

INTERNATIONAL STANDARD

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Photovoltaic (PV) arrays – Design requirements

Groupes photovoltaïques (PV) – Exigences de conception

[IEC 62548:2016](#)

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CONTENTS

FOREWORD.....	5
1 Scope and object.....	7
2 Normative references.....	7
3 Terms, definitions, symbols and abbreviated terms.....	9
3.1 Terms, definitions and symbols.....	9
3.2 Abbreviations.....	16
4 Compliance with IEC 60364 (all parts).....	16
5 PV array system configuration.....	16
5.1 General.....	16
5.1.1 Functional configuration of a PV system.....	16
5.1.2 PV system architectures.....	17
5.1.3 Array electrical diagrams.....	17
5.1.4 Use of PCE with multiple DC inputs.....	22
5.1.5 Strings constructed using DC conditioning units.....	23
5.1.6 Series-parallel configuration.....	24
5.1.7 Batteries in systems.....	25
5.1.8 Considerations due to prospective fault conditions within a PV array.....	25
5.1.9 Considerations due to operating temperature.....	25
5.1.10 Performance issues.....	26
5.2 Mechanical design.....	26
5.2.1 General.....	26
5.2.2 Thermal aspects.....	27
5.2.3 Mechanical loads on PV structures.....	27
5.2.4 Corrosion.....	27
6 Safety issues.....	28
6.1 General.....	28
6.1.1 Overview.....	28
6.1.2 Separation of PV array from main AC power output circuits.....	28
6.2 Protection against electric shock.....	29
6.2.1 General.....	29
6.2.2 Protective measure: double or reinforced insulation.....	29
6.2.3 Protective measure: extra-low-voltage provided by SELV or PELV.....	29
6.3 Protection against thermal effects.....	29
6.4 Protection against the effects of insulation faults.....	29
6.4.1 General.....	29
6.4.2 Detection and fault indication requirements.....	30
6.5 Protection against overcurrent.....	34
6.5.1 General.....	34
6.5.2 Requirement for overcurrent protection.....	34
6.5.3 Requirement for string overcurrent protection.....	34
6.5.4 Requirement for sub-array overcurrent protection.....	35
6.5.5 Overcurrent protection sizing.....	35
6.5.6 Overcurrent protection in PV systems connected to batteries.....	37
6.5.7 Overcurrent protection location.....	37
6.6 Protection against effects of lightning and overvoltage.....	38
6.6.1 General.....	38

6.6.2	Protection against overvoltage	38
7	Selection and erection of electrical equipment.....	39
7.1	General.....	39
7.2	PV array maximum voltage.....	40
7.3	Component requirements	40
7.3.1	General	40
7.3.2	PV modules	41
7.3.3	PV array and PV string combiner boxes.....	41
7.3.4	Circuit breakers	42
7.3.5	Fuses	42
7.3.6	Disconnectors and switch-disconnectors.....	42
7.3.7	Cables	43
7.3.8	Segregation of AC and DC circuits	46
7.3.9	Plugs, sockets and connectors	46
7.3.10	Wiring in combiner boxes	47
7.3.11	Bypass diodes	47
7.3.12	Blocking diodes.....	47
7.3.13	Power conversion equipment (PCE) including DC conditioning units (DCUs)	47
7.4	Location and installation requirements.....	48
7.4.1	Disconnecting means.....	48
7.4.2	Earthing and bonding arrangements.....	49
7.4.3	Wiring system	54
8	Acceptance	56
9	Operation/maintenance.....	56
10	Marking and documentation	56
10.1	Equipment marking	56
10.2	Requirements for signs.....	56
10.3	Identification of a PV installation.....	57
10.4	Labelling of PV array and PV string combiner boxes	57
10.5	Labelling of disconnection devices.....	57
10.5.1	General	57
10.5.2	PV array disconnecting device.....	57
10.6	Documentation.....	57
Annex A (informative)	Examples of signs.....	58
Annex B (informative)	Examples of system functional earthing configurations in PV arrays.....	59
Annex C (informative)	Blocking diode	61
C.1	Introduction.....	61
C.2	Use of blocking diodes to prevent overcurrent/fault current in arrays	61
C.3	Examples of blocking diode use in fault situations.....	61
C.3.1	General	61
C.3.2	Short circuit in PV string.....	61
C.4	Specification of blocking diode	63
C.5	Heat dissipation design for blocking diode	63
Annex D (informative)	Arc fault detection and interruption in PV arrays	65
Annex E (normative)	DVC limits	66
Bibliography	67

