IEC TS 63106-2

Edition 1.0 2022-03

TECHNICAL SPECIFICATION

colour inside

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

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ICS 27.160

ISBN 978-2-8322-1093-5

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

® Registered trademark of the International Electrotechnical Commission

CONTENTS

FOREWORD 5
INTRODUCTION 7
1 Scope 8
2 Normative references 8
3 Terms and definitions 9
4 PCE types with respect to DC voltage levels 10
4.1 General 10
4.2 Module level PCE 11
4.3 String level PCE 11
4.4 Central PCE 11
5 Test setup for utility interactive inverters 11
5.1 General 11
5.2 Test setup examples 11
5.3 System configuration options 12
5.3.1 General 12
5.3.2 PV array 12
5.3.3 PV array simulator 13
5.3.4 DC power supply 13
6 General recommendations for DC power simulator 13
6.1 General 13
6.2 DC output voltage accuracy and ripple 14
6.3 I-V curve stability for EUT testing 14
6.3.1 General 14
6.3.2 DC irradiance change rate 15
6.4 DC power simulator performance and characteristics for utility interaction tests 16
6.5 Additional tests conducted with DC power simulators 34
6.5.1 General 34
6.5.2 PCE operational stability with sudden irradiance changes (due to movement of sun between clouds) 35
6.5.3 Automatic start and stop operation with gradual irradiance changes (representing morning and evening conditions) 36
6.5.4 PCE DC to AC power conversion efficiency measurement 36
6.5.5 PCE maximum power point tracking efficiency measurement 36
6.5.6 PCE total power conversion efficiency measurement 37
6.6 Avoidance measures of transient impact to EUTs 37
Annex A (informative) DC I-V curve dynamic accuracy against MPPT control 38
A.1 General 38
A.2 Example of DC I-V curve stability for MPPT properties 38
A.2.1 MPPT control 38
A.2.2 Recommended stability of operation on the I-V curve 39
A.2.3 Recommended I-V curve resolution 39
A.2.4 Use of DC power supply as an input of EUT 39
Annex B (informative) DC power simulator stability against utility- frequency ripple voltage/current 41
B.1 General 41
B.2 Example of twice the utility- frequency ripple voltage/current 41
B.2.1 Twice the utility frequency ripple voltage/current 41

B.2.2 Stability of I-V curve for the DC ripple 42
Annex C (informative) PV array simulator I-V curve stability against quick power change in UVRT test 44
C.1 General 44
C.2 DC voltage/current shift by withdrawing power change in UVRT test 44
Annex D (informative) DC I-V curve stability against low irradiance at sunrise and sunset 47
D.1 General 47
D.2 Example of a DC I-V curve stability against slow irradiance change rate in the morning and evening – I-V curve with low irradiance periods and EUT input voltage/current transition 47
Annex E (informative) DC I-V curve behaviour in rapidly varying irradiance conditions 49
E.1 General 49
E.2 I-V curve response to varying irradiance 49
E.2.1 Irradiance sudden change on I-V characteristics of the PV array (an example) 49
E.2.2 Recommendation of irradiance quick change rate for test of the EUT by PV array simulator 49
Bibliography 52

Figure 1 – Examples of ports 9
Figure 2 – Examples of fundamental setup of EUT test system 12
Figure A.1 – Voltage and current swing by MPPT control on I-V curve around MPP 38
Figure A.2 – Current and voltage swing by MPPT control on I-V curve below MPP 39
Figure A.3 – Current and voltage swing by MPPT control on I-V characteristic curve of DC power supply 40
Figure B.1 – DC current and voltage ripple on single-phase GCPC 41
Figure B.2 – DC current and voltage ripple on three-phase GCPC with UVRT test 42
Figure B.3 – DC ripple I-V swing on I-V curve of PV array 43
Figure C.1 – DC input voltage/current transition on zero-voltage ride through test – AC voltage sudden reduction 45
Figure C.2 – DC input voltage/current transition on zero-voltage ride through test – AC voltage sudden recovery 46
Figure C.3 – DC input voltage/current transition on UVRT test – AC voltage sudden decrease 46
Figure D.1 – DC input voltage/current transition area in the morning and evening 47
Figure D.2 – DC input voltage transition pattern example in the morning 48
Figure E.1 – DC input voltage/current quick transition and MPPT 50
Figure E.2 – Irradiance quick change example 50
Figure E.3 – Irradiation change rate for PV array and wind orientation 51

Table 1 – Grid qualification/Requalification – In-range AC voltage before connection/reconnection 17
Table 2 – Grid qualification/Requalification – In-range AC frequency before connection/reconnection 18
Table 3 – Power capability: Nameplate P, Q, S under normal and near-normal grid conditions 19
Table 4 – Power capability: Limitation of P/Q/S/PF by setpoint 20
Table 5 – Power capability: Ramp rate or soft start time-developing magnitude by set rate . 21

Table 6 – Grid protection tests – AC over-voltage (OV) and under-voltage (UV) trip tests 22
Table 7 – Grid protection tests: OF/UF trips 22
Table 8 – Grid protection tests: Anti-islanding 23
Table 9 – Grid protection tests: Rate of Change of Frequency (ROCOF) trips 24
Table 10 – Grid protection tests: Open phase 24
Table 11 – Power quality tests: Current harmonics, inter-harmonics, THDi 25
Table 12 – Power quality tests: Flicker (continuous) 26
Table 13 – Power quality tests: Current inrush (at connection switch close) 27
Table 14 – Power quality tests: AC output current imbalance 27
Table 15 – Power quality tests: Transient over-voltage (TrOV) on load dump 28
Table 16 – Grid support tests: UV/OV ride-through with/without Iq injection 29
Table 17 – Grid support tests: UF/OF ride-through 30
Table 18 – Grid support tests: ROCOF ride-through 30
Table 19 – Grid support tests: Phase-jump ride-through 31
Table 20 – Grid support tests: P (f), PF (P, V), Q (V), P (V) 32
Table 21 – External command response tests: Magnitude accuracy for P/Q/S/PF by setpoint 33
Table 22 – External command response tests: Response to external setpoint changes (response time, settling time test) 34
Table 23 – Test items and DC power simulators application for PCE 35

INTERNATIONAL ELECTROTECHNICAL COMMISSION

_____

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

Part 2: DC power simulators

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.

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

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.

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*