



IEC 60364-7-712

Edition 2.0 2017-04

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**Low voltage electrical installations –
Part 7-712: Requirements for special installations or locations – Solar
photovoltaic (PV) power supply systems**

**Installations électriques basse tension –
Partie 7-712: Exigences applicables aux installations ou emplacements
spéciaux – Installations d'énergie solaire photovoltaïque (PV)**



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CONTENTS

FOREWORD	5
INTRODUCTION	7
712 Solar photovoltaic (PV) power supply installations	8
712.1 Scope	8
712.2 Normative references	9
712.3 Terms and definitions	10
712.31 Purposes, supplies and structure	15
712.4 Protection for safety	22
712.41 Protection against electric shock	22
712.410 Introduction	22
712.412 Protective measure: double or reinforced insulation	23
712.414 Protective measure: extra-low-voltage provided by SELV and PELV	23
712.42 Protection against thermal effects	23
712.421 Protection against fire caused by electrical equipment	23
712.43 Protection against overcurrent	24
712.432 Nature of protective devices	25
712.433 Protection against overload current	25
712.434 Protection against short-circuit currents	29
712.44 Protection against voltage disturbances and electromagnetic disturbances	29
712.443 Protection against transient overvoltages of atmospheric origin or due to switching	29
712.444 Measures against electromagnetic influences	30
712.5 Selection and erection of electrical equipment	30
712.51 Common rules	30
712.511 Compliance with standards	31
712.512 Operational conditions and external influences	31
712.513 Accessibility	32
712.514 Identification	32
712.515 Prevention of mutual detrimental influence	34
712.52 Wiring systems	35
712.521 Types of wiring systems	35
712.522 Selection and erection of wiring systems in relation to external influences	37
712.523 Current-carrying capacities	38
712.524 Cross-sectional areas of conductors	38
712.525 Voltage drop in consumers installations	39
712.526 Electrical connections	40
712.527 Selection and erection of wiring systems to minimize spread of fire	41
712.528 Proximity of wiring systems to other services	41
712.529 Selection and erection of wiring systems in relation to maintainability, including cleaning	41
712.53 Isolation, switching and control	41
712.531 Devices for protection against indirect contact (fault protection) by automatic disconnection of supply	41
712.532 Devices for protection against thermal effects	44
712.533 Devices for protection against overcurrent	45

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712.534	Devices for protection against transient overvoltages	46
712.536	Isolation and switching	48
712.54	Earthing arrangements and protective conductors	49
712.542	Earthing arrangements	49
712.55	Other equipment	50
712.6	Inspection and testing	50
Annex A (informative)	PV installation information	51
Annex B (normative)	Calculation of $U_{OC\ MAX}$ and $I_{SC\ MAX}$	54
Annex C (informative)	Examples of signs	56
Annex D (informative)	Blocking diode	57
Annex E (informative)	Arc fault detection and interruption in PV arrays	61
Annex F (informative)	List of notes concerning certain countries	62
Bibliography	63
Figure 712.1	General functional configuration of a PV installation	15
Figure 712.2	PV array diagram – single string case	16
Figure 712.3	PV array diagram – multiple parallel string case	17
Figure 712.4	PV array diagram – multiple parallel string case with array divided into subarrays	18
Figure 712.5	PV array using a PCE with multiple MPPT DC inputs	19
Figure 712.6	PV array using a PCE with multiple DC inputs internally connected to a common DC bus	20
Figure 712.7	Example of a PV array diagram where strings are grouped under one overload protective device per group	27
Figure 712.8	Example of an indication showing the presence of a photovoltaic installation on a building	33
Figure 712.9	Examples of cables with reinforced protection	36
Figure 712.10	PV string wiring with minimum loop area	37
Figure A.712.1	Single string PV array	51
Figure A.712.2	Parallel connected multi-string PV array	52
Figure A.712.3	Unearthed PV array connected to the AC side via a PCE with transformer	53
Figure A.712.4	Unearthed PV array connected to the AC side via a PCE without a transformer	53
Figure A.721.5	Earthed PV array connected to the AC side via a PCE with transformer	53
Figure A.712.6	Earthed PV array connected to the AC side via a PCE without a transformer, the transformer being separate	53
Figure C.712.1	Example of sign required on PV array combiner boxes (712.514.102)	56
Figure C.712.2	Example of switchboard sign for identification of PV on a building	56
Figure D.712.1	Effect of blocking diode at short circuit in PV string	58
Figure D.712.2	Effect of blocking diode where there is an insulation fault on a PV installation with earthing on the DC negative side	58
Figure D.712.3	Effect of blocking diode where there is a fault on a PV installation with earthing on the DC positive side	59
Figure E.712.1	Examples of types of arcs in PV arrays	61

