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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Photovoltaic system power conversion equipment – Design qualification and type approval

Matériel de conversion de puissance des systèmes photovoltaïques – Qualification de la conception et approbation de type

IEC 62093:2022-01(en-fr)

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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PHOTOVOLTAIC SYSTEM POWER CONVERSION EQUIPMENT – DESIGN QUALIFICATION AND TYPE APPROVAL

FOREWORD

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IEC 62093 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems. It is an International Standard.

This second edition cancels and replaces the first edition published in 2005. This edition constitutes a technical revision.

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

a) Title modified.
b) This edition focusses on the design qualification of power conversion electronics (PCE), and eliminates the clauses associated with qualification testing of other balance of system components.
c) While many clause titles remain the same as the first edition, substantial changes have been made.
d) Whereas the first edition establishes requirements for the design qualification of balance-of-system components used in terrestrial photovoltaic (PV) systems, this edition is limited to power conversion equipment.

e) The test protocols have been changed.

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

Draft	Report on voting
82/1963/FDIS	82/1983/RVD

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

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under 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.

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PHOTOVOLTAIC SYSTEM POWER CONVERSION EQUIPMENT – DESIGN QUALIFICATION AND TYPE APPROVAL

1 Scope

This document lays down IEC requirements for the design qualification of power conversion equipment (PCE) suitable for long-term operation in terrestrial photovoltaic (PV) systems.

This document covers electronic power conversion equipment intended for use in terrestrial PV applications. The term PCE refers to equipment and components for electronic power conversion of electric power into another kind of electric power with respect to voltage, current, and frequency. This document is suitable for PCE for use in both indoor and outdoor climates as defined in IEC 60721-3-3 and IEC 60721-3-4. Such equipment may include, but is not limited to, grid-tied and off-grid DC-to-AC PCEs, DC-to-DC converters, battery charger converters, and battery charge controllers.

This document covers PCE that is connected to PV arrays that do not nominally exceed a maximum circuit voltage of 1 500 V DC. The equipment may also be connected to systems not exceeding 1 000 V AC at the AC mains circuits, non-main AC load circuits, and to other DC source or load circuits such as batteries. If particular ancillary parts whereby manufacturers and models are specified in the manual for use with the PCE, then those parts are tested with the PCE.

Exceptions:

a) This document does not address characteristics of power sources other than PV systems, such as wind turbines, fuel cells, rotating machine sources, etc.

b) This document does not address the characteristics of power electronic conversion equipment fully integrated into photovoltaic modules. Separate standards exist or are in development for those types of devices. It is, however, applicable to devices where the manufacturer explicitly specifies the capability of full detachment from and subsequent reattachment to the PV module or if the input and output terminals can be accessed and a specification sheet for the PCE is available. Devices meeting these requirements may be tested as individual samples independent from the PV module.

c) This document does not apply to power conversion equipment with integrated (built-in) electrochemical energy storage (*e.g.* lead acid or lithium-ion). It is, however, applicable to equipment where the manufacturer specifies and permits complete removal of the electrochemical energy storage from the PCE so that stand-alone assessment of the PCE with the storage removed becomes possible.

The object of the test sequences contained herein is to establish a basic level of durability and to show, as far as it is possible within reasonable constraints of cost and time, that the PCE is capable of maintaining its performance after prolonged exposure to the simulated environmental stresses described herein that are based on the intended use conditions specified by the manufacturer. Optional tests contained herein may be selected depending on the intended installation, market, or special environmental conditions that the PCE is anticipated to experience. The categorization imposes differentiated test sequences and test severity levels reflecting the different requirements of mechanical and electrical components in different environments.

PCEs are grouped into categories based on size and installation environment.

The actual life expectancy of components so qualified depends on their design, their environment, and the conditions under which they are operated. Estimation of a lifetime and wear out is not generally covered by this document.

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 60068-2-2:2007, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

IEC 60068-2-6, *Environmental testing – Part 2-6: Tests – Test Fc: Vibration (sinusoidal)*

IEC 60068-2-14, *Environmental testing – Part 2-14: Tests – Test N: Change of temperature*

IEC 60068-2-27, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

IEC 60068-2-52, *Environmental testing – Part 2-52: Tests – Test Kb: Salt mist, cyclic (sodium, chloride solution)*

IEC 60068-2-60:2015, *Environmental testing – Part 2-60: Tests – Test Ke: Flowing mixed gas corrosion test*

IEC 60068-2-68, *Environmental testing – Part 2-68: Tests – Test L: Dust and sand*

