



DPC: 23 / 30456172 DC

BSI Group Headquarters

389 Chiswick High Road London W4 4AL

Tel: +44 (0)20 8996 9000

Fax: +44 (0)20 8996 7400

www.bsigroup.com

Date: 02 February 2023

Origin: International

Latest date for receipt of comments: 22 March 2023

Project No. 2022/01006

Responsible committee: GEL/82 Photovoltaic Energy Systems

Interested committees:

Title: BS EN 63409-3 Photovoltaic power generating systems connection with grid - Testing of power conversion equipment

Part 3: Basic operations

Please notify the secretary if you are aware of any keywords that might assist in classifying or identifying the standard or if the content of this standard

- i) has any issues related to 3rd party IPR, patent or copyright
- ii) affects other national standard(s)
- iii) requires additional national guidance or information

**WARNING: THIS IS A DRAFT AND MUST NOT BE REGARDED OR USED AS A BRITISH STANDARD.
THIS DRAFT IS NOT CURRENT BEYOND 22 March 2023**

This draft is issued to allow comments from interested parties; all comments will be given consideration prior to publication. No acknowledgement will normally be sent. **See overleaf for information on the submission of comments.**

No copying is allowed, in any form, without prior written permission from BSI except as permitted under the Copyright, Designs and Patent Act 1988 or for circulation within a nominating organization for briefing purposes. Electronic circulation is limited to dissemination by e-mail within such an organization by committee members.

Further copies of this draft may be purchased from BSI Shop <http://shop.bsigroup.com> or from BSI Customer Services, Tel: +44(0) 20 8996 9001 or email cservices@bsigroup.com. British, International and foreign standards are also available from BSI Customer Services.

Information on the co-operating organizations represented on the committees referenced above may be obtained from <http://standardsdevelopment.bsigroup.com>

Responsible Committee Secretary: Ms Nicola Young (BSI)

Direct tel:

E-mail: nicola.young@bsigroup.com

Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

- **Annotated drafts are not acceptable and will be rejected.**
- All comments should be submitted online at <https://standardsdevelopment.bsigroup.com/>. You will need to register in order to comment.

Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx
------------------	------------------------

1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex (e.g. 3.1)	Paragraph/Figure/ Table/Note	Type of comment	Commend (justification for change) by the MB	Proposed change by the MB	Secretariat observations on each comment submitted
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	

PROJECT NUMBER:

IEC 63409-3 ED1

DATE OF CIRCULATION:

2023-01-27

CLOSING DATE FOR COMMENTS:

2023-04-21

SUPERSEDES DOCUMENTS:

82/2034/NP, 82/2049A/RVN**IEC TC 82 : SOLAR PHOTOVOLTAIC ENERGY SYSTEMS**

SECRETARIAT:

United States of America

SECRETARY:

Mr George Kelly

OF INTEREST TO THE FOLLOWING COMMITTEES:

TC 8, TC 22, TC 57, TC 69, TC 77, TC 88, ACTAD

PROPOSED HORIZONTAL STANDARD:

☐

Other TC/SCs are requested to indicate their interest, if any, in this CD to the secretary.

FUNCTIONS CONCERNED:

☐ EMC☐ ENVIRONMENT☒ QUALITY ASSURANCE☐ SAFETY

This document is still under study and subject to change. It should not be used for reference purposes.

Recipients of this document are invited to submit, with their comments, notification of

- any relevant patent rights of which they are aware and to provide supporting documentation,
- any local regulations or technical reasons that may exist and should be considered should this proposal proceed, recognizing that failure to address such requirements could result in the need for new or existing "in some countries" clauses. See AC/22/2007.

TITLE:

Photovoltaic power generating systems connection with grid – Testing of power conversion equipment – Part 3: Basic operations

NOTE FROM TC/SC OFFICERS:

This project was discussed and supported by WG6 during their meeting in 2022-11.

Copyright © 2023 International Electrotechnical Commission, IEC. All rights reserved. It is permitted to download this electronic file, to make a copy and to print out the content for the sole purpose of preparing National Committee positions. You may not copy or "mirror" the file or printed version of the document, or any part of it, for any other purpose without permission in writing from IEC.