Table 712.1 – Calculation of the critical length L_{crit}	30
Table 712.2 – Minimum current rating of circuits	39
Table 712.3 – Requirements for different system types based on PCE isolation and PV array functional earthing	42
Table 712.4 – Minimum insulation resistance thresholds for detection of failure of insulation to earth	43
Table 712.5 – Response time limits for sudden changes in residual current	44
Table 712.6 – Rated current of automatic disconnecting device in the functional earthing conductor	45
Table 712.7 – Impulse withstand voltage U_W where no information is available	47
Table 712.8 – Disconnection device requirements in PV array installations	48
Table A.712.1 – PV DC configurations	52

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International Standard IEC 60364-7-712 has been prepared by IEC technical committee 64: Electrical installations and protection against electric shock.

This second edition cancels and replaces the first edition, published in 2002. This edition constitutes a technical revision.

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

- a) The technical content has been extensively revised and expanded, taking into account experience gained in the construction and operation of PV installations, and developments made in technology, since the first edition of this standard was published.

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

FDIS	Report on voting
64/2154/FDIS	64/2163/RVD

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

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

A list of all parts in the IEC 60364 series, published under the general title *Low voltage electrical installations*, can be found on the IEC website.

The reader's attention is drawn to the fact that Annex F lists all of the “in-some-country” clauses on differing practices of a less permanent nature relating to the subject of this standard.

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INTRODUCTION

For the purpose of this part of IEC 60364 (IEC 60364-7-712), the requirements of the general parts 1 to 6 of IEC 60364 apply.

The IEC 60364-7-7XX parts of IEC 60364 contain particular requirements for special installations or locations which are based on the requirements of the general parts of IEC 60364 (IEC 60364-1 to IEC 60364-6). These IEC 60364-7-7XX parts are considered in conjunction with the requirements of the general parts.

The particular requirements of this part of IEC 60364 supplement, modify or replace certain of the requirements of the general parts of IEC 60364 being valid at the time of publication of this part. The absence of reference to the exclusion of a part or a clause of a general part means that the corresponding clauses of the general part are applicable (undated reference).

Requirements of other 7XX parts being relevant for installations covered by this part also apply. This part may therefore also supplement, modify or replace certain of these requirements valid at the time of publication of this part.

The clause numbering of this part follows the pattern and corresponding references of IEC 60364. The numbers following the particular number of this part are those of the corresponding parts, or clauses of the other parts of the IEC 60364 series, valid at the time of publication of this part, as indicated in the normative references of this document (dated reference). If requirements or explanations additional to those of the other parts of the IEC 60364 series are needed, the numbering of such items appears as 712.101, 712.102, 712.103, etc.

Numbering of figures and tables takes the number of this part followed by a sequential number. For annexes, the numbering of figures and tables takes the letter of the annex, the number of the part and a sequential number.

In the case where new or amended general parts with modified numbering were published after this part was issued, the clause numbers referring to a general part in this 712 part may no longer align with the latest edition of the general part. Dated references should be observed.

