IEC 61643-32

Edition 1.0 2017-09

# INTERNATIONAL STANDARD

# NORME INTERNATIONALE

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## Low-voltage surge protective devices – Part 32: Surge protective devices connected to the d.c. side of photovoltaic installations – Selection and application principles

## Parafoudres basse tension – Partie 32: Parafoudres connectés au côté courant continu des installations photovoltaïques – Principes de choix et d'application

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IEC 61643-32:2017-07(en-fr)



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# LOW-VOLTAGE SURGE PROTECTIVE DEVICES –

# Part 32: Surge protective devices connected to the d.c. side of photovoltaic installations – Selection and application principles

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International Standard IEC 61643-32 has been prepared by subcommittee 37A: Low-voltage surge protective devices, of IEC technical committee 37: Surge arresters.

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

| FDIS | Report on voting |
|---|---|
| 37A/302/FDIS | 37A/303/RVD |

Full information on the voting for the approval of this International Standard 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.

The following differing practices of a less permanent nature exist in the countries indicated below.

Annex D: Class I tested SPDs are not required (United States)

A list of all parts of the IEC 61643 series can be found, under the general title *Low-voltage surge protection devices*, on the IEC website.

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

The contents of the corrigendum of June 2019 have been included in this copy.

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# INTRODUCTION

This part of IEC 61643 provides useful information for the selection of SPDs connected to photovoltaic installations.

This part of IEC 61643 provides information to evaluate, with reference to the IEC 62305 series, IEC 60364 series and IEC 61643-12, the additional needs for surge protective devices (SPDs) to be installed on the DC side of a photovoltaic (PV) system, to protect against induced and direct lightning effects. It gives guidance for selection, operation and installation of SPDs, including the selection of SPD test class, surge current values and cross section of bonding conductors. Guidance for selection of SPDs connected to the AC side is also given.

The specific electrical parameters of a PV array or a PV source require specific SPDs on the DC side.

This part of IEC 61643 considers SPDs used in different locations and in different kinds of PV systems. It gives examples and provides a simplified and common approach to determine impulse discharge current values for the DC side of different PV installations.

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# LOW-VOLTAGE SURGE PROTECTIVE DEVICES –

# Part 32: Surge protective devices connected to the DC side of photovoltaic installations – Selection and application principles

## 1 Scope

This part of IEC 61643 describes the principles for selection, installation and coordination of SPDs intended for use in Photovoltaic (PV) systems up to 1 500 V DC and for the AC side of the PV system rated up to 1 000 V rms 50/60 Hz.

The photovoltaic installation extends from a PV array or a set of interconnected PV-modules to include the associated cabling and protective devices and the inverter up to the connection point in the distribution board or the utility supply point.

This part of IEC 61643 considers SPDs used in different locations and in different kinds of PV systems:

– PV systems located on the top of a building.
– PV systems located on the ground like free field power plants characterized by multiple earthing and a meshed earthing system.

The term PV installation is used to refer to both kinds of PV systems. The term PV power plant is only used for extended free-field multi-earthed power systems located on the ground.

For PV installations including batteries additional requirements may be necessary.

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NOTE 1 IEC 60364 series, IEC 62305 series and IEC 61643-12 also apply.

NOTE 2 This standard deals only with SPDs and not with surge protective components integrated inside equipment (e.g. inverters, (PCE) power conversion equipment).

## 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 60364-4-44:2007, *Low-voltage electrical installations – Part 4-44: Protection for safety – Protection against voltage disturbances and electromagnetic disturbances*
IEC 60364-4-44:2007/AMD1:2015

IEC 60364-5-53:2015, *Electrical installations of buildings – Part 5-53: Selection and erection of electrical equipment – Isolation, switching and control*

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

IEC 60364-7-712:2017, *Low voltage electrical installations – Part 7-712: Requirements for special installations or locations – Solar photovoltaic (PV) power supply systems*

IEC 60664-1:2007, *Insulation coordination for equipment within low-voltage systems – Part 1: Principles, requirements and tests*

IEC 61000-4-5:2014, *Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test*

IEC 61643-11:2011, *Low-voltage surge protective devices – Part 11: Surge protective devices connected to low-voltage power systems – Requirements and test methods*

IEC 61643-12, *Low-voltage surge protective devices – Part 12: Surge protective devices connected to low-voltage power distribution systems – Selection and application principles*

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 61643-31, *Low-voltage surge protective devices – Part 31: Surge protective devices connected to the DC side of photovoltaic installations – Requirements and test methods*[1]

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

IEC 62305-3:2010, *Protection against lightning – Part 3: Physical damage to structures and life hazard*

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IEC 62305-4, *Protection against lightning – Part 4: Electrical and electronic systems within structures*

ITU-T, Recommendation K.20, *Resistibility of telecommunication equipment installed in a telecommunications centre to overvoltages and overcurrents*

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ITU-T, Recommendation K.21, *Resistibility of telecommunication equipment installed in customer premises to overvoltages and overcurrents*

## 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

**3.1**
**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 d.c. input terminals of the PCE or other power conversion equipment or DC loads. A PV array does not include its foundation, tracking apparatus, thermal control and other such components.