Figure 1 – General functional configuration of a PV powered system.....	17
Figure 2 – PV array diagram – single string example	18
Figure 3 – PV array diagram – multiple parallel string example	19
Figure 4 – PV array diagram – multiple parallel string example with array divided into sub-arrays	20
Figure 5 – PV array example using a PCE with multiple MPPT DC inputs	21
Figure 6 – PV array example using a PCE with multiple DC inputs internally connected to a common DC bus	22
Figure 7 – PV string constructed using DC conditioning units.....	24
Figure 8 – Example of a PV array diagram where strings are grouped under one overcurrent protection device per group	36
Figure 9 – Examples of reinforced protection of wiring	45
Figure 10 – PV array exposed conductive parts functional earthing/bonding decision tree ...	51
Figure 11 – Exposed conductive parts earthing in a PV array.....	52
Figure 12 – Examples of PV string wiring with minimum loop area	55
Figure A.1 – Example of sign required on PV array combiner boxes (10.4).....	58
Figure A.2 – Example of switchboard sign for identification of PV on a building	58
Figure B.1 – System functional earthing/grounding	59
Figure B.2 – Examples different PV configurations in common use.....	60
Figure C.1 – Effect of blocking diode where there is a short circuit in PV string	62
Figure C.2 – Effect of blocking diode where there is an earth fault on a system with earthing on the minus side	62
Figure C.3 – Effect of blocking diode where there is an earth fault on a system with positive side earthing	63
Figure D.1 – Examples of types of arcs in PV arrays.....	65
Table 1 – Requirements for different system types based on PCE isolation and PV array functional earthing	31
Table 2 – Minimum insulation resistance thresholds for detection of failure of insulation to earth	32
Table 3 – Rated current of automatic earth fault interrupting means	33
Table 4 – Voltage correction factors for crystalline and multi-crystalline silicon PV modules	40
Table 5 – Minimum current rating of circuits	44
Table 6 – Disconnection device requirements in PV array installations	49
Table E.1 – Summary of the limits of the decisive voltage classes.....	66

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**PHOTOVOLTAIC (PV) ARRAYS –
DESIGN REQUIREMENTS**

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International Standard IEC 62548 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

This International Standard cancels and replaces the first edition of IEC TS 62548 published in 2013.

This International Standard includes the following significant technical changes with respect to IEC TS 62548:

- a) provisions for systems including DC to DC conditioning units;
- b) considerable revision of Clause 6 on safety issues which includes provisions for protection against electric shock including array insulation monitoring and earth fault detection.

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

FDIS	Report on voting
82/1149/FDIS	82/1166/RVD

Full information on the voting for the approval of this document 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.

Attention is drawn to the co-existence of IEC 60364-7-712 and IEC 62548. Both standards have been developed in close coordination by different technical committees.

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

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PHOTOVOLTAIC (PV) ARRAYS – DESIGN REQUIREMENTS

1 Scope and object

This International Standard sets out design requirements for photovoltaic (PV) arrays including DC array wiring, electrical protection devices, switching and earthing provisions. The scope includes all parts of the PV array up to but not including energy storage devices, power conversion equipment or loads. An exception is that provisions relating to power conversion equipment are covered only where DC safety issues are involved. The interconnection of small DC conditioning units intended for connection to PV modules are also included.

The object of this document is to address the design safety requirements arising from the particular characteristics of photovoltaic systems. Direct current systems, and PV arrays in particular, pose some hazards in addition to those derived from conventional AC power systems, including the ability to produce and sustain electrical arcs with currents that are not greater than normal operating currents.