LOW VOLTAGE ELECTRICAL INSTALLATIONS –

Part 7-712: Requirements for special installations or locations – Solar photovoltaic (PV) power supply systems

712 Solar photovoltaic (PV) power supply installations

NOTE The abbreviation “PV” is used for “Photovoltaic”. Photovoltaic installations are, hereafter, known as PV installations.

712.1 Scope

This part of IEC 60364 applies to the electrical installation of PV systems intended to supply all or part of an installation.

The equipment of a PV installation, like any other item of equipment, is dealt with only so far as its selection and application in the installation is concerned.

A PV installation starts from a PV module or a set of PV modules connected in series with their cables, provided by the PV module manufacturer, up to the user installation or the utility supply point (point of common coupling).

Requirements of this document apply to

- PV installations not connected to a system for distribution of electricity to the public,
- PV installations in parallel with a system for distribution of electricity to the public,
- PV installations as an alternative to a system for distribution of electricity to the public,
- appropriate combinations of the above.

This document does not cover the specific installation requirements for batteries or other energy storage methods.

NOTE 1 Additional requirements for PV installations with battery storage capabilities on the DC side are under consideration.

NOTE 2 This document does cover the protection requirements of PV arrays which develop as a result of the use of batteries in PV installations.

For systems using DC-DC converters, additional requirements regarding voltage and current rating, switching, and protective devices can apply. These requirements are under consideration.

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

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

712.2 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*

IEC 60332-1-2, *Tests on electric and optical fibre cables under fire conditions – Part 1-2: Test for vertical flame propagation for a single insulated wire or cable – Procedure for 1 kW pre-mixed flame*

IEC 60364 (all parts), *Low-voltage electrical installations*

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

IEC 60364-4-43, *Low-voltage electrical installations – Part 4-43: Protection for safety – Protection against overcurrent*

IEC 60364-4-44, *Low-voltage electrical installations – Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances*

IEC 60670 (all parts), *Boxes and enclosures for electrical accessories for household and similar fixed electrical installations*

IEC 60898 (all parts), *Electrical accessories – Circuit-breakers for overcurrent protection for household and similar installations*

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 61140, *Protection against electric shock – Common aspects for installation and equipment*

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

IEC 61439 (all parts), *Low-voltage switchgear and controlgear assemblies*

IEC 61439-2, *Low-voltage switchgear and controlgear assemblies – Part 2: Power switchgear and controlgear assemblies*

IEC 61557-8:2014, *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 62109 (all parts), *Safety of power converters for use in photovoltaic power systems*

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 62262, *Degrees of protection provided by enclosures for electrical equipment against external mechanical impacts (IK code)*

IEC 62423, *Type F and type B residual current operated circuit-breakers with and without integral overcurrent protection for household and similar uses*

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

IEC 62852:2014, *Connectors for DC-application in photovoltaic systems – Safety requirements and tests*

712.3 Terms and definitions

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>

712.3.1

PV cell

photovoltaic cell

solar cell

solar photovoltaic 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".

[SOURCE: IEC 61836:2007, 3.1.43 a), modified — "that exhibits ... electrical energy" has been added]

712.3.2

PV module

smallest complete environmentally protected assembly of interconnected cells

Note 1 to entry: See IEC 60904-3.

712.3.3

PV string

circuit of one or more series-connected modules

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[SOURCE: IEC 61836:2007, modified – "or one or more" has been added]

712.3.4

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 an inverter or DC loads. A PV array does not include its foundation, tracking apparatus, thermal control, and other such components.

Note 2 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 712.2 to Figure 712.4). For the purposes of this document the boundary of a PV array is the output side of the PV array disconnecting device.

712.3.5

PV sub-array

electrical subset of a PV array formed of parallel connected PV modules or PV strings

712.3.6

PV string cable

cable interconnecting the modules in a PV string, or connecting the string to a combiner box, PCE or other DC loads

Note 1 to entry: Examples of PV string cable are shown in Figure 712.3 and Figure 712.4.

