrium mean solar cell temperature within a module under reference conditions of 800 $W \cdot m^{-2}$ irradiance, 20 °C ambient air temperature, 1 $m \cdot s^{-1}$ wind speed, electrically open-circuit and open-rack mounted at normal incidence, at solar noon. (IEC 60904-3) Unit: °C

3.35 *open-circuit voltage ($V_{oc}$):* The voltage across an unloaded (open) photovoltaic (PV) generator at a particular temperature and irradiance. (IEC 60904-3) Unit: V

3.36 *optional test conditions*: Test irradiance as measured with a reference device of 1 000 $W \cdot m^{-2}$ and cell temperature at any conveniently measured ambient conditions. (IEC 60904-3)

3.37 *ozone content:* The volume of ozone at standard temperature and pressure in a vertical column of the atmosphere $1 \times 10^{-4}$ $m^2$ in cross section. (IEC 60904-3) Unit: m

3.38 *panel:* A group of modules fastened together, pre-assembled and wired, designed to serve as an installable unit in an array and/or subarray. (IEC 61277)

3.39 *photovoltaic effect:* Direct conversion of radiant energy into electrical energy. (IEC 60904-3)

3.40 *power conditioner:* The electrical equipment used to convert electrical power into a form or forms of electrical power suitable for subsequent use. (IEC 61277)

3.41 *precipitable water vapour content:* The volume of precipitable water vapour in a vertical column of the atmosphere $1 \times 10^{-4}$ $m^2$ in cross section expressed as the height of the corresponding vertical column of water. (IEC 60904-3) Unit: m

3.42 *primary reference solar cell:* A reference cell whose calibration is based on a radiometer or standard detector conforming to the standard World Radiometric Reference (WRR). (IEC 60904-2)

3.43 *pyranometer:* A radiometer normally used to measure global irradiance (or, with a shade ring or disc, diffuse irradiance) on a horizontal plane. Can also be used at an angle to measure the total irradiance on an inclined plane, which in this case includes an element due to radiation reflected from the foreground. (IEC 60904-3)

3.44 *pyrheliometer:* A radiometer, completed with a collimator, used to measure direct irradiance (sometimes called Normal Incidence Pyrheliometer, or NIP). (IEC 60904-3)

3.45 *rated current ($I_R$):* The assigned value of current of a photovoltaic (PV) generator at the rated voltage under specified operating conditions. (IEC 60904-3) Unit: A

3.46 *rated power ($P_R$):* The assigned value of power output of a photovoltaic (PV) generator at rated voltage under specified operating conditions. (IEC 60904-3) Unit: W

3.47 *rated voltage ($V_R$):* The assigned value of voltage at which a photovoltaic (PV) generator is designed to provide near maximum electrical power under specified operating conditions. (IEC 60904-3) Unit: V

3.48 *reference solar cell:* A specially calibrated cell, which is used to measure irradiance or to set simulator irradiance levels in terms of a reference solar spectral irradiance distribution. (IEC 60904-2)

3.49 *reference spectral irradiance distribution:* The tabulation of spectral irradiance, spectral photon irradiance and cumulative integrated irradiance versus wavelength, defined by the tabulation given by table 1 of IEC 60904-3. (IEC 60904-3)

3.50 *relative spectral response ($S(\lambda)_{rel}$):* The spectral response normalized to unity at wavelength of maximum response. (IEC 60904-3)

$$S(\lambda)_{rel} = S(\lambda)/S(\lambda)_{max}$$

NOTE – The term response is commonly used, but responsivity is strictly speaking correct.

3.51 *secondary reference solar cell:* A reference cell calibrated in natural or simulated sunlight against a primary reference cell. (IEC 60904-2)

3.52 *short-circuit current ($I_{sc}$):* The output current of a photovoltaic (PV) generator in the short circuit condition at a particular temperature and irradiance. (IEC 60904-3) Unit: A

3.53 *solar cell:* The basic photovoltaic (PV) device which generates electricity when exposed to sunlight. (IEC 60904-3)

3.54 *solar elevation ($\theta$):* Angle between the direct solar beam and the horizontal plane. (IEC 60904-3) Unit: rad

3.55 *spectral irradiance ($E\lambda$):* Irradiance per unit bandwidth at a particular wavelength. (IEC 60904-3) Unit: $W \cdot m^{-2} \cdot \mu m^{-1}$

3.56 *spectral irradiance distribution:* Spectral irradiance plotted as a function of wavelength. (IEC 60904-3) Unit: $W \cdot m^{-2} \cdot \mu m^{-1}$