IEC 60068-2-78, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC 60068-3-5:2018, *Environmental testing – Part 3-5: Supporting documentation and guidance – Confirmation of the performance of temperature chambers*

IEC 60068-3-6, *Environmental testing – Part 3-6: Supporting documentation and guidance – Confirmation of the performance of temperature/ humidity chambers*

IEC 60529:1989, *Degrees of protection provided by enclosures (IP Code)*
IEC 60529:1989/AMD1:1999
IEC 60529:1989/AMD2:2013

IEC 60721-3-3, *Classification of environmental conditions – Part 3-3: Classification of groups of environmental parameters and their severities – Stationary use at weather protected locations*

IEC 60721-3-4, *Classification of environmental conditions – Part 3-4: Classification of groups of environmental parameters and their severities – Stationary use at non-weather protected locations*

IEC 61000-3-2, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤16 A per phase)*

IEC 61000-3-12, *Electromagnetic compatibility (EMC) – Part 3-12: Limits – Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current >16 A and ≤75 A per phase*

IEC TR 61000-3-14, *Electromagnetic compatibility (EMC) – Part 3-14: Assessment of emission limits for harmonics, interharmonics, voltage fluctuations and unbalance for the connection of disturbing installations to LV power systems*

IEC 61180, *High-voltage test techniques for low-voltage equipment – Definitions, test and procedure requirements, test equipment*

IEC 61557-1, *Electrical safety in low voltage distribution systems up to 1 000 V AC and 1 500 V DC – Equipment for testing, measuring or monitoring of protective measures – Part 1: General requirements*

IEC TS 61836, *Solar photovoltaic energy systems – Terms, definitions and symbols*

IEC 62109-1:2010, *Safety of power converters for use in photovoltaic power systems – Part 1: General requirements*

IEC 62116:2014, *Utility-interconnected photovoltaic inverters – Test procedure of islanding prevention measures*

IEC 62477-1:2012, *Safety requirements for power electronic converter systems and equipment – Part 1: General*
IEC 62477-1:2012/AMD1:2016

IEC 62716:2013, *Photovoltaic (PV) modules – Ammonia corrosion testing*

IEC 62852, *Connectors for DC-application in photovoltaic systems – Safety requirements and tests*

IEC 62894:2014, *Photovoltaic inverters – Data sheet and name plate*
IEC 62894:2014/AMD1:2016

IEC TS 63106-2, *Basic requirements for simulator used for testing of photovoltaic power conversion equipment – Part 2: DC power simulator*

ISO 4892-2, *Plastics – Methods of exposure to laboratory light sources – Part 2: Xenon-arc lamps*

ISO 12103-1:2016, *Road vehicles – Test contaminants for filter evaluation – Part 1: Arizona test dust*

ISO 22479:2019, *Corrosion of metals and alloys – Sulfur dioxide test in a humid atmosphere (fixed gas method)*

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 platform: available at http://www.iso.org/obp

NOTE Symbols and variable names for PCE input and output values follow the terminology of IEC 62894.

3.1
power conversion equipment
PCE
electrical device converting one kind of electrical power from a voltage or current source into another kind of electrical power with respect to voltage, current and frequency

Note 1 to entry: Examples include AC-DC converters, DC-AC inverters, DC-DC charge controllers, frequency converters, etc.

3.2
module-level power electronics: Category 1 PCE
MLPE
referring to PCE that is specified by the manufacturer to operate on a PV module basis, interfacing with up to four individual PV modules

3.3
string-level power electronics: Category 2 PCE
category comprising PCE that is designed to interface more than four series- and/or parallel-connected PV modules and not meeting the conversion power of the Category 3 PCE or Category 4 PCE definition

3.4
large-scale power electronics: Category 3 PCE
category comprising PCE predominantly in a single unit capable of power conversion equal to or greater than 100 kVA and less than 1 000 kVA

Note 1 to entry: This class of PCE may have multiple power conversion units built into the larger containing unit.

3.5
central large-scale power electronics: Category 4 PCE
category comprising PCE predominantly in a single enclosure capable of power conversion equal to or greater than 1 000 kVA

Note 1 to entry: This class of PCE may have multiple power conversion units built into the larger containing unit.

3.6
derating temperature
ambient temperature limit at which the PCE starts to actively curtail its input and output power to maintain a certain maximum operating temperature

Note 1 to entry: This temperature may also depend on input power and other electrical parameters, and thus may not be unique.