[1] Under preparation: Stage at the time of publication: IEC/FDIS 61643-31:2017.

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. For the purposes of this standard the boundary of a PV array is the output side of the PV array disconnecting device.

[SOURCE: IEC 60364-7-712:2017, 712.3.4]

**3.2**
**PV module**
smallest complete environmentally protected assembly of interconnected cells

[SOURCE: IEC 60364-7-712:2017, 712.3.2]

**3.3**
**PV string**
circuit of one or more series-connected modules

[SOURCE: IEC 60364-7-712:2017, 712.3.3]

**3.4**
**PV installation**
erected equipment of a PV power supply installation

[SOURCE: IEC 60364-7-712:2017, 712.3.11]

**3.5**
**origin of the electrical installation**
point at which the electric energy is delivered to the electrical installation

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[SOURCE: IEC 60050-826:2004, 826-10-02]

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**3.6**
**lightning protection system**
**LPS**
complete system used to reduce physical damage due to lightning flashes to a structure

Note 1 to entry: It consists of both external and internal lightning protection systems.

[SOURCE: IEC 62305-1:2010, 3.42]

**3.7**
**external LPS isolated from the structure to be protected**
LPS with an air-termination system and down conductor system installed in such a way that the path of the lightning current has no contact with the structure to be protected

Note 1 to entry: In an isolated LPS dangerous sparks between the LPS and the structure are avoided

[SOURCE: IEC 62305-3:2010, 3.3]

**3.8**
**surge protective device**
**SPD**
device that contains at least one nonlinear component that is intended to limit surge voltages and divert surge currents

Note 1 to entry: An SPD is a complete assembly, having appropriate connecting means

[SOURCE: IEC 61643-11:2011, 3.1.1]

**3.9**
**separation distance**
***s***
distance between two conductive parts at which no dangerous sparking can occur

[SOURCE: IEC 62305-3:2010, 3.28]

**3.10**
**lightning equipotential bonding**
**EB**
bonding to the LPS of separated conductive parts, by direct connections or via surge protective devices, to reduce potential differences caused by lightning current

[SOURCE: IEC 62305-3:2010, 3.23]

**3.11**
**bonding bar**
metal bar on which metal installations, external conductive parts, electric power and telecommunication lines, and other cables can be bonded to an LPS

[SOURCE: IEC 62305-3:2010, 3.24]

**3.12**
**bonding conductor**
conductor connecting separated conductive parts to LPS

[SOURCE: IEC 62305-3:2010, 3.25]

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**3.13**
**standard test conditions**
**STC**
standard set of reference conditions used for the testing and rating of photovoltaic cells and modules

Note 1 to entry: See product standard (eg. IEC 61215).

Note 2 to entry: The standard test conditions given in IEC 61215 for PV modules are
a) PV cell temperature of 25 °C
b) Irradiance in plane of the PV cell or module of 1000 W/m2
c) Light spectrum corresponding to an atmospheric air mass of 1,5.

[SOURCE: IEC 60364-7-712:2017, 712.3.12]

**3.14**
**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-inverter or power conversion equipment

[SOURCE: IEC 60364-7-712:2017, 712.3.13, modified (addition of "-inverter or power conversion equipment")]

**3.15**
**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-inverter or power conversion equipment

Note 1 to entry: Calculation of $U_{OC\ MAX}$ is performed in Annex B.

**3.16**
**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

[SOURCE: IEC 60364-7-712:2017, 712.3.15]

**3.17**
**short-circuit maximum current**
**$I_{SC\ MAX}$**
maximum short-circuit current of a PV module, PV string or PV array

Note 1 to entry: Calculation of $I_{SCMAX}$ is performed in Annex B.

[SOURCE: IEC 60364-7-712:2017, 712.3.16]

**3.18**
**maximum continuous operating voltage for PV application**
**$U_{CPV}$**
maximum DC voltage which may be continuously applied to the SPD´s mode of protection

Note 1 to entry: This value is equal to, or greater than $U_{OC\ MAX}$.

[SOURCE: IEC 61643-31:−, 3.1.10]

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**3.19**
**short-circuit current rating of the SPD**
**$I_{SCPV}$**
maximum prospective short-circuit current from the power system for which the SPD, in conjunction with the disconnector specified, is rated

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https://ecommerce.sist.si/catalog/standards/sist/88eb586e-ba4d-4ff5-8586-9357fce4b1c7/iec-61643-32-2017

Note 1 to entry: This value is equal to or greater than $I_{SC\ MAX}$.