712.3.7

PV array cable

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

712.3.8

PV AC supply cable

cable connecting the AC terminals of the PV PCE to a distribution board of the electrical installation

712.3.9

PV AC supply circuit

circuit connecting the AC terminals of the PV PCE to a distribution board of the electrical installation

712.3.10

PV AC module

integrated module/PCE assembly where the electrical interface terminals are alternating current only and where no access is provided to the DC side

712.3.11

PV installation

erected equipment of a PV power supply installation

712.3.12

standard test conditions

STC

standard set of reference conditions used for the testing and rating of photovoltaic cells and modules as given in the relevant product standard for example IEC 61215

Note 1 to entry: The standard test conditions given in IEC 61215 for PV modules are:

- a) PV cell temperature of 25 °C;
- b) irradiance in the plane of the PV cell or module of 1 000 W/m²;
- c) light spectrum corresponding to an atmospheric air mass of 1,5.

Note 2 to entry: This note applies to the French language only.

712.3.13**open-circuit voltage under standard test conditions** $U_{OC\ STC}$

voltage under standard test conditions across an unloaded (open) PV module, PV string, or PV array, or on the DC side of the PV PCE

712.3.14**open-circuit maximum voltage** $U_{OC\ MAX}$

maximum voltage across an unloaded (open) PV module, PV string, or PV array, or on the DC side of the PV PCE

Note 1 to entry: The method for determining $U_{OC\ MAX}$ is given in Annex B.

712.3.15**short-circuit current under standard test conditions** $I_{SC\ STC}$

short-circuit current of a PV module, PV string, or PV array under standard test conditions

712.3.16**short-circuit maximum current** $I_{SC\ MAX}$

maximum short-circuit current of a PV module, PV string or PV array

Note 1 to entry: The method for determining $I_{SC\ MAX}$ is given in Annex B.

712.3.17**backfeed current**

maximum current that can pass from PCE to the PV array and its wiring under normal or single fault conditions

712.3.18**reverse current**

current that can backfeed into a PV circuit from parallel connected strings or sub-arrays as the result of a fault, for example a short-circuit in the affected circuit

712.3.19**short-circuit current rating** I_{SCPV}

maximum prospective short-circuit current from the PV array for which the SPD, in conjunction with the disconnectors specified, is rated

712.3.20**DC side**

part of a PV installation from the PV modules to the DC terminals of the PV PCE

712.3.21**AC side**

part of a PV installation from the AC terminals of the PV PCE to the point of connection of the PV supply cable to the electrical installation

712.3.22**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

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Note 1 to entry: This note applies to the French language only.

712.3.23

$I_{MOD_MAX_OCPR}$

PV module maximum overcurrent protection rating

Note 1 to entry: See IEC 61730-2.

712.3.24

blocking diode

diode connected in series with module(s), strings and sub-array(s) to block reverse current

712.3.25

bypass diode

diode connected across one or more cells in the forward current direction

Note 1 to entry: The purpose is 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.

712.3.26

functional earthing

FE

earthing a point or points in a system or in an installation or in equipment for purposes other than electrical 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 a 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.

Note 4 to entry: This note applies to the French language only.

[SOURCE: IEC 60050-826:2004, 826-13-10, modified – the notes have been added]

712.3.27

irradiance

G

electromagnetic radiated solar power per unit of area

Note 1 to entry: Irradiance is expressed in W/m^2 .

[SOURCE: IEC 61836:2007, 3.6.25 modified – the note and sub-entries have been deleted]

712.3.28

$I_{SC\ ARRAY}$

short-circuit current of the PV array at standard test conditions

712.3.29

$I_{SC\ MOD}$

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 $I_{SC\ MOD}$.

712.3.30

$I_{SC\ S-ARRAY}$

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

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712.3.31**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

SEE: Figure 712.2 to Figure 712.4.

Note 1 to entry: This note applies to the French language only.

712.3.32**inverter**

PCE which converts DC voltage and DC current of the PV array into AC voltage and AC current

Note 1 to entry: This note applies to the French language only.