CONTENTS

FOREWORD	4
INTRODUCTION	6
1 Scope	8
2 Normative references	8
3 Terms and definitions	8
4 General requirements	10
4.1 General conditions for testing	10
4.1.1 Sequence of tests	10
4.1.2 Test equipment conditions	10
4.1.3 Manufacturer's stated accuracy	10
4.1.4 Required setting for EUT	10
4.1.5 PCE firmware used during the test	11
4.1.6 Reporting the test results	11
4.2 Test setup	11
4.3 Parameters used in the tests	11
5 Test procedures	13
5.1 Steady State characteristics	13
5.1.1 General	13
5.1.2 Active power and reactive power	13
5.1.3 Operable voltage	14
5.1.4 Operable frequency	15
5.1.5 Power factor	17
5.2 Transient-response characteristics	17
5.2.1 General	17
5.2.2 Active power control	17
5.2.3 Reactive power control	18
5.2.4 Level of grid voltage	19
5.2.5 Phase angle of grid voltage	20
5.2.6 Grid voltage unbalance	21
5.2.7 Grid frequency	22
Annex A (informative) Summary of test items	23
Annex B (normative) Format for recording test results	25
B.1 Steady State characteristics	25
B.1.1 Active power and reactive power (Cl.5.1.2)	25
B.1.2 Operable voltage (Cl.5.1.3)	26
B.1.3 Operable frequency (Cl.5.1.4)	27
B.1.4 Power factor (Cl.5.1.5)	27
B.2 Transient-response characteristics	27
B.2.1 Active power control (Cl.5.2.2)	27
B.2.2 Reactive power control (Cl.5.2.3)	28
B.2.3 Level of grid voltage (Cl.5.2.4)	29
B.2.4 Phase angle of grid voltage (Cl.5.2.5)	30
B.2.5 Grid voltage unbalance (Cl.5.2.6)	31

B.2.6	Grid frequency (Cl.5.2.7).....	32
Bibliography		34
IEC publications		34
National or regional standards		34
Figure 1- Scopes of IEC 63409		7
Figure 2 – Test setup example -		11
Figure 3– Example operational parameters in PQ capability curve of PCE.....		12
Figure B.1 – P-Q capability curve showing Active power and reactive power test results and Power factor test results (example)		26
Figure B.2 – Active power control test waveform example when active power setpoint was changed from 100% to 50%.....		28
Figure B.3 – Reactive power control test waveform example when reactive power setpoint was changed from 52.7% to 0%		29
Figure B.4 – Level of grid voltage change test waveform example when AC voltage was changed from 100% to 110%.....		30
Figure B.5 – Phase angle of grid voltage change test waveform example when 10 degree step change was applied to AC voltages		31
Figure B.6 – Grid voltage unbalance test waveform example when 10 % negative sequence voltage was applied to AC voltages		32
Figure B.7 – Grid frequency change test waveform example when AC frequency was changed from 50Hz to 50.5Hz		33
Table 1 – Parameters defined for the tests		11
Table 2: Test conditions for operable voltage test		14
Table 3: Test conditions for operable frequency test		16
Table A.1: Test items for Steady state characteristics (example).....		23
Table A.2: Test items for Transient-response characteristics (example)		23
Table B.1:Record of Active power and reactive power test (example).....		25
Table B.2:Record of Operable voltage test (example).....		26
Table B.3:Record of Operable frequency test (example).....		27
Table B.4:Record of Power factor test (example).....		27
Table B.5:Record of Active power control test (example).....		27
Table B.6:Record of Reactive power control test (example).....		28
Table B.7:Record of Level of grid voltage change test (example)		29
Table B.8:Record of Phase angle of grid voltage test (example).....		30
Table B.9:Record of Grid voltage unbalance test (example)		31
Table B.10:Record of Grid frequency change test (example)		32

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**PHOTOVOLTAIC POWER GENERATING SYSTEMS CONNECTION WITH THE GRID –
TESTING OF POWER CONVERSION EQUIPMENT –****Part 3: Basic operations**

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.

International Standard IEC 63409-3 ED1, PHOTOVOLTAIC POWER GENERATING SYSTEMS CONNECTION WITH THE GRID – TESTING FOR POWER CONVERSION EQUIPMENT – Part 3: Basic operations has been prepared by IEC technical committee 82.

The text of this International Standard is based on the following documents:

FDIS	Report on voting
XX/XX/FDIS	XX/XX/RVD

Full information on the voting for the approval of this International Standard 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.

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.

The National Committees are requested to note that for this document the stability date is 20XX..

THIS TEXT IS INCLUDED FOR THE INFORMATION OF THE NATIONAL COMMITTEES AND WILL BE DELETED AT THE PUBLICATION STAGE.

INTRODUCTION

Background

TC82 has been making efforts to contribute the standardization of DER connection with the grid. In 2016, It joined TC8/JWG10 to harmonize with utility power system operation requirements. In parallel with such a liaison work, TC82 has also been preparing the standardization of testing of grid connection requirements for power conversion equipment (PCE) for use in PV systems since 2016.

Purpose

This working draft (WD) proposes the Part 3 of this series which gives test procedures for confirming the basic operation characteristics of PCE.

