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Solar photovoltaic energy systems – Terms, definitions and symbols

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FOREWORD

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

IEC 61836, which is a technical specification, has been prepared IEC technical committee 82: Solar photovoltaic energy systems.

This second edition cancels and replaces the first edition published in 1997. This edition constitutes a technical revision.

This edition included the following significant technical changes with respect to the previous edition:

1) The number of terms has increased. Abbreviations have been included.

2) The terms in Edition 2 are organised into categories and families. Terms contained in families are cross referenced with an alphabetical listing. A bibliography and an index were added. The purpose of aggregating terms into families is to allow readers to easily see the relationships between terms that speak of similar quantities and subjects but that have slight variations.

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

Enquiry draft	Report on voting
82/442/DTS	82/487/RVC

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 publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

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

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual edition of this document may be issued at a later date.

INTRODUCTION

Following the development of solar photovoltaic (PV) technology, specific Standards have been prepared by IEC Technical Committee 82 since 1987. The terms and symbols used in the PV industry necessitate a systematisation in order to have a consolidated glossary for experts' common understanding.

This Glossary lists the terms and symbols that the PV industry commonly uses. It is a living document that will change as new terms and symbols are added. These have been harmonized with IEC 60050 and other IEC documents as far as possible. All definitions not included in this Technical Specification may be found elsewhere in other IEC documents.

NOTE 1 The terms "PV", "photovoltaic" and "solar photovoltaic" can be read and used interchangeably and without the need for stating each term to show that each are applicable and commonly used by the solar photovoltaic industry.

NOTE 2 All terms beginning with "solar photovoltaic" and "PV" are listed under their respective "photovoltaic" names.

NOTE 3 The terms are listed alphabetically in ten categories. Under these categories, some of the terms have been grouped into families of related meaning in order for the reader to readily see the differences between the terms.

NOTE 4 This Glossary lists the precise usage of terms. Cross-references are provided to efficiently point the reader to the location of definitions. For example, a "solar photovoltaic array" may also be referred to as "photovoltaic array" or "array" when the reference to it is particularly clear. The definition for this term, for example, occurs under the family heading of "photovoltaic" in the "Solar photovoltaic systems" section.

NOTE 5 The colloquial use of "solar" as the sole adjective of a noun is discouraged. For example, though "solar array" may be commonly used in non-technical conversations, the precise terms are "solar photovoltaic array", "photovoltaic array", and "array".

NOTE 6 Unless specifically noted otherwise, the terms "device", "cell", "module", "array", "sub-array", "field", "component", "system", and "product" refer to items incorporating a photovoltaic device. As a result, each of these terms can be understood to read as "PV device", "PV cell", "PV module", *etc.*, without having to re-state the term "PV" each time, though now and then it is useful to re-state "PV".

NOTE 7 The numeric quantities described by many of the terms can be expressed over any convenient unit of time that the user may wish, such as day, month or year.

NOTE 8 "W_p" is not a recommended unit for rated power. For example for a 50 W module, the correct terminology is "the rated power is 50 W", and not "the power is 50 W_p".

NOTE 9 The documents from which these terms originated are shown in square brackets [ ]. Some adaptations may have occurred.

NOTE 10 This Glossary document recognises the related IEC co-ordinating Technical Committees:

1	Terminology	77	Electromagnetic compatibility
21	Secondary cells and batteries	82	Solar photovoltaic energy systems
22	Power electronic systems and equipment	88	Wind turbines
47	Semiconductor devices	105	Fuel cell technologies
64	Electrical installations and protection against electric shock	106	Methods for the assessment of electric, magnetic and electromagnetic fields associated with human exposure

SOLAR PHOTOVOLTAIC ENERGY SYSTEMS – TERMS, DEFINITIONS AND SYMBOLS

1 Scope and object

This Technical Specification deals with the terms and symbols from national and international solar photovoltaic standards and relevant documents used within the field of solar photovoltaic (PV) energy systems. It includes the terms and symbols compiled from the published IEC technical committee 82 standards, previously published as technical report IEC 61836:1997.