In grid connected systems, the safety requirements of this document are however critically dependent on the inverters associated with PV arrays complying with the requirements of IEC 62109-1 and IEC 62109-2.

Installation requirements are also critically dependent on compliance with the IEC 60364 series (see Clause 4).

PV arrays of less than 100 W and less than 35 V DC open circuit voltage at STC are not covered by this document.

PV arrays in grid connected systems connected to medium or high voltage systems are not covered in this document. Variations and additional requirements for large-scale ground mounted PV power plants with restricted access to personnel will also be addressed in IEC TS 62738¹.

Additional requirements may be needed for more specialized installations, for example concentrating systems, tracking systems or building integrated PV.

The present international standard also includes extra protection requirements of PV arrays when they are directly connected with batteries at the DC level.

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 60228, *Conductors of insulated cables*

IEC 60269-6, *Low-voltage fuses – Part 6: Supplementary requirements for fuse-links for the protection of solar photovoltaic energy systems*

¹ Under preparation. Stage at the time of publication: IEC 2CD 62738.

IEC 60287 (all parts), *Electric cables – Calculation of the current rating*

IEC 60364-1, *Low-voltage electrical installations – Part 1: Fundamental principles, assessment of general characteristics, definitions*

IEC 60364-4 (all parts), *Low-voltage electrical installations – Part 4: Protection for safety*

IEC 60364-4-41:2005, *Low-voltage electrical installations – Part 4-41: Protection for safety – Protection against electric shock*

IEC 60364-5 (all parts), *Electrical installations of buildings – Part 5: Selection and erection of electrical equipment*

IEC 60364-5-52, *Low-voltage electrical installations – Part 5-52: Selection and erection of electrical equipment – Wiring systems*

IEC 60364-5-54, *Low-voltage electrical installations – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements and protective conductors*

IEC 60364-6, *Low-voltage electrical installations – Part 6: Verification*

IEC 60445:2010, *Basic and safety principles for man-machine interface, marking and identification – Identification of equipment terminals, conductor terminations and conductors*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 60898-2, *Circuit-breakers for overcurrent protection for household and similar installations – Part 2: Circuit-breakers for a.c. and d.c. operation*

IEC 60947 (all parts), *Low-voltage switchgear and controlgear*

IEC 60947-1, *Low-voltage switchgear and controlgear – Part 1: General rules*

IEC 60947-2, *Low-voltage switchgear and controlgear – Part 2: Circuit-breakers*

IEC 60947-3, *Low-voltage switchgear and controlgear – Part 3: Switches, disconnectors, switch-disconnectors and fuse-combination units*

IEC 61215 (all parts), *Terrestrial photovoltaic (PV) modules – Design qualification and type approval*

IEC 61557-2, *Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. – Equipment for testing, measuring or monitoring of protective measures – Part 2: Insulation resistance*

IEC 61557-8, *Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. – Equipment for testing, measuring or monitoring of protective measures – Part 8: Insulation monitoring devices for IT systems*

IEC 61643-21, *Low-voltage surge protective devices – Part 21: Surge protective devices connected to telecommunications and signalling networks – Performance requirements and testing methods*

IEC 61643-22, *Low-voltage surge protective devices – Part 22: Surge protective devices connected to telecommunications and signalling networks – Selection and application principles*

IEC 61730-1, *Photovoltaic (PV) module safety qualification – Part 1: Requirements for construction*

IEC 61730-2, *Photovoltaic (PV) module safety qualification – Part 2: Requirements for testing*

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

IEC 62109-2, *Safety of power converters for use in photovoltaic power systems – Part 2: Particular requirements for inverters*

IEC 62305-2, *Protection against lightning – Part 2: Risk management*

IEC 62305-3, *Protection against lightning – Part 3: Physical damage to structures and life hazard*

IEC 62446-1, *Photovoltaic (PV) systems – Requirements for testing, documentation and maintenance – Part 1: Grid connected systems – Documentation, commissioning tests and inspection*

