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TECHNICAL SPECIFICATION

Simulators used for testing of photovoltaic power conversion equipment – Recommendations – Part 2: DC power simulators

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Simulators used for testing of photovoltaic power conversion equipment – Recommendations – Part 2: DC power simulators

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FOREWORD

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IEC TS 63106-2 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems. It is a Technical Specification.

The text of this Technical Specification is based on the following documents:

Draft	Report on voting
82/1954/DTS	82/1999/RVDTS

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Technical Specification is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/standardsdev/publications.

A list of all parts in the IEC TS 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 webstore.iec.ch in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
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- amended.

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INTRODUCTION

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

Along with IEC TS 63106-1, it provides guidance for the selection or development of 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.

It is intended for this document to be used in conjunction with parallel PCE standards developed for specific performance or grid-interaction requirements.

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

Part 2: DC power simulators

1 Scope

The purpose of this part of IEC TS 63106 is to provide recommendations for Low Voltage (LV) DC power simulators used for testing photovoltaic (PV) power conversion equipment (PCE) to utility interconnection or PV performance standards.

NOTE Low Voltage refers to DC voltage 1 500 V and less.

In this document, the term “DC power simulator” refers to any source that is used during testing to provide DC power to the Equipment Under Test (EUT). That includes, but is not limited to, PV array simulators designed to simulate the DC output I-V curve of a photovoltaic array operating in real-world conditions.

This document primarily addresses DC power simulators used for testing of grid-interactive PCE, also referred to as grid-connected power converters (GCPCs). It also addresses some uses of DC power simulators for testing stand-alone and multi-mode PCEs.

There are many types of tests that can be conducted by utilizing a DC power simulator. Certain tests require the use of a PV array or PV array simulator, such as measurements of the PCE’s PV input static and dynamic characteristics related to maximum power point tracking, while other tests may be appropriate to conduct with a static DC power supply. Test requirements and procedures are specified in IEC standards and local utility grid requirements, selected by the system integrator, PCE manufacturer, network operator, utility, or third-party inspector.

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 61683, *Photovoltaic systems – Power conditioners – Procedure for measuring efficiency*

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

IEC 62116, *Utility-interconnected photovoltaic inverters – Test procedure of islanding prevention measures*

IEC 62891, *Maximum power point tracking efficiency of grid connected photovoltaic inverters*

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

IEC TS 63106-1:2020, *Simulators used for testing of photovoltaic power conversion equipment – Recommendations – Part 1: AC power simulators*

EN 50530, *Overall efficiency of grid connected photovoltaic inverters*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC TS 61836, and the following 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
DC power simulator
system or device able to source and/or absorb DC power, for use in testing of PCE

Note 1 to entry: In this document, DC power simulator is the general term including PV array, conventional DC power supply or PV array simulator.

3.2
PV array simulator
type of DC power simulator that implements the key characteristics of the I-V curve of real photovoltaic module types, having a maximum power point, operating voltage, and available current that vary with load and irradiance

3.3
power conversion equipment
PCE
electrical device converting one kind of electrical power from a voltage or current source into another kind of electrical power with respect to voltage, current and frequency

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

3.4
port
terminal or set of terminals where the PCE connects to conductors of an external power, control, or communications system

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

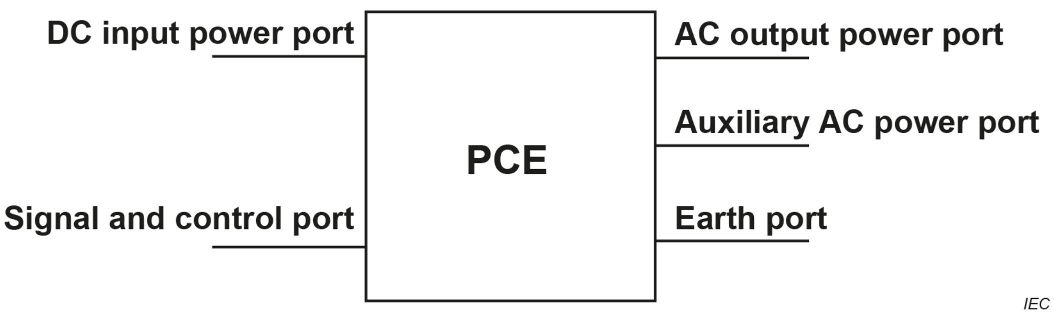

Figure 1 – Examples of ports

3.5
equipment under test
EUT
PCE that is tested by connecting and supplying DC and AC power to each port

