

This is a preview of "IEC/TS 62548 Ed. 1.0...". [Click here to purchase the full version from the ANSI store.](#)



Edition 1.0 2013-07

TECHNICAL SPECIFICATION



Photovoltaic (PV) arrays – Design requirements

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

PRICE CODE **XA**

ICS 27.160

ISBN 978-2-8322-1006-2

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD.....	5
1 Scope and object.....	7
2 Normative references	7
3 Terms and definitions, symbols and abbreviations	9
3.1 Terms, definitions and symbols	9
4 Compliance with IEC 60364.....	15
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	16
5.1.3 Array electrical diagrams	16
5.1.4 Use of PCE with multiple d.c. inputs	21
5.1.5 Series-parallel configuration	22
5.1.6 Batteries in systems	22
5.1.7 Considerations due to prospective fault conditions within a PV array.....	22
5.1.8 Considerations due to operating temperature	23
5.1.9 Performance issues	23
5.2 Mechanical design.....	24
5.2.1 General	24
5.2.2 Thermal aspects	24
5.2.3 Mechanical loads on PV structures	24
5.2.4 Wind.....	24
5.2.5 Material accumulation on PV array	24
5.2.6 Corrosion.....	24
6 Safety issues.....	25
6.1 General.....	25
6.2 Protection against electric shock	25
6.3 Protection against overcurrent.....	25
6.3.1 General	25
6.3.2 Requirement for overcurrent protection.....	25
6.3.3 Overcurrent protection in PV systems connected to batteries	25
6.3.4 Requirement for string overcurrent protection	26
6.3.5 Requirement for sub-array overcurrent protection	26
6.3.6 Overcurrent protection sizing	26
6.3.7 Overcurrent protection location.....	28
6.4 Requirements for PV arrays operating at DVC-B and DVC-C voltages.....	29
6.4.1 Detection and alarm requirements	29
6.4.2 Earth fault alarm	31
6.5 Protection against effects of lightning and overvoltage	32
6.5.1 General	32
6.5.2 Protection against overvoltage.....	32
7 Selection and erection of electrical equipment.....	32
7.1 General.....	32
7.2 PV array maximum voltage.....	33
7.3 Component requirements	33
7.3.1 General	33

7.3.2	PV modules	34
7.3.3	PV array and PV string combiner boxes	34
7.3.4	Circuit breakers	34
7.3.5	Disconnectors and switch-disconnectors	35
7.3.6	Cables	35
7.3.7	Segregation of a.c. and d.c. circuits	38
7.3.8	Plugs, sockets and connectors	38
7.3.9	Wiring in combiner boxes	39
7.3.10	Fuses	39
7.3.11	Bypass diodes	39
7.3.12	Blocking diodes	39
7.4	Location and installation requirements	40
7.4.1	Disconnecting means	40
7.4.2	Earthing and bonding arrangements	42
7.4.3	Wiring system	46
8	Acceptance	47
9	Operation/maintenance	47
10	Marking and documentation	48
10.1	Equipment marking	48
10.2	Requirements for signs	48
10.3	Identification of a PV installation	48
10.4	Labelling of PV array and PV string combiner boxes	48
10.5	Labelling of disconnection devices	48
10.5.1	General	48
10.5.2	PV array disconnecting device	48
10.6	Documentation	49
Annex A (informative)	Examples of signs	50
Annex B (informative)	Examples of system functional earthing configurations in PV arrays	51
Annex C (informative)	Blocking diode	53
Annex D (informative)	Arc fault detection and interruption in PV arrays	57
Annex E (informative)	DVC limits	59
Bibliography	60
Figure 1	– General functional configuration of a PV powered system	16
Figure 2	– PV array diagram – single string case	17
Figure 3	– PV array diagram – multiple parallel string case	18
Figure 4	– PV array diagram – multiple parallel string case with array divided into sub-arrays	19
Figure 5	– PV array using a PCE with multiple MPPT d.c. inputs	20
Figure 6	– PV array using a PCE with multiple d.c. inputs internally connected to a common d.c. bus	21
Figure 7	– Example of a PV array diagram where strings are grouped under one over-current protection device per group	27
Figure 8	– Reinforced protection of wiring	38
Figure 9	– PV array exposed-conductive parts functional earthing/bonding decision tree	43
Figure 10	– Exposed conductive parts earthing in a PV array	44