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

IEC 62930, *Electric cables for photovoltaic systems*

EN 50539-11, *Low-voltage surge protective devices – Surge protective devices for specific application including DC – Part 11: Requirements and tests for SPDs in photovoltaic applications*

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3 Terms, definitions, symbols and abbreviated terms

3.1 Terms, definitions and symbols

For the purposes of this document, the following terms and definitions 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 browsing platform: available at <http://www.iso.org/obp>

3.1.1

blocking diode

diode connected in series with module(s), panel(s), sub-arrays and array(s) to block reverse current into such module(s), panel(s), sub-array(s) and array(s)

3.1.2

bonding conductor

conductor provided for functional or protective equipotential bonding

3.1.3

bypass diode

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

**3.1.4
cable**

assembly of one or more conductors and/or optical fibers, with a protective covering and possibly filling, insulating and protective material

[SOURCE: IEC 60050-151:2001, 151-12-38]

**3.1.5
charge controller**

unit used between a battery and a PV array to regulate charge delivered to the battery

**3.1.6
closed electrical operating area**

room or location for electrical equipment to which access is restricted to skilled or instructed persons by the opening of a door or the removal of a barrier by the use of a key or tool and which is clearly marked by appropriate warning signs

**3.1.7
competent person**

person, who has acquired, through training, qualification or experience or a combination of these, the knowledge and skill enabling that person to perform the required task correctly

**3.1.8
DC conditioning units
DCU**

unit connected to individual PV modules or groups of PV modules to allow DC conditioning of the PV output

**3.1.9
decisive voltage classification
DVC**

highest voltage which occurs continuously between any two arbitrary live parts or between live parts and earth of the PV array during worst-case rated operating conditions when used as intended

Note 1 to entry: See decisive voltage class limits in Annex E.1.

[SOURCE: IEC 62109-1:2010, 3.12 modified — The word "classification" has been added to the term, a note has been added, and the definition has been modified to make applicable to PV array application.]

**3.1.10
disconnecter**

mechanical switching device which provides, in the open position, an isolating distance in accordance with specified requirements

Note 1 to entry: A disconnecter is capable of opening and closing a circuit when either negligible current is broken or made, or when no significant change in the voltage across the terminals of each of the poles of the disconnecter occurs. It is also capable of carrying currents under normal circuit conditions and carrying currents for a specified time under abnormal conditions such as those of short circuit.

[SOURCE: IEC 60050-441:2000, 441-14-05]

**3.1.11
double insulation**

insulation comprising both basic insulation and supplementary insulation

[SOURCE: IEC 60050-195:1998, 195-06-08]

3.1.12**extraneous conductive part**

conductive part not forming part of the electrical installation and liable to introduce an electric potential, generally the electric potential of a local earth

[SOURCE: IEC 60050-851:2008, 851-14-57, modified — The note has been deleted.]

3.1.13**functionally earthed PV array**

PV array that has one conductor intentionally connected to earth for purposes other than safety

Note 1 to entry: Such a system is not considered to be an earthed array.

Note 2 to entry: Examples of functional array earthing include earthing one conductor through an impedance, or only temporarily earthing the array for functional or performance reasons.

Note 3 to entry: In PCE intended for an array not connected to a functional earth that uses a resistive measurement network to measure the array impedance to earth, that measurement network is not considered a form of functional earth.

3.1.14**independent manual operation****independent manual operation of a mechanical switching device**

stored energy operation where the energy originates from manual power, stored and released in one continuous operation (e.g. spring release), such that the speed and force of the operation are independent of the action of the operator

[SOURCE: IEC 60050-441:2000, 441-16-16, modified — The brackets have been added to the definition.]

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3.1.15**irradiance****G**

electromagnetic radiated solar power per unit of area

Note 1 to entry: Expressed in W/m^2 .

[SOURCE: IEC TS 61836:2007, 3.6.25, modified — The adjective "solar" has been added to the definition, and the note has been replaced.]