[SOURCE: IEC 61643-31:−, 3.1.25]

**3.20**
**Open-Circuit Failure Mode**
**OCFM**
failure behaviour whereby an SPD changes to a permanent high impedance or open circuit state under certain conditions

Note 1 to entry: A low impedance intermediate state is possible for a limited time until the final failure mode is reached.

[SOURCE: IEC 61643-31:−, 3.1.40]

**3.21**
**Short-Circuit Failure Mode**
**SCFM**
failure behaviour whereby an SPD changes to a permanent low impedance or short circuit state under certain conditions

[SOURCE: IEC 61643-31:−, 3.1.41]

**3.22**
**Rated impulse voltage**
**$U_W$**
impulse withstand voltage value assigned by the manufacturer to the equipment or to a part of it, characterizing the specified withstand capability of its insulation against transient overvoltages

Note 1 to entry: For the purpose of this standard only withstand voltages between live conductors and earth is considered.

Note 2 to entry: $U_W$ is measured with a 1,2/50 µs voltage impulse wave shape.

Note 3 to entry: In some other standards also called $U_{imp}$.

[SOURCE: IEC 60664-1:2007, 3.9.2, modified (addition of Notes to entry)]

**3.23**
**total discharge current**
**$I_{Total}$**
current which flows through the earth conductor of a multipole SPD during the total discharge current test

Note 1 to entry: The aim is to take into account cumulative effects that occur when multiple modes of protection of a multipole SPD conduct at the same time.

Note 2 to entry: $I_{Total}$ is particularly relevant for SPDs tested according to test class I, and is used for the purpose of lightning protection equipotential bonding according to IEC 62305 series.

[SOURCE: IEC 61643-11:2011, 3.1.44, modified ("PE or PEN conductor" replaced by "earth conductor")]

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## 4 Systems and equipment to be protected

IEC 61643-32:2017
https://ecommerce.sist.si/catalog/standards/sist/8bb9b8be-6a4d-4fb5-8580-955fice4b1c7/iec-61643-32-2017

Equipment within a PV installation that may require protection includes:

– The inverter, i.e. both the AC interface with the AC LV power system and the DC interface;
– The PV array;
– The wiring (installation itself)
– Components installed between the inverter and the PV array;
– Equipment for controlling and monitoring the PV installation.

Overvoltages can destroy or degrade a PV installation or can cause malfunction, therefore PV installations should be protected.

The evaluation of the need for protection and the proper selection of protective measures requires information from the manufacturer concerning the withstand voltage of the equipment. If such information is not readily available, the rated impulse voltage $U_W$ for the equipment provided in Subclause 9.1.2 and in Table 2 can be used as a guide. Partial lightning currents can cause uncontrolled flashovers and trigger fires. Surge protection measures may help to reduce the risk of fire (see the IEC 62305 series).

## 5 Overvoltages in a PV installation

Several conditions may cause overvoltages in a PV installation. These include:

– direct strikes (S1) to the external lightning protection system (LPS) of the building or lightning flashes near (S2) to the buildings and/or PV installation,
– direct strikes (S3) and lightning induced currents (S4) distributed into the electrical network,

– overvoltages created by the distribution network, e.g., those due to switching operations

NOTE 1 S1, S2, S3 and S4 are addressed in IEC 62305 series.

NOTE 2 Overvoltages are described in IEC 60364-4-44.

Repetitive switching overvoltages (spikes) on the AC voltage created by electronic inverter / converter technology may require special consideration for the selection of SPDs.

The protection requirements in this document are based on the assumption that the cables interconnecting the DC components of the PV installation are sufficiently protected from direct lightning flashes, either by appropriate routing or by shielding (e.g. the use of an appropriate cable management system).

## 6 Installation and location of SPDs

### 6.1 General

According to IEC 61643-12 and the IEC 62305 series, selection and installation of SPDs for protection of PV systems depend on many factors, but primarily:

– the lightning ground flash density $N_G$ (1/km$^2$ / year) or the isokeraunic level $T_D$ (number of thunder storm days per year) of the location,
– the characteristics of the low-voltage power system (e.g. overhead lines or underground cables) and of the equipment to be protected,
– whether the PV installation needs to be protected against direct lightning with an external LPS.

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When installations are protected by an external LPS, the requirements for SPDs depend on:

– the selected class of the LPS (see simplified method in Annex A),
– whether the separation distance (s) is maintained between the LPS and the PV installation (isolated LPS) or not maintained (non-isolated LPS).

IEC 61643-32:2017
https://ecommerce.sist.si/catalog/standards/sist/[illegible]-4fb5-8586-9557fce4b1c7/iec-61643-32-2017

For further details on external LPS and separation distance requirements, see IEC 62305-3.

For optimum inverter overvoltage protection, a direct earthing connection between the SPD and the inverter is recommended.

The selection of SPD test class and minimum cross section of bonding conductors shall be done according to Table 1.