

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

Systèmes photovoltaïques connectés au réseau électrique – Exigences minimales pour la documentation du système, les essais de mise en service et l'examen



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CONTENTS

FOREWORD.....	4
INTRODUCTION.....	6
1 Scope and object.....	7
2 Normative references	7
3 Terms and definitions	7
4 System documentation requirements	8
4.1 General.....	8
4.2 System data	8
4.2.1 Basic system information.....	8
4.2.2 System designer information	8
4.2.3 System installer information.....	9
4.3 Wiring diagram	9
4.3.1 General	9
4.3.2 Array - general specifications	9
4.3.3 PV string information	9
4.3.4 Array electrical details	9
4.3.5 Earthing and overvoltage protection.....	9
4.3.6 AC system.....	10
4.4 Datasheets.....	10
4.5 Mechanical design information	10
4.6 Operation and maintenance information	10
4.7 Test results and commissioning data.....	10
5 Verification	10
5.1 General.....	10
5.2 General.....	11
5.3 Inspection.....	11
5.3.1 General	11
5.3.2 DC system inspection.....	11
5.3.3 Protection against overvoltage / electric shock	12
5.3.4 AC system.....	12
5.3.5 Labelling and identification	12
5.4 Testing.....	13
5.4.1 General	13
5.4.2 Continuity of protective earthing and/or equipotential bonding conductors.....	13
5.4.3 Polarity test.....	13
5.4.4 PV string - open circuit voltage measurement.....	13
5.4.5 PV string - current measurement	14
5.4.6 Functional tests	15
5.4.7 PV array Insulation resistance test	15
5.5 Verification reports	17
5.5.1 General	17
5.5.2 Initial verification	17
5.5.3 Periodic verification	17
Annex A (informative) Model verification certificate.....	18
Annex B (informative) Model inspection report.....	19

Annex C (informative) Model PV array test report 21

Annex D (informative) PV array infrared camera inspection procedure..... 23

Table 1 – Minimum values of insulation resistance..... 17



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

**GRID CONNECTED PHOTOVOLTAIC SYSTEMS –
MINIMUM REQUIREMENTS FOR SYSTEM DOCUMENTATION,
COMMISSIONING TESTS AND INSPECTION**

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

FDIS	Report on voting
82/558A/FDIS	82/564/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.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result 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

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INTRODUCTION

Grid connected PV systems are expected to have a lifetime of decades, with maintenance or modifications likely at some point over this period. Building or electrical works in the vicinity of the PV array are very likely, for example roof works adjacent to the array or modifications (structural or electrical) to a home that has a PV system. The ownership of a system may also change over time, particularly for systems mounted on buildings. Only by the provision of adequate documentation at the outset can the long term performance and safety of the PV system and works, on or adjacent to the PV system, be ensured.

This standard is split into 2 parts:

- **System documentation requirements** (Clause 4) – This clause details the information that shall be provided, as a minimum, within the documentation provided to the customer following the installation of a grid connected PV system.
- **Verification** (Clause 5) – This clause provides the information expected to be provided following initial (or periodic) verification of an installed system. It includes requirements for inspection and testing.

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GRID CONNECTED PHOTOVOLTAIC SYSTEMS – MINIMUM REQUIREMENTS FOR SYSTEM DOCUMENTATION, COMMISSIONING TESTS AND INSPECTION

1 Scope and object

This International Standard defines the minimal information and documentation required to be handed over to a customer following the installation of a grid connected PV system. This standard also describes the minimum commissioning tests, inspection criteria and documentation expected to verify the safe installation and correct operation of the system. The document can also be used for periodic retesting.

This standard is written for grid connected PV systems only and not for AC module systems or systems that utilize energy storage (e.g. batteries) or hybrid systems.

NOTE It is expected that additional information and commissioning tests will be required in some circumstances, e.g. for large commercial installations.

This standard is for use by system designers and installers of grid connected solar PV systems as a template to provide effective documentation to a customer. By detailing the expected minimum commissioning tests and inspection criteria, it is also intended to assist in the verification / inspection of a grid connected PV system after installation and for subsequent re-inspection, maintenance or modifications.