3.1.16 $I_{MOD_MAX_OCPR}$

PV module maximum overcurrent protection rating determined by IEC 61730-2

Note 1 to entry: This is often specified by module manufacturers as the maximum series fuse rating which refers to the fuse rated current in IEC 60269-1 and IEC 60269-6.

3.1.17 I_n

nominal rated current

3.1.18 $I_{SC\ ARRAY}$

short-circuit current of the PV array at standard test conditions (STC), and is equal to

$$I_{SC\ ARRAY} = I_{SC\ MOD} \times N_S$$

where

N_S is the total number of parallel-connected PV strings in the PV array

3.1.19 $I_{SC\ MOD}$

short circuit current of a PV module or PV string at standard test conditions (STC), as specified by the manufacturer in the product specification plate

Note 1 to entry: As PV strings are a group of PV modules connected in series, the short circuit current of a string is equal to $I_{SC\ MOD}$.

3.1.20 $I_{SC\ S-ARRAY}$

short circuit current of a PV sub-array at standard test conditions (STC), and equal to

$$I_{SC\ S-ARRAY} = I_{SC\ MOD} \times N_{SA}$$

where

N_{SA} is the number of parallel-connected PV strings in the PV sub-array

3.1.21**separated PCE**

PCE with at least simple separation between the AC output circuits and PV circuits

Note 1 to entry: The separation may be either integral to the PCE or provided externally by a transformer with at least simple separation.

3.1.22**junction box**

closed or protected enclosure in which circuits are electrically connected

[SOURCE: IEC TS 61836: 2007, 3.2.16]

3.1.23**live part**

conductor or conductive part intended to be energized in normal operation, including a neutral conductor, but by convention not a PEN conductor or PEM conductor or PEL conductor

Note 1 to entry: This concept does not necessarily imply a risk of electric shock.

[SOURCE: IEC 60050-195:1998, 195-02-19]

3.1.24**low voltage**

voltage exceeding DVC-A, but not exceeding 1 000 V AC or 1 500 V DC

3.1.25**main earthing terminal**

terminal or bar provided for the connection of the main protective earthing conductor, bonding conductors and, if provided, the conductor for functional earthing

3.1.26**maximum power point tracking****MPPT**

control strategy whereby PV array operation is always at or near the point on a PV device's current-voltage characteristic where the product of electric current and voltage yields the maximum electrical power under specified operating conditions

3.1.27**non-separated PCE**

PCE without at least simple separation between the AC output and PV circuits

3.1.28**PEL conductor**

conductor combining the functions of both a protective earthing conductor and a line conductor

[SOURCE: IEC 60050-195:1998, 195-02-14]

3.1.29**PEM conductor**

conductor combining the functions of both a protective earthing conductor and a mid-point conductor

[SOURCE: IEC 60050-195:1998, 195-02-13]

3.1.30**PEN conductor**

conductor combining the functions of both a protective earthing conductor and a neutral conductor

[SOURCE: IEC 60050-195:1998, 195-02-12]

3.1.31**power conversion equipment****PCE**

system that converts the electrical power delivered by the PV array into the appropriate frequency and/or voltage values to be delivered to the load, or stored in a battery or injected into the electricity grid

Note 1 to entry: See Figure 2 to Figure 4.

[IEC 62548:2016](#)

<https://standards.iteh.ai/catalog/standards/sist/157457f7-d655-4b5a-886d-78f0bf02ee55/iec-62548-2016>

3.1.32**protective earthing**

earthing of a point in an equipment or in a system for safety reasons

3.1.33**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 (see Figure 2 to Figure 4). For the purposes of this document the boundary of a PV array is the output side of the PV array disconnecting device.

3.1.34**PV array main cable**

output cable of a PV array that carries the total output current of the array

3.1.35**PV cell**

most elementary device that exhibits the photovoltaic effect, i.e the direct non-thermal conversion of radiant energy into electrical energy

Note 1 to entry: The preferred term is "solar photovoltaic cell" or "photovoltaic cell", colloquially referred to as a "solar cell".