The focus of this Technical Specification is "what do the words mean" and not "under what conditions do the terms apply".

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

3 Glossary of terms, definitions and symbols for solar photovoltaic energy systems

3.1 Solar photovoltaic cells and modules

This subclause addresses vocabulary pertaining to photovoltaic materials, photovoltaic cells and photovoltaic modules. Other photovoltaic components are described in subclause 3.2. Photovoltaic systems are described in subclause 3.3.

3.1.1 **amorphous photovoltaic material**

solid-state material in a semi-stable condition with no long-range order in the structural arrangement of the atoms

3.1.2 **amorphous silicon**

see "silicon/amorphous", 3.1.58a).

3.1.3 **anti-reflective coating**

layer formed on the surface of a PV cell to reduce reflective loss

3.1.4 **back surface field effect**

see "effect/back surface field effect", 3.1.25a)

3.1.5 **band gap energy**

(Unit: eV)

amount of energy required to bring an electron from the state of valence electron to the state of free electron

3.1.6 **barrier energy**

(Unit: eV)

energy given up by an electron in penetrating the PV cell barrier

NOTE The barrier energy is a measure of the electrostatic potential of the barrier.

3.1.7 **bus lines**

see "metallisation line/bus bar", 3.1.37a)

3.1.8 **bypass diode (on a module level)**

diode connected across one or more PV cells in the forward electric current direction to allow the PV module electric current to bypass cells to prevent hot spot or hot cell damage resulting from the reverse voltage biasing from the other cells in that module

3.1.9 **cell**

see "photovoltaic/photovoltaic cell", 3.1.43a).

The following terms are used to describe the structure of PV cells and materials.

a) **CIS photovoltaic cell**

PV cell fabricated of copper indium diselenide ($CuInSe_2$, abbreviation CIS) material as a main constituent (thin film type)

b) **compound semiconductor photovoltaic cell**

PV cell made of compound semiconductor, which consists of different chemical elements, such as GaAs (III-V compounds), CdS/CdTe (II-VI compounds), $CdS/CuInSe_2$, etc.

c) **concentrator photovoltaic cell**

see "concentrator photovoltaic cell", 3.8.5a)

d) **dye-sensitized photovoltaic cell**

photoelectrochemical device using dye molecules with two electrodes and an electrolyte

e) **integrated type photovoltaic cell**

multiple PV cells connected in series produced on a single substrate that appears like a single cell

NOTE 1 Integrated type PV cells may include stacked or side-by-side configurations.

f) **multijunction photovoltaic cell**

see "cell/stacked photovoltaic cell", 3.1.9k)

g) **organic photovoltaic cell**

PV cell fabricated of organic materials being polymers and/or small molecules (thin film type)

h) **PN junction photovoltaic cell**

PV cell using a PN junction

NOTE 2 See also "PN junction", 3.1.34f).

i) **Schottky barrier photovoltaic cell**

PV cell using a Schottky junction formed at the metal-semiconductor interface

j) silicon photovoltaic cell

PV cell fabricated of silicon material as a main constituent

k) stacked photovoltaic cell

PV cell consisting of layers of different PV cells having different optical properties in which incident light is absorbed by each cell layer

l) tandem photovoltaic cell

common name for a stack of two or more PV cells behind each other

m) thin film photovoltaic cell

PV cell made of thin layers of semiconductor material

NOTE 3 See also "silicon/polycrystalline silicon", 3.1.58e).

3.1.10 **cell barrier**

very thin electric-potential barrier along the interface between the P-type layer and the N-type layer of a PV cell

NOTE 1 A cell barrier is also known as the "depletion zone".

NOTE 2 An enlectric-potential barrier is a region of high electric field strength opposing the passage of an electrically charged particle in a direction depending on the sign of the electric charge.