712.3.33**isolated PCE**

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

Note 1 to entry: The simple separation may be either integral to the PCE or provided externally, for example a PCE with an external isolating transformer.

Note 2 to entry: In a PCE with more than two external circuits, there may be isolation between some pairs of circuits and no isolation between others. For example, an inverter with PV, battery, and mains circuits may provide isolation between the mains circuit and the PV circuit, but no isolation between the PV and battery circuits.

712.3.34**non-isolated PCE**

PCE without the minimum separation between the main power output and PV circuits or with leakage currents greater than the requirements for an isolated PCE

712.3.35**PV array combiner box**

enclosure where PV sub-arrays are connected and which may also contain overcurrent protection and/or switch-disconnection devices

Note 1 to entry: Small arrays generally do not contain sub-arrays but are simply made up of strings, whereas large arrays are generally made up of multiple sub-arrays.

712.3.36**PV string combiner box**

enclosure where PV strings are connected which may also contain overcurrent protective devices and/or switch-disconnectors

712.3.37**PV sub-array cable**

output cable of a PV sub-array that carries the output current of its associated sub-array

712.3.38 **U_{OC} ARRAY**

open-circuit voltage at standard test conditions of a PV array

712.3.39 **V_{OC} MOD**

open circuit voltage of a PV module at standard test conditions, as specified by the manufacturer in the product specification

712.31 Purposes, supplies and structure

712.31.101 PV array configuration

712.31.101.1 General

PV arrays are used to supply power to an application circuit.

Figure 712.1 illustrates the general functional configuration of a PV installation.

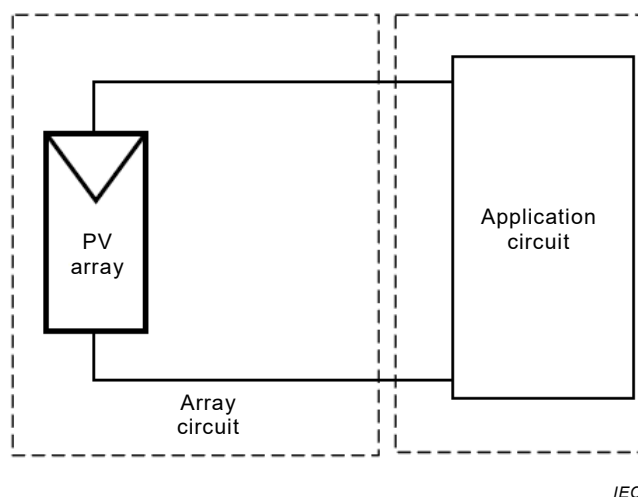


Figure 712.1 – General functional configuration of a PV installation

Three kinds of application circuit are considered:

- PV array is connected to DC loads;
- PV array is connected to AC installation via a PCE which includes at least simple separation;
- PV array is connected to AC installation via a PCE which does not include simple separation.

712.31.101.1.1 PV Installation architectures

The relation of a PV array to earth is determined by whether any earthing of the array for functional reasons is in use, the impedance of the earthing connection and also by the earth status of the application circuit (e.g. PCE or other equipment) to which it is connected. This and the location of the earth connection all affect safety for the PV array (refer to Annex A).

The requirements of manufacturers of PV modules and manufacturers of the PCE to which the PV array is connected shall be taken into account in determining the most appropriate system earthing arrangement.

Protective earthing of any of the conductors of the PV array is not permitted. Earthing of one of the conductors of the PV array for functional reasons is not allowed unless there is at least simple separation from mains earth provided either internally in the PCE or externally via a separate transformer.

If the simple separation is provided externally there shall be no other equipment connected to the same circuit as the PCE.

NOTE A DC current-carrying conductor that is connected to earth is considered to be a live conductor.

712.31.101.1.2 Array electrical diagrams

The diagrams in Figure 712.2 to Figure 712.4 show the basic electrical configurations of single-string, multiple parallel-string and multi-sub-array PV respectively.