3.6
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

3.7
DC input power port
port used to connect the PCE to the DC power simulator during testing, or a PV array or other DC source in the installation

3.8
type test
conformity test performed on one or more items representative of the production

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

3.9
maximum power point
MPP
operational voltage and current point on the output characteristic of photovoltaic module or array that delivers the largest output power depending on solar irradiance and temperature

3.10
maximum power point tracking
MPPT
PCE control function to survey the maximum input DC power point on the characteristic of photovoltaic modules power generation

3.11
under voltage ride through
UVRT
PCE operational durability for the situation of low voltage supply by the AC power system

3.12
open circuit voltage
V_{oc}
open circuit voltage that appears at the output terminal of photovoltaic module or array under solar irradiation

3.13
short circuit current
I_{sc}
short circuit current that appears at the output terminal of photovoltaic module or array under solar irradiation

4 PCE types with respect to DC voltage levels

4.1 General

PV PCE may be connected to PV modules or arrays in a variety of ways.

The maximum limit of the operating DC voltage range of PV PCE takes into account the absolute maximum value of the open circuit voltage of the array under any condition (irradiance, temperature, etc.).

Therefore, an upper limit of 1 500 V for the DC voltage range of a PCE test system is sufficient.

4.2 Module level PCE

Module level PCE is connected to a single PV module with operating voltages typically in the DC voltage 65 V to 100 V range.

However, some DC to DC converters are used in series connection, so it may be necessary for the DC power simulator to be able to superimpose the system voltage (e.g. DC 1 000 V), with respect to earth, depending on the test purpose.

4.3 String level PCE

String level PCE is connected to series strings of PV modules, with operating and system voltages typically from DC voltage 600 V to 1 500 V maximum.

4.4 Central PCE

Central PCE is connected to a large number of series strings of PV modules in parallel, with operating and system voltages typically from DC voltage 600 V to 1 500 V maximum.

5 Test setup for utility interactive inverters

5.1 General

In order to realize valid and reproducible testing, the DC power source should be appropriate for the test being performed. This may mean utilizing an actual PV array, a conventional DC power supply, or a PV array simulator depending on the needs of the specific test under consideration.

In order to realize valid and reproducible testing, the AC power source should also be appropriate for the test being performed. Recommendations for AC power simulators are addressed in IEC TS 63106-1.

5.2 Test setup examples

Figure 2 illustrates basic configuration examples for the EUT test system. Here, EUT is the 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 2 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.