3.1.11 **cell junction**

see "junction/cell junction", 3.1.34a)

3.1.12 **CIS photovoltaic cell**

see "cell/CIS photovoltaic cell", 3.1.9a)

3.1.13 **compound semiconductor photovoltaic cell**

see "cell/compound semiconductor photovoltaic cell", 3.1.9b)

3.1.14 **conversion efficiency**

(Unit: dimensionless, usually expressed as a percentage, %)

ratio of electric power generated by a PV device per unit area to its incident irradiance as measured under standard test conditions, STC

NOTE See also "conditions/standard test conditions", 3.4.16e).

3.1.15 **crystalline silicon**

see "silicon/crystalline silicon", 3.1.58b).

3.1.16 **current**

For PV devices and related entries, see "photovoltaic/photovoltaic current", 3.1.43b)

NOTE There are many uses for the electrical term "current".

3.1.17 **Czochralski process**

see "ingot manufacturing process/Czochralski process", 3.1.32a)

3.1.18 **dark current**

(Unit: A)

electric current remaining in a PV device when its incident irradiance is zero

3.1.19 **device**

see "photovoltaic/photovoltaic device", 3.1.43c)

3.1.20 **diffusion layer**

portion of P-layer or N-layer prepared by a diffusion of dopants to form a PN junction

3.1.21 **directional solidification**

see "ingot manufacturing process/directional solidification", 3.1.32b)

3.1.22 **donor** (in photovoltaic cells)

dopant (such as phosphorus in the case of silicon material) that supplies an additional electron to an otherwise balanced material structure

3.1.23 **dopant** (in photovoltaic cells)

chemical added in small amounts to a semiconductor material to modify its electrical properties

NOTE 1 An N-dopant introduces more electrons than are required for the structure of the material (e.g., phosphorus for silicon material).

NOTE 2 A P-dopant creates electron vacancies in the material structure (e.g., boron for silicon material).

3.1.24 **dye-sensitized photovoltaic cell**

see "cell/dye-sensitized photovoltaic cell", 3.1.9d)

3.1.25 **effect**

see "photovoltaic/photovoltaic effect", 3.1.43d).

a) **back-surface field effect**

effect where the charge carriers generated near the back side of a PV cell are collected effectively by the inner electric field that is formed by a heavily doped zone near the rear electrode

b) **light-confinement effect**

effect where the short-circuit electric current is increased by trapping incident light inside a PV cell using textured surfaces and structures, etc.

3.1.26 **electromagnetic casting**

see "ingot manufacturing process/electromagnetic casting", 3.1.32c).

3.1.27 **energy gap**

(Unit: eV)

smallest energy difference between two neighbouring allowed bands separated by a forbidden band

[IEV 111-14-37]

NOTE See also "band gap energy", 3.1.5).

3.1.28 **float zone melting**

see "ingot manufacturing process/float zone melting", 3.1.32d)

3.1.29 **grid lines**

see "metallisation line/grid line", 3.1.37b)

3.1.30 **heterojunction**

see "junction/heterojunction", 3.1.34b)

3.1.31 **hot spot**

intense localised heating occurring in a PV module when its operating electric current exceeds the reduced short-circuit current of a shadowed or faulty PV cell or group of cells within it

NOTE When a hot spot occurs, the affected cell or group of cells is forced into reverse bias and must dissipate power, which can cause overheating. The voltage bias or damage creates a small, localized shunt path where a large portion of the PV module current appears.

3.1.32 **ingot manufacturing process**

process by which an ingot is manufactured

a) **Czochralski process**

method of growing a perfect large-size single crystal by slowly lifting, under careful cooling conditions, a rotating seed crystal from a counter-rotating molten silicon bath

NOTE 1 The Czochralski process produces a cylindrical-section silicon ingot, which can be cut into wafers that are usually round or pseudo-square.

b) **directional solidification**

method of making large-grain multicrystalline silicon ingots by controlling the cooling rate of molten silicon that has been placed in a square-section crucible

NOTE 2 Directional solidification produces a square-section silicon ingot that can be cut into wafers that are square or rectangular.

c) **electromagnetic casting**

method of making multicrystalline silicon ingots by which a continuously fed square-sectional open-bottom cold crucible of molten silicon is continuously pulled downward through an electromagnetic field

