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TECHNICAL SPECIFICATION

Simulators used for testing of photovoltaic power conversion equipment – Recommendations – Part 1: AC power simulators

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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SIMULATORS USED FOR TESTING OF PHOTOVOLTAIC POWER CONVERSION EQUIPMENT – RECOMMENDATIONS –

Part 1: AC power simulators

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

IEC TS 63106-1, which is a Technical Specification, has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

The text of this Technical Specifications based on the following documents:

Draft TS	Report on voting
82/1731/DTS	82/1776A/RVDTS

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 document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 63106 series, published under the general title *Simulators used for testing of photovoltaic power conversion equipment – Recommendations*, can be found on the IEC web site.

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- withdrawn,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
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INTRODUCTION

The objective of this document is to establish terminology, and create a framework for, and provide guidance regarding the electrical performance of AC power simulators used to test utility interactive photovoltaic (PV) power conversion equipment (PCE) for compliance with grid interconnection standards.

It serves as a generalized guideline for the development of AC power simulators used within a test and evaluation system for PV PCEs.

Testing laboratories are responsible for selecting the appropriate test items and procedures as well as defining the required performance for adequate evaluation of utility interactive PV PCEs, considering utility power requirements, local codes and regulations.

Utility interactive PCEs are used not only for PV, but also for various distributed generation technologies such as wind power, battery energy storage, engine co-generation or fuel cells. Some of the recommendations in this document may be similar and applicable for AC simulators used to test these other generation technologies, but they are not intended to supersede testing requirements found in related IEC standards.

This document may be used in conjunction with regional or national grid standards and codes, such as:

a) European level utility interaction requirements such as:
   EN 50549-1:2019,
   EN 50549-2:2019.
b) German FGW TG3.
c) UL1741 supplement SA, SRD-UL-1741-SA-V1.1.
d) IEEE 1547-2003, IEEE1547a (Amendment 1) -2014 and IEEE1547.1-2005.
e) IEEE 1547-2018 and IEEE 1547.1-2020.

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SIMULATORS USED FOR TESTING OF PHOTOVOLTAIC POWER CONVERSION EQUIPMENT – RECOMMENDATIONS –

Part 1: AC power simulators

1 Scope

The purpose of this part of IEC 63106 is to provide recommendations for Low Voltage (LV) AC power simulators used for testing utility interactive photovoltaic power conversion equipment (PCE).

NOTE Low Voltage refers to 1 000 Va.c. and less.

The AC power simulators connect to the AC output power port of a PCE under test and simulate the utility grid by generating comparable AC voltage.

The AC power simulators can be used to test a PCE's utility interaction characteristics, including protection, ride through, immunity and power quality. The requirements and procedures are specified in IEC standards and local utility grid requirements, selected by the network operator, utility, or authority having jurisdiction.

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2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes recommendations 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 61000-4-7:2002, *Electromagnetic compatibility (EMC) – Part 4-7: Testing and measurement techniques – General guide on harmonics and interharmonics measurements and :instrumentation, for power supply systems and equipment connected thereto*
IEC 61000-4-7:2002/AMD1:2008

IEC TS 61836:2016, *Solar photovoltaic energy systems – Terms, definitions and symbols*

IEC TS 62910:2020, *Utility-interconnected photovoltaic inverters – Test procedure for under voltage ride-through measurements*

IEC TS 63106-2, *Simulators used for testing of photovoltaic power conversion equipment – recommendations – Part 2: DC power simulators*

IEC TS 63217:–[1], *Utility-interconnected photovoltaic (PV) inverters – Test procedure of high-voltage ride-through measurements*

3 Terms, definitions and abbreviated terms

For the purposes of this document, the terms and definitions given in IEC TS 61836 and the following apply.

[1] Under preparation. Stage at the time of publication: ACD.

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
AC power simulator
system or device able to source and/or absorb AC power, for use in testing of PCE

Note 1 to entry: This document includes a real utility grid, where appropriate, as well as synthetic sources as rotating machines or power converters.

3.2
power conversion equipment
PCE
electrical device converting one form of electrical power to another form of electrical power with respect to voltage, current, frequency, phase and the number of phases

[SOURCE: IEC 62109-1:2010, 3.66]

3.3
port
particular interface of the PCE with external circuits

Note 1 to entry: see Figure 1 for examples of ports.

