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Recommendations for small renewable energy and hybrid systems for rural electrification –

Part 7-1:
Generators – Photovoltaic arrays

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RECOMMENDATIONS FOR SMALL RENEWABLE ENERGY AND HYBRID SYSTEMS FOR RURAL ELECTRIFICATION –

Part 7-1: Generators – Photovoltaic arrays

FOREWORD

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– 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 62257-7-1, which is a technical specification, has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

This first edition of IEC 62257-7-1 is based on IEC/PAS 62111 (1999); it cancels and replaces the relevant parts of IEC/PAS 62111.

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

Enquiry draft	Report on voting
82/406A/DTS	82/446/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.

A list of all parts of the IEC 62257 series, published under the general title, *Recommendations for small renewable energy and hybrid systems for rural electrification* can be found on the IEC website.

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

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- withdrawn,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

A bilingual edition of this document may be issued at a later date.

INTRODUCTION

The IEC 62257 series of publications intends to provide to different players involved in rural electrification projects (such as project implementers, project contractors, project supervisors, installers, etc.) documents for the setting-up of renewable energy and hybrid systems with a.c. voltage below 500 V, d.c. voltage below 750 V and power below 100 kVA.

These publications provide recommendations for

– choosing the right system for the right place;

– designing the system;

– operating and maintaining the system.

These publications are focused only on rural electrification concentrated in, but not specific to, developing countries. They must not be considered as all-inclusive of rural electrification. The publications try to promote the use of renewable energies in rural electrification. They do not deal with clean mechanism developments at this time (CO_2 emission, carbon credit, etc.). Further developments in this field could be introduced in future steps.

This consistent set of publications is best considered as a whole, with different parts corresponding to items for the safety and sustainability of systems at the lowest possible life-cycle cost. One of the main objectives of the series is to provide the minimum sufficient requirements relevant to the field of application, i.e. for small renewable energy and hybrid off-grid systems.

The purpose of this part of IEC 62257 is to propose a framework for project development and management and it includes recommended information that must be taken into consideration during all the steps of the electrification project.

RECOMMENDATIONS FOR SMALL RENEWABLE ENERGY AND HYBRID SYSTEMS FOR RURAL ELECTRIFICATION –

Part 7-1: Generators – Photovoltaic arrays

1 Scope

This part of IEC 62257 specifies the general requirements for erection and operation of PV arrays in decentralized rural electrification systems.

This technical specification contains requirements for ELV and LV PV arrays (see Table 1). Particular attention must be paid to voltage level, as this is important for safety reasons and has an influence on protective measures and on the skill and ability level of people operating the systems.

Table 1 – Voltage domains for PV arrays

Voltage domain	Voltage (volts)	
	Alternating current	Smoothed direct current
ELV	$U_n \leq 50$ V	$U_{oc} \leq 120$ V
LV	50 V < $U_n \leq 1\,000$ V	120 V < $U_{oc} \leq 1\,500$ V
Note ELV limits are provided by IEC 61201.		

For the sake of completeness, this technical specification gives requirements for d.c. voltages below and above 120 V. However for rural electrification projects it is strongly recommended to choose a voltage in the range of extra low voltage, taking into account the assumed skills of the operators, installers and users. Nevertheless, designers must be aware that decreasing the voltage means increasing the current and thus transferring voltage hazards to current risks (risk of fire, etc.).

The following PV array configurations are considered (see Figure 5 to Figure 7):

a) single string of modules;

b) multi-string PV array;

c) PV array divided into several sub-arrays.

Direct current systems, and photovoltaic systems in particular, pose various hazards in addition to those derived from conventional a.c. power systems, for example the ability to produce and sustain electrical arcs with currents that are not much greater than normal operating currents. This technical specification addresses those safety requirements arising from the particular characteristics of photovoltaic systems.

The aim is to provide safety and fire protection requirements for:

– uninformed persons, including owner(s)/occupier(s) and users of the premises where photovoltaic arrays are installed;

– informed workers (e.g. electricians) working on these systems; and

– emergency workers (for example fire fighters).

For installation of PV arrays see IEC 60364-7-712.

2 Normative references

The following referenced documents are indispensable for the application 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 60050-811:1991, *International Electrotechnical Vocabulary – Chapter 811: Electric traction*

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

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

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

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

IEC 60449, *Voltage bands for electrical installations of buildings*

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

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

IEC 61173, *Over-voltage protection for photovoltaic (PV) power generating systems – Guide*

IEC 61201, *Extra-low voltage (ELV) – Limit values*

IEC 61215, *Crystalline silicon terrestrial photovoltaic (PV) modules – Design qualification and type approval*

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

IEC 62257-5, *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 5: Protection against electrical hazards*

IEC 62257-6, *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 6: Acceptance, operation, maintenance and replacement*

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*

3 Terms and definitions

3.1
available, readily
capable of being reached for inspection, maintenance or repairs without necessitating the dismantling of structural parts, cupboards, benches or the like

3.2
blocking diode
diode connected in series to 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)

3.3
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

3.4
cable
assembly of one or more conductors and/or optical fibres, with a protective covering and possibly filling, insulating and protective material

[IEV 151-12-38]

3.5
cable core
the conductor with its insulation but not including any mechanical protective covering

3.6
shield (of a cable)
a surrounding earthed metallic layer to confine the electric field within the cable and/or to protect the cable from external electrical influence

Note Metallic sheaths, armour and earthed concentric conductors may also serve as shields.

[IEV 461-03-04]

3.7
class I equipment
equipment in which protection against electric shock does not rely on basic insulation only, but which includes an additional safety precaution in that accessible conductive parts are connected to the protective earthing conductor in the fixed wiring of the electrical installation in such a way that accessible parts cannot become live in the event of a failure of the basic insulation

NOTE 1 Class I equipment may have parts with double insulation or parts operating at SELV.