NOTE 3 Electromagnetic casting produces a square-section silicon ingot that can be cut into wafers that are square or rectangular.

d) **float zone melting**

method of growing and purifying high quality single crystal ingots

3.1.33 **integrated type photovoltaic cell**

see "cell/integrated type cell", 3.1.9e)

3.1.34 **junction** (of semiconductors)

transition layer between semiconducting regions of different electrical properties, or between a semiconductor and a layer of a different type, being characterized by a potential barrier impeding the movement of charge carriers from one region to the other

[IEV 521-02-72]

a) cell junction

junction between the P-type semiconductor and N-type semiconductor of a PV cell

NOTE 1 The PV cell junction lies within the cell barrier or depletion zone.

b) heterojunction

PN junction in which the two regions differ in their doping conductivities, and also in their atomic compositions

c) homojunction

PN junction in which the two regions differ in their doping conductivities, but not in their atomic compositions

d) Schottky barrier

junction between a metal and a semiconductor in which a transition region, formed at the surface of the semiconductor, acts as a rectifying barrier

[IEV 521-02-71]

e) PIN junction

junction consisting of an intrinsic semiconductor between a P-type semiconductor and an N-type semiconductor, intended to reduce the recombination of minority carriers

NOTE 2 A PIN junction is widely used in thin film amorphous silicon PV cells.

f) PN junction

junction between a P-type semiconductor and an N-type semiconductor

3.1.35 **light confinement effect**

see "effect/light-confinement effect", 3.1.25b)

3.1.36 **material**

see "photovoltaic/photovoltaic material", 3.1.43e)

3.1.37 **metallisation line**

metallic conductor on the front or back of a PV cell intended to conduct the electric current generated by the PV cell

NOTE 1 A metallisation line can be screen-printed, vapour-deposited or extruded (line-written).

The lines are of two types

a) bus bar (of photovoltaic cells)

metallisation line with a cross-section area greater than that of the grid lines, connected to grid lines and intended to carry their electric current to the wires or ribbons interconnecting the PV cell with other PV cells

NOTE 2 Interconnect wires are connected to the bus bars by soldering or welding.

b) grid line

metallisation line intended to collect electric current from the surface of the semiconductor of the PV cell

3.1.38 **microcrystalline silicon**

see "silicon/microcrystalline silicon", 3.1.58c).

3.1.39 **module**

see "photovoltaic/photovoltaic module", 3.1.43f).

3.1.40 **multicrystalline silicon**

see "silicon/multicrystalline silicon", 3.1.58d).

3.1.41 **multijunction photovoltaic cell**

see "cell/multijunction photovoltaic cell", 3.1.9f).

3.1.42 **organic photovoltaic cell**

see "cell, organic photovoltaic cell", 3.1.9g).

3.1.43 **photovoltaic, photovoltaics**

(Abbreviation: PV)

photovoltaic, adjective

photovoltaics, noun

relating to electrical phenomena caused by the photovoltaic effect

The following terms are commonly used in describing photovoltaic devices. The term "photovoltaic" is commonly referred to "PV". See also "photovoltaic", 3.2.21 and 3.3.56.

a) photovoltaic cell

most elementary photovoltaic device

NOTE 1 In solar PV energy system applications, another term for "photovoltaic cell" is "solar photovoltaic cell", colloquially referred to as a "solar cell".

b) photovoltaic current

(Unit: A)

DC electric current generated in a photovoltaic device

NOTE 2 See also "dark current", 3.1.18.

c) photovoltaic device

component that exhibits the photovoltaic effect

NOTE 3 Examples of a photovoltaic device includes a photovoltaic cell, module or array.

d) photovoltaic effect

production of DC voltage by the absorption of photons

NOTE 4 Currently the photovoltaic effect is known to be produced by specifically designed semiconductors. This results in the direct non-thermal conversion of radiant energy into electrical energy.

e) photovoltaic material

material that exhibits the photovoltaic effect

f) photovoltaic module

complete and environmentally protected assembly of interconnected photovoltaic cells