3.7
electrically independent inputs
ports for input of power to the PCE that are not ohmically connected to one another internally but serve to supply power to the PCE at different operating points of current and voltage at the same time provided by, for example, a boost converter stage in the PCE for each such electrically independent input

3.8
enclosure
part of the equipment which surrounds internal parts, intended to provide protection against external influences, against the spread of fire, or against access to hazards

Note 1 to entry: Enclosures may be free standing, wall, rack, ceiling, frame or skid mounted.

3.9
maximum total PV array short circuit current
$I_{\text{sc max}}$
absolute maximum total PV array short circuit current (DC) that the PCE is rated to have connected to its PV input, under most severe-case conditions of ambient temperature, irradiance, etc.

Note 1 to entry: This rating of the PCE refers to the absolute maximum current the PV input to the PCE is designed for under conditions of expected use. This differs from the simple sum of the marked I_{sc} ratings of the connected PV modules, since those markings are based on short-circuit conditions under standard test conditions, and may be exceeded at high temperatures or with irradiance above the standard level.

3.10
rated
value assigned, generally by a manufacturer, to a specified operating condition of a component, device or equipment

3.11
rated input voltage
$V_{dc,r}$
rated input voltage specified by the manufacturer, or if not specified, the midpoint of the maximum power point (MPP) input voltage range of the PCE

3.12
rated power
P_r
maximum active power the PCE can deliver in continuous operation

3.13
maximum power point voltage
maximum MPP voltage
$V_{mpp\ max}$
maximum voltage at the DC input port at which the inverter can deliver its rated power continuously without power curtailing

3.14
minimum MPP voltage
$V_{mpp\ min}$
minimum voltage at the DC input port at which the inverter can deliver its rated power continuously

3.15
port
location giving access to a device or network where electromagnetic energy or signals may be supplied or received or where the device or network variables may be observed or measured

3.16
photovoltaic array
PV array
assembly of electrically interconnected PV modules, PV strings or PV sub-arrays

Note 1 to entry: For the purposes of this document a PV array is all components up to the DC input terminals of the inverter or other power conversion equipment or DC loads.

Note 2 to entry: A PV array does not include its foundation, tracking apparatus, thermal control, and other such components.

Note 3 to entry: A PV array may consist of a single PV module, a single PV string, or several parallel-connected strings, or several parallel-connected PV sub-arrays and their associated electrical components. For the purposes of this document the boundary of a PV array is the output side of the PV array disconnecting device.

3.17
printed circuit board
PCB
electronic circuit consisting of thin strips of a conducting material such as copper, which have been etched from a layer fixed to a flat insulating sheet; integrated circuits and other components are attached

3.18
terminal
component provided for the connection of a device (equipment) to external conductors

3.19
capacitor temperature
T_C
measured capacitor temperature on its surface

3.20
maximum capacitor temperature
T_{C2}
highest measured capacitor temperature, T_C

3.21
ambient setpoint for maximum capacitor temperature
$T_{amb,set\ C}$
ambient temperature of the test environment (as in the climatic chamber) at which the measured peak capacitor temperature T_{C2} is obtained

3.22
power transistor case or reference temperature
T_I
measured power transistor case or reference temperature

3.23
maximum power transistor case or reference temperature
T_{I2}
highest measured power transistor case or reference temperature

3.24
ambient setpoint for maximum power transistor case or reference temperature
$T_{amb,set\ I}$
ambient temperature of the test environment (as in a climatic chamber) at which the measured highest power transistor case or reference temperature T_{I2} is obtained

4 Sampling

For the test procedure described in Clause 6, a number of test samples according to Table 1 shall be taken at random from a production batch or batches. The PCE samples shall have been manufactured from specified materials and components in accordance with the relevant drawings and process sheets and shall have been subjected to the manufacturer's normal inspection, quality control, and production acceptance procedures. The samples shall be complete in every detail and shall be accompanied by the manufacturer's product specifications, handling, mounting, and connection instructions. When the PCE to be tested are prototypes of a new design and not from production, this fact shall be noted in the test report (Clause 8).

If a Category 3 PCE or Category 4 PCE consists of identical parallel power converters within an enclosure, it is permitted to operate only one of those converters as a sample for testing in order to reduce the cooling requirements of the climate chamber. In such a case, any active cooling capability of the PCE common to the whole enclosure shall be proportionally reduced. For example, if there are three converters and only one is powered in the test, then fans common to all three units shall be blocked in area by two-thirds or powered intermittently only one-third of the time. Applied electrical power to the inputs of the main unit shall also be scaled to one-third.

Testing of PCE in Category 3 PCE and 4 PCE may involve the use of the same sample for the various test sequence if desired, therefore a range of sample count is given. Samples specified in Table 1 may be reused any number of times for optional tests described in Clause 7.