NOTE 2 For equipment intended for use with a flexible cord or cable, this provision includes a protective earthing conductor as part of the flexible cord or cable.

3.8
class II equipment
equipment in which protection against electric shock does not rely on basic insulation only, but in which additional safety precautions such as double insulation or reinforced insulation are provided, there being no provision for protective earthing or reliance upon installation conditions. Such equipment may be one of the following types:

– equipment having durable and substantially continuous enclosures of insulating material which envelops all metal parts, with the exception of small parts, such as nameplates, screws and rivets, which are isolated from live parts by insulation at least equivalent to reinforced insulation. Such equipment is called insulation-encased Class II equipment;

– equipment having a substantially continuous metal enclosure, in which double insulation is used throughout, except for those parts where reinforced insulation is used, because the application of double insulation is manifestly impracticable. Such equipment is called metal-encased Class II equipment;

– equipment that is a combination of the types described in Items (a) and (b)

NOTE 1 The enclosure of insulation-encased Class II equipment may form part of the whole of the supplementary insulation or of the reinforced insulation.

NOTE 2 If the equipment with double insulation or reinforced insulation throughout has an earthing terminal or earthing contact, it is considered to be of Class I construction.

NOTE 3 Class II equipment may be provided with means for maintaining the continuity of protective circuits, insulated from accessible conductive parts by double insulation or reinforced insulation.

NOTE 4 Class II equipment may have parts operating at SELV.

3.9
class III equipment
equipment in which protection against electric shock relies on supply at SELV and in which voltages higher than those of SELV are not generated

NOTE Equipment intended to be operated at SELV and which have internal circuits that operate at a voltage other than SELV are not included in the classification and are subject to additional requirements.

3.10
double insulation
insulation comprising both basic insulation and supplementary insulation

[IEV 195-06-08]

3.11
earthing
a protection against electric shocks

3.12
extra-low voltage
ELV
voltage not exceeding the relevant voltage limit of band I specified in IEC 60449

[IEV 826-12-30]

NOTE 1 See also IEC 61201.

NOTE 2 Voltage not exceeding 50 V a.c. and 120 V d.c. ripple free are considered to be ELV.

3.13
$I_{MOD\_REVERSE}$
the current a module can withstand in the reverse direction to normal without damage to the module. This rating is obtained from the manufacturer at expected operating conditions

NOTE 1 This current rating does not relate to bypass diode rating. The module reverse current is the current flowing through the PV cells in the reverse direction to normal current.

NOTE 2 A typical figure for crystalline silicon modules is between 2 and 2,6 times the normal short circuit current rating ISC MOD.

3.14
$I_{SC\ MOD}$
the 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 As PV strings are a group of PV modules connected in series, the short circuit current of a string is equal to $I_{SC\ MOD}$.

3.15
$I_{SC\ S\text{-}ARRAY}$
the short circuit current of a PV sub-array at Standard Test Conditions (STC), and equal to:

$$I_{SC\ S\text{-}ARRAY} = I_{SC\ STC\ MOD} \times S_{SA}$$

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

3.16
$I_{SC\ ARRAY}$
the short circuit current of the PV array at Standard Test Conditions, and is equal to:

$$I_{SC\ ARRAY} = I_{SC\ STC\ MOD} \times S_{A}$$

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

3.17
junction box
closed or protected connecting device allowing making of one or several junctions

[IEV 442-08-03]

3.18
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 This concept does not necessarily imply a risk of electric shock.

[IEV 195-02-19]

3.19
PEL conductor
conductor combining the functions of both a protective earthing conductor and a line conductor

[IEV 195-02-14]

3.20
protected extra-low voltage
PELV
an extra-low voltage system which is not electrically separated from earth, but which otherwise satisfies all the requirements for SELV

3.21
PEM conductor
conductor combining the functions of both a protective earthing conductor and a midpoint conductor

[IEV 195-02-13]

3.22
PEN conductor
conductor combining the functions of both a protective earthing conductor and a neutral conductor

[IEV 195-02-12]

3.23
power conditioning unit
PCU
a 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 5 to Figure 7)

3.24
power conditioning unit, isolated
a power conditioning unit where there is electrical separation between the input and output circuits (e.g. by means of an isolation transformer)

3.25
power conditioning unit, non-isolated
a power conditioning unit where there is no electrical separation between the input and output circuits

3.26
PV array
a) a mechanically integrated assembly of modules or panels and support structure that forms a d.c. electricity-producing unit. An array does not include foundation, tracking apparatus, thermal control, and other such components

[IEC 61836, Ed.2[1)], definition 3.3.45 a)]

b) a mechanically and electrically integrated assembly of PV modules, and other necessary components, to form a DC power supply unit

[IEC 60364-7-712, definition 712.3.4]

NOTE 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 5 to Figure 7). For the purposes of this standard the boundary of a PV array is the output side of the PV array disconnecting device. Two or more PV arrays, which are not interconnected in parallel on the generation side of the power conditioning unit, shall be considered as independent PV arrays.

3.27
PV array cable
the output cable of a PV array that connects the PV array junction box to the PV array disconnecting device

3.28
PV array, earthed
a PV array where one of the poles of the d.c. output circuit is electrically bonded to earth

3.29
PV array, floating
a PV array where none of the poles of the d.c. output circuit is electrically bonded to earth

3.30
PV array, isolated
a PV array where there is at least a simple electrical separation between the PV array output circuit (d.c. side) and the a.c. system

NOTE A simple electrical separation of power circuits is usually achieved by means of a power transformer.

3.31
PV array junction box
a junction box where all strings of any array are connected

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1) In preparation.