



BSI Standards Publication

# Simulators used for testing of photovoltaic power conversion equipment — Recommendations

---

Part 1: AC power simulators

## National foreword

This Published Document is the UK implementation of IEC TS 63106-1:2020.

The UK participation in its preparation was entrusted to Technical Committee GEL/82, Photovoltaic Energy Systems.

A list of organizations represented on this committee can be obtained on request to its committee manager.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2020  
Published by BSI Standards Limited 2020

ISBN 978 0 580 97395 6

ICS 27.160

**Compliance with a British Standard cannot confer immunity from legal obligations.**

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 30 November 2020.

### Amendments/corrigenda issued since publication

| Date | Text affected |
|------|---------------|
|------|---------------|

---



# IEC TS 63106-1

Edition 1.0 2020-11

## TECHNICAL SPECIFICATION

---

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

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

---

ICS 27.160

ISBN 978-2-8322-9035-4

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

## CONTENTS

|                                                                                                        |    |
|--------------------------------------------------------------------------------------------------------|----|
| FOREWORD.....                                                                                          | 4  |
| INTRODUCTION.....                                                                                      | 6  |
| 1 Scope.....                                                                                           | 7  |
| 2 Normative references .....                                                                           | 7  |
| 3 Terms, definitions and abbreviated terms .....                                                       | 7  |
| 4 PCE types with respect to AC voltage levels and grid interconnection .....                           | 9  |
| 5 Test setup for utility interactive PCEs .....                                                        | 10 |
| 5.1 General.....                                                                                       | 10 |
| 5.2 Test setup examples for utility interaction test.....                                              | 11 |
| 5.2.1 General .....                                                                                    | 11 |
| 5.2.2 Types of AC power simulator systems .....                                                        | 11 |
| 5.2.3 Load .....                                                                                       | 12 |
| 5.2.4 Line impedance .....                                                                             | 13 |
| 6 General recommendations for AC power simulators.....                                                 | 13 |
| 6.1 General.....                                                                                       | 13 |
| 6.1.1 Overview .....                                                                                   | 13 |
| 6.1.2 AC main connections .....                                                                        | 13 |
| 6.1.3 Output transformer .....                                                                         | 13 |
| 6.1.4 Number of phases and voltage range.....                                                          | 13 |
| 6.1.5 Frequency ranges supplied to EUT.....                                                            | 14 |
| 6.1.6 Voltage stability and accuracy .....                                                             | 14 |
| 6.1.7 Frequency stability and accuracy.....                                                            | 14 |
| 6.1.8 AC output voltage harmonic distortion .....                                                      | 14 |
| 6.1.9 Signal interface for hardware in the loop.....                                                   | 15 |
| 6.1.10 Durability against impulse test voltage.....                                                    | 15 |
| 6.1.11 Other requirements for test properties .....                                                    | 15 |
| 6.2 AC power simulator performance and characteristics .....                                           | 15 |
| Bibliography.....                                                                                      | 38 |
| Figure 1 – Examples of ports .....                                                                     | 8  |
| Figure 2 – Example of connection of DG systems to utility grid .....                                   | 10 |
| Figure 3 – Examples of fundamental setup of EUT test system .....                                      | 11 |
| Table 1 – Typical maximum harmonic voltage distortion (as per IEC 61000-4-7:2002) .....                | 14 |
| Table 2 – Grid qualification/Requalification – In-range voltage before connection/reconnection .....   | 16 |
| Table 3 – Grid qualification/Requalification – In-range frequency before connection/reconnection ..... | 17 |
| Table 4 – Power capability: Nameplate P, Q, S under normal and near-normal grid conditions .....       | 18 |
| Table 5 – Power capability: Limitation of P/Q/S/PF by setpoint .....                                   | 19 |
| Table 6 – Power capability: Ramp rate or soft start time-developing magnitude by set rate .....        | 20 |
| Table 7 – Grid protection tests – AC over-voltage (OV) and under-voltage (UV) trip tests .....         | 21 |

|                                                                                                                        |    |
|------------------------------------------------------------------------------------------------------------------------|----|
| Table 8 – Grid protection tests: OF/UF trips .....                                                                     | 22 |
| Table 9 – Grid protection tests: Anti-islanding .....                                                                  | 23 |
| Table 10 – Grid protection tests: ROCOF trips .....                                                                    | 24 |
| Table 11 – Grid protection tests: Open phase .....                                                                     | 25 |
| Table 12 – Power quality tests: Current harmonics, inter-harmonics, THDi .....                                         | 26 |
| Table 13 – Power quality tests: Flicker (continuous) .....                                                             | 27 |
| Table 14 – Power quality tests: Current inrush (at connection switch close) .....                                      | 28 |
| Table 15 – Power quality tests: Current imbalance .....                                                                | 29 |
| Table 16 – Power quality tests: Transient OV on load dump .....                                                        | 30 |
| Table 17 – Grid support tests: UV/OV ride-through with/without $I_q$ injection .....                                   | 31 |
| Table 18 – Grid support tests: UF/OF ride-through .....                                                                | 32 |
| Table 19 – Grid support tests: ROCOF ride-through .....                                                                | 33 |
| Table 20 – Grid support tests: Phase-jump ride-through .....                                                           | 34 |
| Table 21 – Grid support tests: P (f), PF (P, V), Q (V), P (V) .....                                                    | 35 |
| Table 22 – External command response tests: Magnitude accuracy for $I_q$ , Q, PF by setpoint .....                     | 36 |
| Table 23 – External command response tests: Response to external setpoint changes (response time, settling time) ..... | 37 |

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**SIMULATORS USED FOR TESTING OF PHOTOVOLTAIC POWER  
CONVERSION EQUIPMENT – RECOMMENDATIONS –****Part 1: AC 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.

The main task of IEC technical committees is to prepare International Standards. In exceptional circumstances a technical committee may propose the publication of a Technical Specification when

- 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 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
- amended.

## 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.

# 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.

### 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.

---

<sup>1</sup> Under preparation. Stage at the time of publication: ACD.