2 Normative references

The following referenced documents are indispensable for the application of this standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

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/TR 60755:2008, *General requirements for residual current operated protective devices*

IEC 61557 (all parts), *Electrical safety in low voltage distribution systems up to 1000 V AC and 1500 V DC – Equipment for testing, measuring or monitoring of protective measures*

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

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply:

3.1 verification

all measures by means of which compliance of the electrical installation to the relevant standards is checked

NOTE It comprises inspection, testing and reporting.

3.2 inspection

examination of an electrical installation using all the senses in order to ascertain correct selection and proper erection of electrical equipment

3.3 testing

implementation of measures in an electrical installation by means of which its effectiveness is proved

NOTE It includes ascertaining values by means of appropriate measuring instruments, said values not being detectable by inspection.

3.4 reporting

recording of the results of inspection and testing

3.5 data sheet

a basic product description and specification

NOTE Typically one or two pages. Not a full product manual.

4 System documentation requirements

4.1 General

The purpose of this Clause is to list the minimum documentation that should be provided following the installation of a grid connected PV system. This information will ensure key system data is readily available to a customer, inspector or maintenance engineer. The documentation includes basic system data and the information expected to be provided in the operation and maintenance manual.

4.2 System data

4.2.1 Basic system information

As a minimum, the following basic system information shall be provided. This “nameplate” information would typically be presented on the cover page of the system documentation pack.

- a) Project identification reference (where applicable).
- b) Rated system power (kW DC or kVA AC).
- c) PV modules and inverters - manufacturer, model and quantity.
- d) Installation date.
- e) Commissioning date.
- f) Customer name.
- g) Site address.

4.2.2 System designer information

As a minimum, the following information shall be provided for all bodies responsible for the design of the system. Where more than one company has responsibility for the design of the system, the following information should be provided for all companies together with a description of their role in the project.

- a) System designer, company.

- b) System designer, contact person.
- c) System designer, postal address, telephone number and e-mail address.

4.2.3 System installer information

As a minimum, the following information shall be provided for all bodies responsible for the installation of the system. Where more than one company has responsibility for the installation of the system, the following information should be provided for all companies together with a description of their role in the project.

- a) System installer, company.
- b) System installer, contact person.
- c) System installer, postal address, telephone number and e-mail address.

4.3 Wiring diagram

4.3.1 General

As a minimum, a single line wiring diagram shall be provided. This diagram shall be annotated to include the information detailed in the following subclauses:

NOTE In general, it is expected that this information will be presented as annotations to the single line wiring diagram. In some circumstances, typically for larger systems where space on the diagram may be limited, this information may be presented in table form.

4.3.2 Array - general specifications

The wiring diagram shall include the following array design information

- a) Module type(s)
- b) Total number of modules
- c) Number of strings
- d) Modules per string

4.3.3 PV string information

The wiring diagram shall include the following PV string information

- a) String cable specifications – size and type.
- b) String over-current protective device specifications (where fitted)- type and voltage/current ratings.
- c) Blocking diode type (if relevant).

4.3.4 Array electrical details

The wiring diagram shall include the following array electrical information

- a) Array main cable specifications – size and type.
- b) Array junction box locations (where applicable).
- c) DC isolator type, location and rating (voltage / current).
- d) Array over-current protective devices (where applicable) – type, location and rating (voltage / current).

4.3.5 Earthing and overvoltage protection

The wiring diagram shall include the following earthing and overvoltage protection information

- a) Details of all earth / bonding conductors – size and connection points. Including details of array frame equipotential bonding cable where fitted.

- b) Details of any connections to an existing Lightning Protection System (LPS).
- c) Details of any surge protection device installed (both on AC and DC lines) to include location, type and rating.

4.3.6 AC system

The wiring diagram shall include the following AC system information

- a) AC isolator location, type and rating.
- b) AC overcurrent protective device location, type and rating.
- c) Residual current device location, type and rating (where fitted).

4.4 Datasheets

As a minimum, datasheets shall be provided for the following system components

- a) Module datasheet for all types of modules used in the system - to the requirements of IEC 61730-1.
- b) Inverter datasheet for all types of inverters used in the system.

NOTE The provision of datasheets for other significant system components should also be considered.

4.5 Mechanical design information

A data sheet for the array mounting system shall be provided.