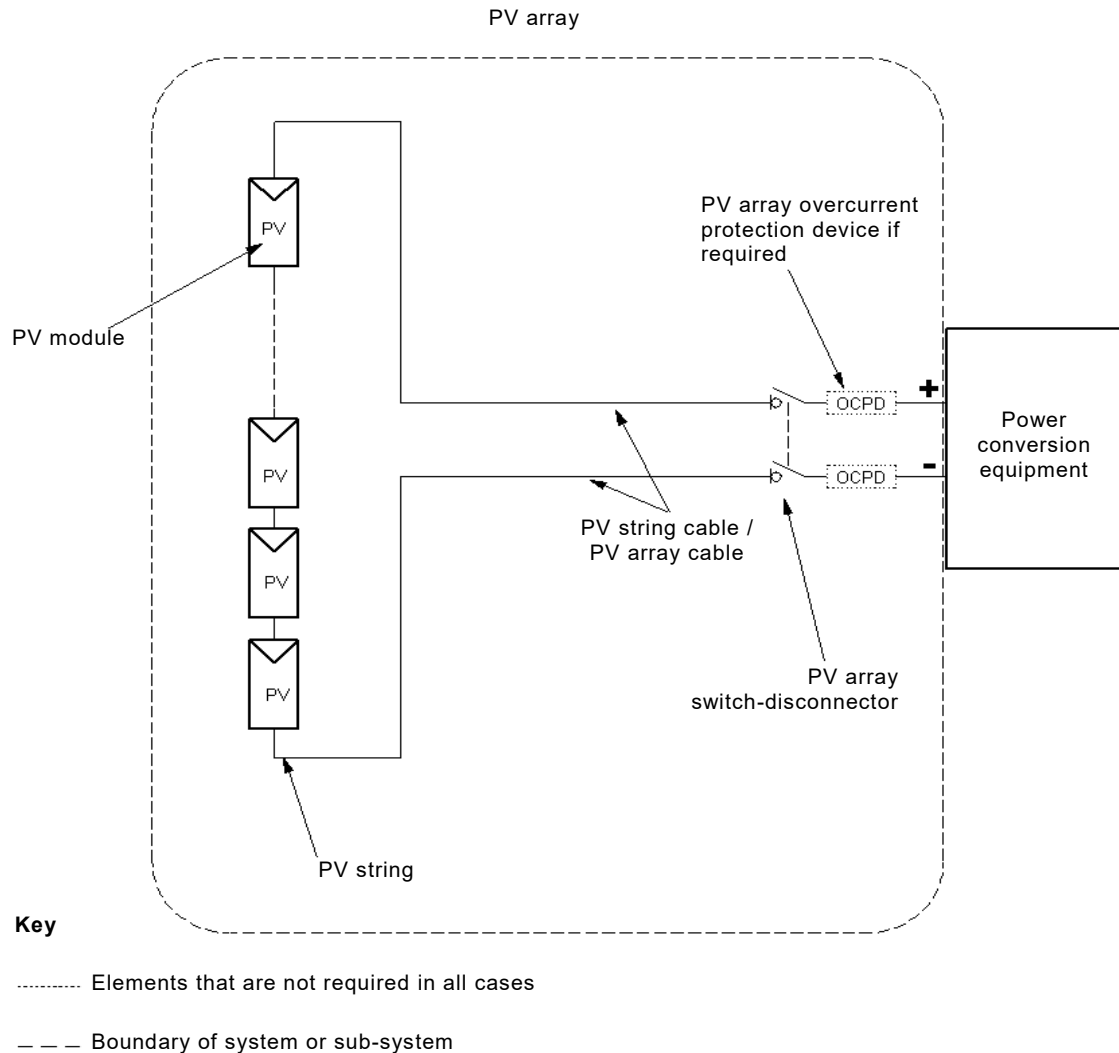
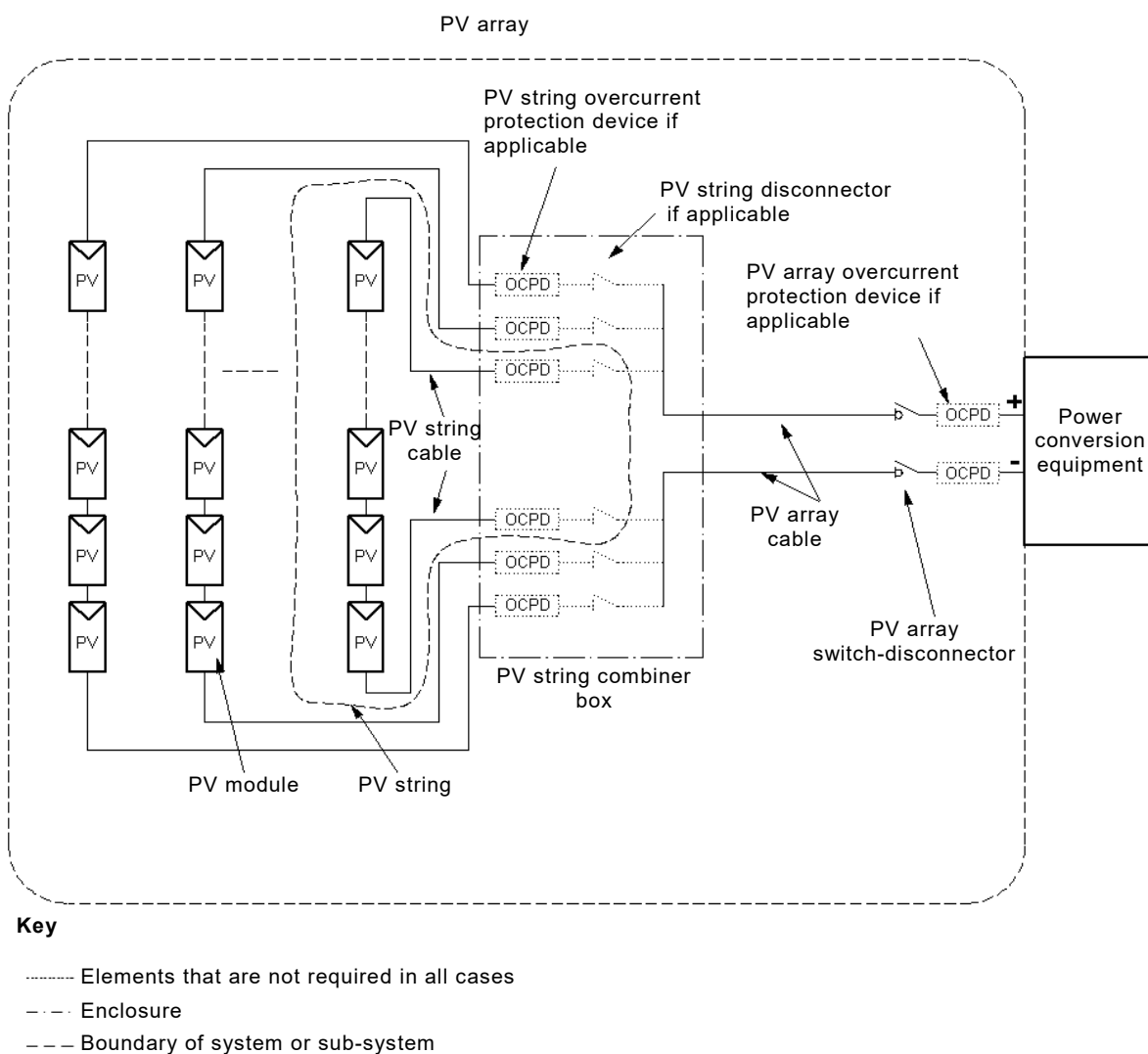


Figure 712.2 – PV array diagram – single string case



IEC

Figure 712.3 – PV array diagram – multiple parallel string case