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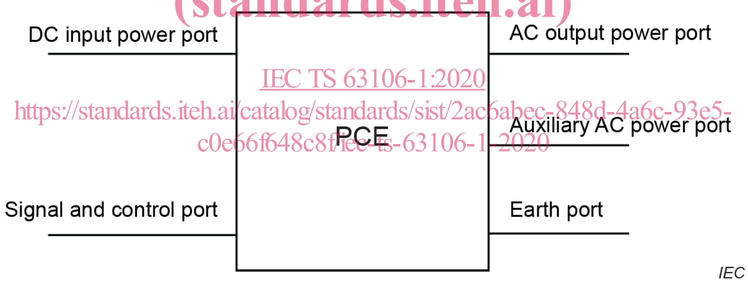

Figure 1 – Examples of ports

3.4
equipment under test
EUT
PCE that is tested by connecting and supplying DC and AC power to each port

3.5
AC output power port
port used to connect to a public low voltage AC mains power distribution network or other low voltage AC mains installation

3.6
DC input power port
port used to connect the PCE to a low voltage DC photovoltaic power generating sub-system

3.7
distributed generation
DG
decentralized power generation system that is connected to the utility grid in a distributed manner

3.8
low voltage
LV
set of voltage levels used for the distribution of electricity

[SOURCE: IEC 60050-601:1985, 601-01-26, modified to delete upper limit voltage]

3.9
high voltage
HV
set of upper voltage levels used in power system for bulk transmission of electricity

[SOURCE: IEC 60050-601:1985, 601-01-27]

3.10
medium voltage
MV
any set of voltage levels lying between low and high voltage

[SOURCE: IEC 60050-601:1985, 601-01-28]

3.11
type test
conformity test made on one or more items representative of the production

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[SOURCE: IEC 60050-151:2001, 151-16-16]

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3.12
OVRT
over voltage ride through for utility failure durability of operation

3.13
UVRT
under voltage ride through for utility failure durability of operation

3.14
OFRT
over frequency ride through for utility failure durability of operation

3.15
UFRT
under frequency ride through for utility failure durability of operation

3.16
ROCOF
rate of change of power system frequency in Hz/s in the transient period

4 PCE types with respect to AC voltage levels and grid interconnection

In this document, utility interconnected voltage or capacity categories are not specified. PCE based DG may be connected to the utility in any of the voltage ranges described below:

a) High voltage transmission or sub-transmission line connection.
b) Medium voltage distribution line connection.
c) Low voltage distribution line connection, including PCEs for residential use and micro inverter or module integrated electronics.

Figure 2 shows examples of DG systems connected to the utility grid.

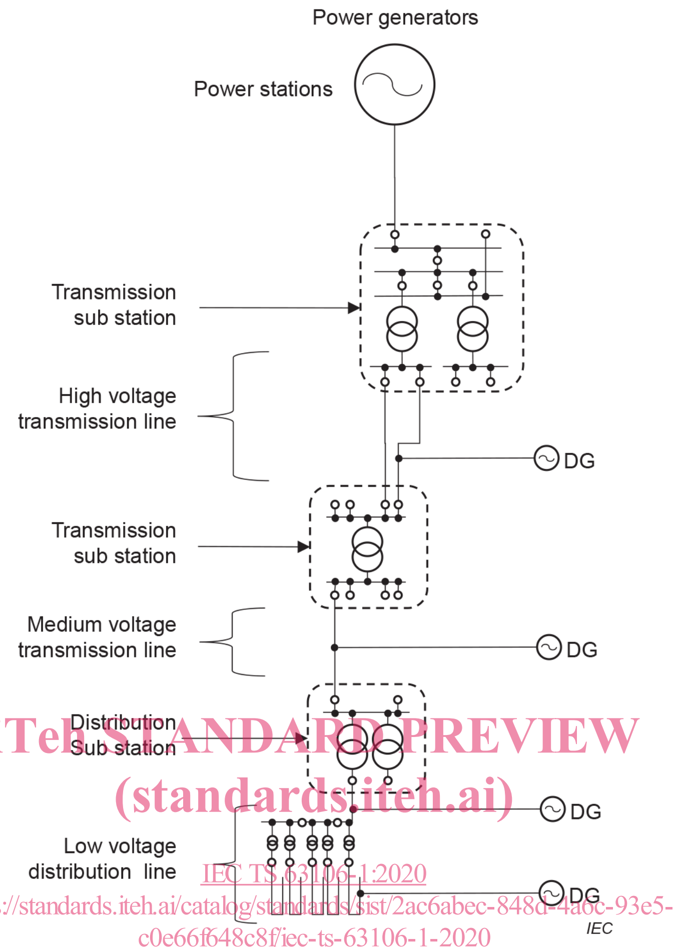

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Figure 2 – Example of connection of DG systems to utility grid

Utility-interactive PCEs typically have AC voltage outputs in the range of 100 V to 1 000 V, determined by the input DC voltage window of the PCE or the input voltage from a DC/DC converter. Connections to the utility grid at higher voltages require the use of step-up transformers. Therefore, an upper limit of 1 000 Va.c. for the AC voltage range of a PCE test system is sufficient.

5 Test setup for utility interactive PCEs

5.1 General

In order to realize valid and reproducible testing, the AC power source shall be appropriate for the test being performed. This may mean utilizing an actual power grid, an AC power generator or an electronic AC power simulator depending on the needs of the specific test under consideration. In this document, recommendations of AC power simulators for a wide range of typical utility interconnection tests are described.

Similarly, the DC power source shall be appropriate for the test being performed. This may mean utilizing an actual PV array output, a conventional power supply, or an electronic PV power simulator depending on the needs of the specific test under consideration. Recommendations for DC power simulators are addressed in IEC TS 63106-2.