4.6 Operation and maintenance information

Operation and maintenance information shall be provided and shall include, as a minimum, the following items:

- a) Procedures for verifying correct system operation.
- b) A checklist of what to do in case of a system failure.
- c) Emergency shutdown / isolation procedures.
- d) Maintenance and cleaning recommendations (if any).
- e) Considerations for any future building works related to the PV array (e.g. roof works).
- f) Warranty documentation for PV modules and inverters - to include starting date of warranty and period of warranty.
- g) Documentation on any applicable workmanship or weather-tightness warranties.

4.7 Test results and commissioning data

Copies of all test and commissioning data shall be provided. As a minimum, these shall include the results from the verification tests detailed in Clause 5 of this standard.

5 Verification

5.1 General

Much of the verification of a grid connected PV system should be done with reference to IEC 60364-6 which provides the requirements for initial and periodic verification of any electrical installation.

This Clause provides the requirements for the initial and periodic verification of a grid connected PV electrical installation in particular. It references IEC 60364-6 where appropriate and also details additional requirements or considerations for the verification of a PV system.

Initial verification takes place upon completion of a new installation or completion of additions or of alterations to existing installations. Periodic verification is to determine, as far as reasonably practicable, whether the installation and all its constituent equipment remain in a satisfactory condition for use.

NOTE Typical verification test sheets are provided in the annexes to this standard.

5.2 General

Every installation of subsystems and components shall be verified during erection, as far as reasonably practicable, and on completion, before being put into service by the user with reference to IEC 60364-6. Initial verification shall include comparison of the results with relevant criteria to confirm that the requirements of IEC 60364 have been met.

For an addition or alteration to an existing installation, it shall be verified that the addition or alteration complies with IEC 60364 and does not impair the safety of the existing installation.

Initial and periodic verifications shall be made by a skilled person, competent in verification.

5.3 Inspection

5.3.1 General

Inspection shall precede testing and shall normally be done prior to energizing the installation. The inspection shall be done to the requirements of IEC 60364-6.

It is to be ensured that the following items, specific to grid connected PV systems, are included in the inspection:

5.3.2 DC system inspection

Inspection of the DC installation shall include, at least verification that:

- a) The DC system has been designed, specified and installed to the requirements of IEC 60364 in general and IEC 60364-7-712 in particular.
- b) All DC components are rated for continuous operation at DC and at the maximum possible DC system voltage and maximum possible DC fault current ($V_{oc\ stc}$ corrected for local temperature range and based on module type; and current at $1,25 \times I_{sc\ stc}$ according to IEC 60364-7-712.433:2002).
- c) Protection by use of class II or equivalent insulation adopted on the DC side – yes / no (class II preferred - IEC 60364-7-712.413.2:2002).
- d) PV string cables, PV array cables and PV DC main cables have been selected and erected so as to minimize the risk of earth faults and short-circuits (IEC 60364-7-712.522.8.1:2002). Typically achieved by the use of cables with protective and reinforced insulation (often termed “double insulated”).
- e) Wiring systems have been selected and erected to withstand the expected external influences such as wind, ice formation, temperature and solar radiation (IEC 60364-7-712.522.8.3:2002).
- f) For systems without string over-current protective device: verify that the module reverse current rating (I_r) is greater than the possible reverse current; also, verify that the string cables are sized to accommodate the maximum combined fault current from parallel strings (IEC 60364-7-712.433:2002).
- g) For systems with string over-current protective device: verify that the string over-current protective devices are fitted and correctly specified to local codes or to the manufacturer's instructions for protection of PV modules according to the NOTE of IEC 60364-7-712.433.2:2002.
- h) Verify that a DC switch disconnector is fitted to the DC side of the inverter (IEC 60364-7-712.536.2.2.5:2002).

- i) If blocking diodes are fitted, verify that their reverse voltage rating is at least $2 \times V_{oc\ stc}$ of the PV string in which they are fitted (IEC 60364-7-712.512.1.1:2002).
- j) If one of the DC conductors is connected to earth, verify that there is at least simple separation between the AC and DC sides and that earth connections have been constructed so as to avoid corrosion (IEC 60364-7-712.312.2:2002).

NOTE 1 Inspection of the DC system requires knowledge of the maximum system voltage and current.

- The maximum system voltage is a function of the string / array design, the open circuit voltage (V_{oc}) of the modules and a multiplier to account for temperature and irradiance variations.
- The maximum possible fault current is a function of the string / array design, the short circuit current (I_{sc}) of the modules and a multiplier to account for temperature and irradiance variations (IEC 60364-7-712.433:2002).