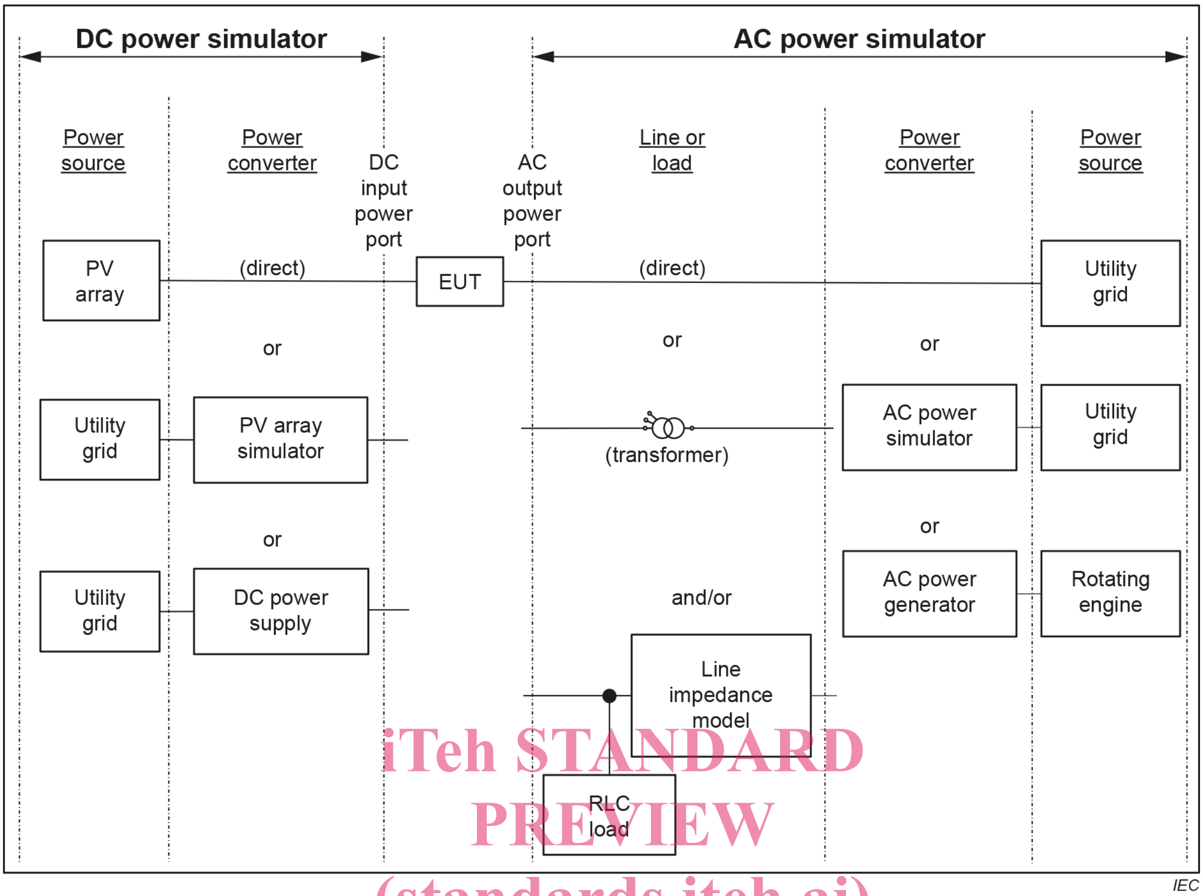

Figure 2 – Examples of fundamental setup of EUT test system

5.3 System configuration options

5.3.1 General

DC power simulators may consist of one or more of the following types of equipment. Other approaches are possible depending on the test(s) under consideration.

As different tests have different power simulator needs, it may be necessary or optimal for a facility to have more than one type of DC power simulator.

5.3.2 PV array

A PV array provides real-world irradiance variations, etc., which may be useful or necessary for some types of tests. However, irradiance conditions may make it impractical for tests that need stable, continuous and full capacity output power, so test feasibility and scheduling are subject to time and weather conditions.

For module level or very small array level PCE, an indoor array with artificial lighting may be a viable option.

In all cases where a real PV array is used, the response depends on the module technology (crystalline, thin film, etc.) and cannot be changed.

A PV array is also used as an option for an evaluation of output voltage/current characteristics of a PV array simulator or DC power supply, in case the performance of the PV array simulator or DC power supply has to be compared to a real PV array for the test combined with PCE.

5.3.3 PV array simulator

A PV array simulator is a power supply that has I-V curve characteristics resembling an actual PV module array.

The I-V curve can be based on information from PV module manufacturers or could be specified in the standards that the PCE is being tested to (e.g., IEC 62891 or EN 50530).

PV array simulators provide voltage, current and power with the characteristics of real PV modules but without dependence on time and weather conditions.

They can be configured to simulate different irradiance levels and module technologies (crystalline, thin film, etc.).

As some aspects of PCE functionality and performance may be critically dependent on, or influenced by, the I-V curve, use of an PV array simulator may be necessary or preferred for certain types of tests.

NOTE The I-V curve characteristics examples of crystalline and thin film PV modules used for the EUT testing are indicated in IEC 62891 and EN 50530.

5.3.4 DC power supply

A DC power supply is a general-purpose AC to DC power converter with no capability for simulating the I-V curve of a PV module. Such power supplies typically operate their output in constant voltage or constant current mode and offer stable control over DC voltage and the available current and power.

However, this square-shaped I-V curve represents a unity fill-factor, which does not occur in real PV arrays.

The extent to which a DC power supply will work for certain type tests depends on whether or not the test results rely on or can be affected by the I-V curve of the source. Also, the EUT's MPPT control software may not find a stable operating point when the source has a rectangular I-V curve.

The issue may be rectified by applying a series resistance between the DC power supply and the EUT, creating a roll-off curve and MPP that is easier for the EUT's control software to locate.

When applying a series resistance, the maximum DC voltage applied to EUT with zero-current output, should be known and should not exceed the maximum rated voltage of EUT.

However, when the EUT's power capacity is at MW-scale, the power consumption and heat dissipation due to series resistance may be prohibitively large.

6 General recommendations for DC power simulator

6.1 General

In this clause, general recommendations for DC power simulators are indicated.

The AC power input frequency and voltage requirements for DC power simulators are specified by the manufacturer considering the DC output voltage/current accuracy, including dynamic performance.