NOTE Hardware in the loop (HIL) or software to control the voltage and frequency at the EUT output port point by detecting output power (active and reactive) and calculating the voltage and frequency or phase properties by given utility network model with simulated generators and line impedances are discussed and developed. They are not used for type certification tests but still have potential usefulness in the future for testing the performance of multiple DGs in combination with a smart grid.

5.2 Test setup examples for utility interaction test

5.2.1 General

The test system shall be able to simulate steady state and transient utility grid conditions with respect to AC voltage, frequency, line impedance, load, and other conditions as required for the testing. Figure 3 illustrates basic configuration examples for the EUT test system. Here, EUT is the utility interactive PV PCE under test. A DC power simulator is connected to the DC input power port. An AC power simulator is connected to the AC output power port, with other optional impedance and load equipment.

Figure 3 shows only the main power line connections to DC port, AC port in both sides. An earth line may be shared between DC side and AC side devices.

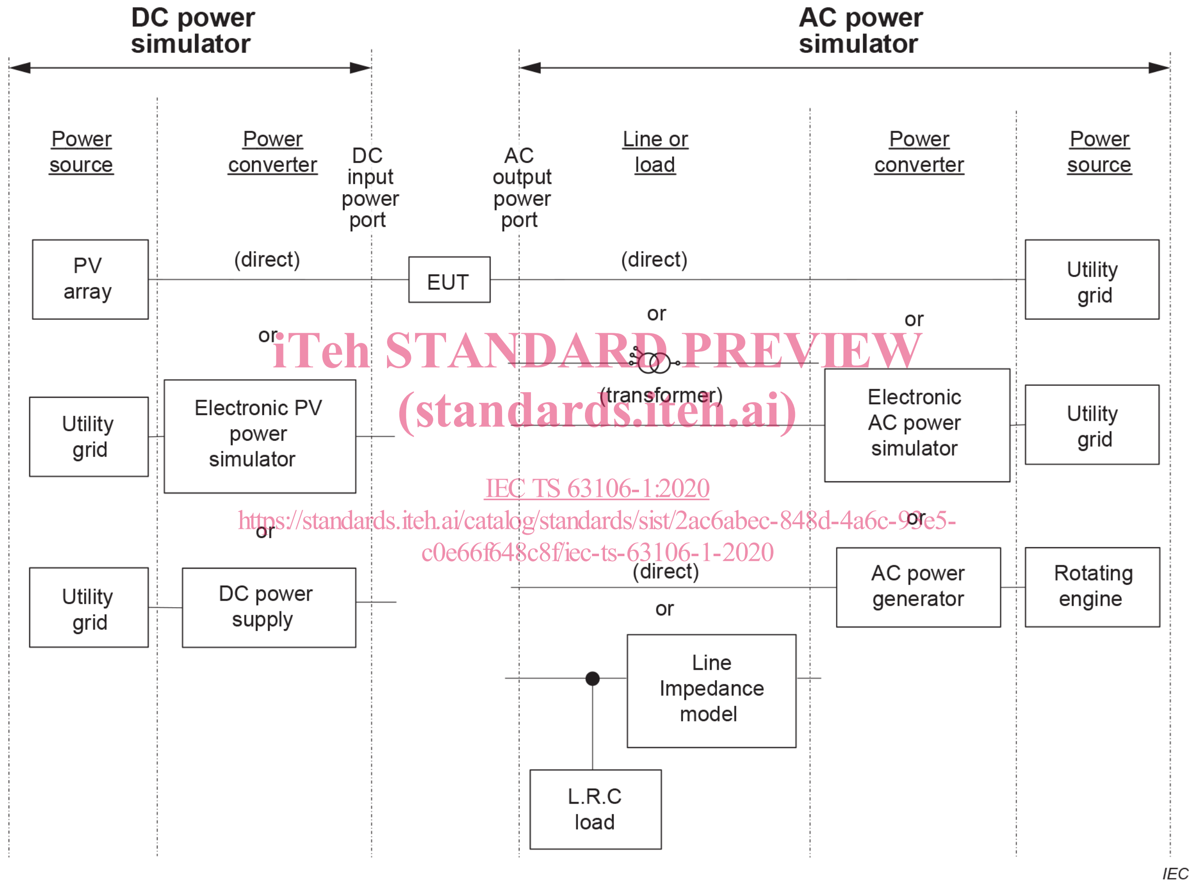

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Figure 3 – Examples of fundamental setup of EUT test system

5.2.2 Types of AC power simulator systems

5.2.2.1 General

AC power simulator systems may consist of one or more of the following types of equipment: in 5.2.2 through 5.2.4. Other approaches are possible depending on the test(s) under consideration. As different tests have different power simulator needs, it may be required or optional for a facility to have more than one type of AC power simulator.

The internal resistance of an AC power simulator including connections to the EUT so measured at the EUT AC output power port should be designed referring the real-world distribution and transmission line impedance, for attaining the reasonable test result for power qualities, as harmonics, DC injection, or flicker tests.