NOTE 2 Where a module reverse current rating (I_r) is not provided by the manufacturer it should be taken to be $1,35 \times$ the modules over-current protection rating.

NOTE 3 Module over-current protection rating should be taken as the value provided by the manufacturer as per the requirements of IEC 61730-1.

5.3.3 Protection against overvoltage / electric shock

Inspection of the PV system shall include, at least verification that:

- a) Verification of type B RCD where: an RCD is installed and the PV inverter is without at least simple separation between the AC side and the DC side, - according to IEC 60755 (IEC 60364-7-712.413.1.1.1.2:2002 and Figure 712.1).
- b) To minimize voltages induced by lightning, verify that the area of all wiring loops has been kept as small as possible (IEC 60364-7-712.444.4:2002).
- c) Where required by local codes, verify that array frame and/or module frame protective earthing conductors have been correctly installed and are connected to earth. Where protective earthing and/or equipotential bonding conductors are installed, verify that they are parallel to, and bundled with, the DC cables (IEC 60364-7-712.54:2002).

5.3.4 AC system

Inspection of the PV system shall include, at least verification that:

- a) a means of isolating the inverter has been provided on the AC side;
- b) all isolation and switching devices have been connected such that PV installation is wired to the "load" side and the public supply to the "source" side? (IEC 60364-7-712.536.2.2.1:2002);
- c) the inverter operational parameters have been programmed to local regulations.

5.3.5 Labelling and identification

Inspection of the PV system shall include, at least, a verification that:

- a) All circuits, protective devices, switches and terminals are suitably labelled.
- b) All DC junction boxes (PV generator and PV array boxes) carry a warning label indicating that active parts inside the boxes are fed from a PV array and may still be live after isolation from the PV inverter and public supply.
- c) The main AC isolating switch is clearly labelled.
- d) Dual supply warning labels are fitted at point of interconnection.
- e) A single line wiring diagram is displayed on site.
- f) Inverter protection settings and installer details are displayed on site.
- g) Emergency shutdown procedures are displayed on site.
- h) All signs and labels are suitably affixed and durable.

5.4 Testing

5.4.1 General

Testing of the electrical installation shall be done to the requirements of IEC 60364-6.

Measuring instruments and monitoring equipment and methods shall be chosen in accordance with the relevant parts of IEC 61557. If other measuring equipment is used, it shall provide an equivalent degree of performance and safety. The test methods described in this Clause are given as reference methods; other methods are not precluded, provided they give no less valid results.

In the event of a test indicating a fault: once that fault has been rectified, all previous tests shall be repeated in case the fault influenced the result of these tests.

The following tests shall be carried out where relevant and should preferably be made in the following sequence:

- a) Tests to all AC circuit(s) to the requirements of IEC 60364-6.

Once tests to the AC circuit(s) are complete, the following tests shall be carried out on the DC circuit(s) forming the PV array.

- b) continuity of protective earthing and/or equipotential bonding conductors, where fitted (see 5.4.2);
- c) polarity test (see 5.4.3);
- d) string open circuit voltage test (see 5.4.4)
- e) string short circuit current test (see 5.4.5)
- f) functional tests (see 5.4.6);
- g) insulation resistance of the DC circuits (see 5.4.7).

In the event of any test indicating failure to comply with the requirements, that test and any preceding test that may have been influenced by the fault shall be repeated.

5.4.2 Continuity of protective earthing and/or equipotential bonding conductors

Where protective or bonding conductors are fitted on the DC side, such as bonding of the array frame, an electrical continuity test shall be made on all such conductors. The connection to the main earthing terminal should also be verified.

5.4.3 Polarity test

The polarity of all DC cables shall be verified using suitable test apparatus. Once polarity is confirmed, cables shall be checked to ensure they are correctly identified and correctly connected into system devices such as switching devices or inverters.

NOTE For reasons of safety and for the prevention of damage to connected equipment, it is extremely important to perform the polarity check before other tests and before switches are closed or string over-current protective devices inserted. If a check is made on a previously connected system and reverse polarity of one string is found, it is then important to check modules and bypass diodes for any damage cause by this error.

5.4.4 PV string - open circuit voltage measurement

The open circuit voltage of each PV string should be measured using suitable measuring apparatus. This should be done before closing any switches or installing string over-current protective devices (where fitted).