Figure 11 – PV string wiring with minimum loop area	46
Figure A.1 – Example of sign required on PV array combiner boxes (10.4)	50
Figure A.2 – Example of switchboard sign for identification of PV on a building	50
Figure B.1 – System functional earthing/grounding	51
Figure B.2 – Examples different PV configurations in common use	52
Figure C.1 – Effect of blocking diode at short circuit in PV string	54
Figure C.2 – Effect of blocking diode where there is an earth fault on a system with earthing on the minus side	54
Figure C.3 – Effect of blocking diode where there is an earth fault on a system with positive side earthing	55
Figure D.1 – Examples of types of arcs in PV arrays	57
Table 1 – Nominal overcurrent rating of functional earth fault interrupter	28
Table 2 – Requirements for different system types based on PCE isolation and PV array functional earthing	29
Table 3 – Minimum insulation resistance thresholds for detection of failure of insulation to earth	30
Table 4 – Response time limits for sudden changes in residual current	31
Table 5 – Voltage correction factors for crystalline and multi-crystalline silicon PV modules	33
Table 6 – Minimum current rating of circuits	36
Table 7 – Disconnection device requirements in PV array installations	41
Table E.1 – Summary of the limits of the decisive voltage classes	59

INTERNATIONAL ELECTROTECHNICAL COMMISSION

PHOTOVOLTAIC (PV) ARRAYS – DESIGN REQUIREMENTS

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances, a technical committee may propose the publication of a technical specification when

- the required support cannot be obtained for the publication of an International Standard, despite repeated efforts, or
- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

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

IEC 62548, which is a technical specification, has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

This is a preview of "IEC/TS 62548 Ed. 1.0...". [Click here to purchase the full version from the ANSI store.](#)

The present Technical Specification is intended to be withdrawn as soon as an International Standard in the IEC 60364 series, under joint development by IEC technical committees 64 and 82, will be published.

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

Enquiry draft	Report on voting
82/746/DTS	82/765A/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 stability 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 version of this publication may be issued at a later date.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

PHOTOVOLTAIC (PV) ARRAYS – DESIGN REQUIREMENTS

1 Scope and object

This Technical Specification sets out design requirements for photovoltaic (PV) arrays including d.c. 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.

The object of this Technical Specification 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 a.c. 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 Technical Specification 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 IEC 60364 series (see Clause 4).

PV arrays of less than 100 W and less than 35 V d.c. open circuit voltage at STC are not covered by this Technical Specification.

Attention is drawn to Annex D describing arc fault detection and interruption in PV arrays. It is expected that requirements for the use of this type of equipment will be included in this Technical Specification when reliable commercial equipment for detection of arcs in PV systems is available.

NOTE 1 This Technical Specification covers the protection requirements of PV arrays which develop as a result of the use of batteries in PV systems.

NOTE 2 Additional requirements may be needed for more specialized installations e.g. concentrating systems, tracking systems or building integrated PV.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60228:2004, *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 60287 (all parts), *Electric cables – Calculation of the current rating*

IEC 60332-1-2:2004, *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*

This is a preview of "IEC/TS 62548 Ed. 1.0...". [Click here to purchase the full version from the ANSI store.](#)

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 60364-5-54:2011, *Low-voltage electrical installations – Part 5-54: Selection and erection of electrical equipment – Earthing arrangements and protective conductors*

IEC 60364-7-712:2002, *Electrical installations of buildings – Part 7-712: Requirements for special installations or locations – Solar photovoltaic (PV) power supply systems*

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 60947-1, *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 61215:2005, *Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval*

IEC 61646, *Thin-film terrestrial photovoltaic (PV) modules – Design qualification and type approval*

IEC 61730-1:2004, *Photovoltaic (PV) module safety qualification – Part 1: Requirements for construction*

IEC 61730-2:2004, *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 62305-4, *Protection against lightning – Part 4: Electrical and electronic systems within structures*

IEC 62446, *Grid connected photovoltaic systems – Minimum requirements for system documentation, commissioning tests and inspection*

EN 50521, *Connectors for photovoltaic systems – Safety requirements and tests*