The main purpose of Part 3 is to confirm basic power conversion control of PCE at steady state condition and at transient response. Figure 1 shows the relationships of the seven parts in IEC 63409. Part 3 is focused on the control functions in PCE in respect of power conversion. Power flow control and grid support functions will generate active and reactive power commands according to the grid conditions. The commands are sent to power conversion control, and power conversion control will make current or voltage references, which manipulate signals for the switching devices.

It is important to confirm the basic control performance of the PCE as power conversion equipment without power flow control and grid support functions so that additional functions such as power flow control and grid support functions can perform appropriately.

Power flow control and grid support functions will be covered in Part 6.

The responses of PCE against abnormal grid conditions will be covered in Part 4.

Power quality of the PCE output will be covered in Part 5.

Responses against commands through communication will be covered Part 7.

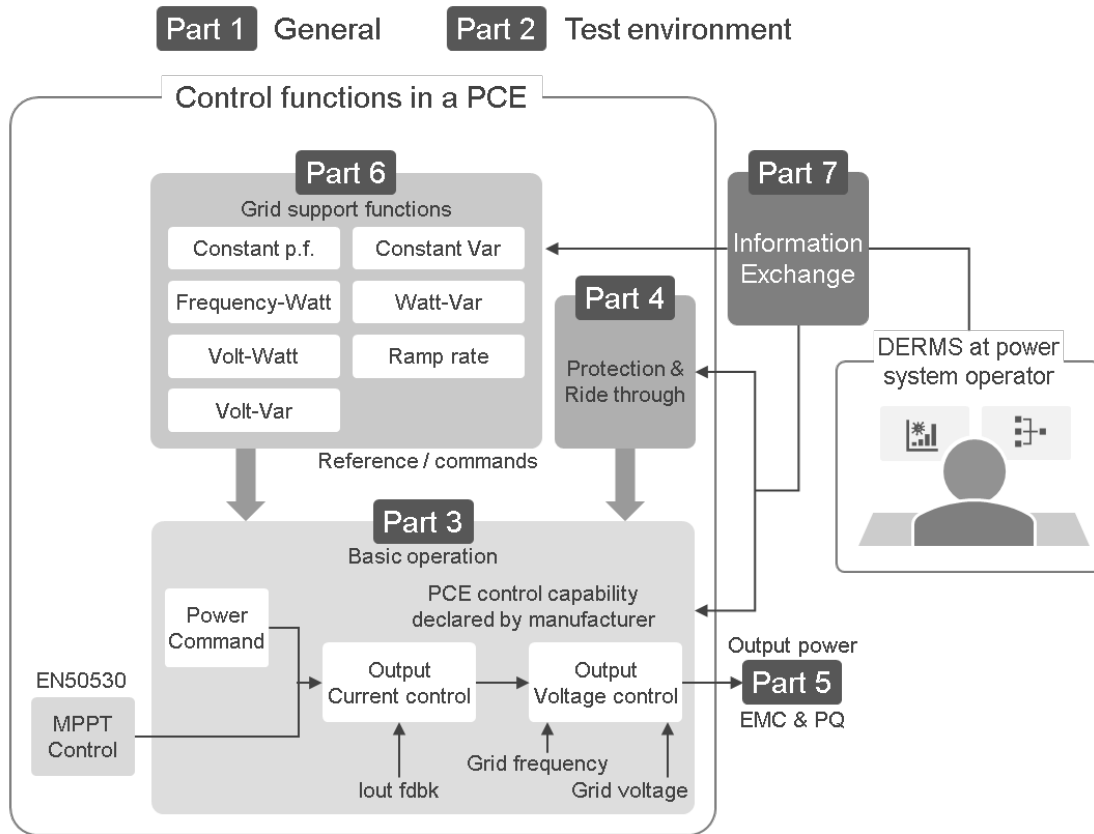


Figure 1- Scopes of IEC 63409

PHOTOVOLTAIC POWER GENERATING SYSTEMS CONNECTION WITH THE GRID – TESTING OF POWER CONVERSION EQUIPMENT –

Part 3: Basic operations

1 Scope

This International Standard specifies test procedures for confirming the basic operational characteristics of power conversion equipment (PCE) for use in photovoltaic (PV) power systems. The basic operational characteristics are the capability of the PCE before any limitations due to internal settings are applied to the PCE to meet specific grid support functions or specific behaviours against abnormal changes.

It will cover the testing of following items:

a) Steady state characteristics

Test procedures to confirm operational range of PCE at steady state condition will be described. The operational ranges in apparent power, active power output, reactive power output, power factor, grid voltage and grid frequency will be confirmed.

b) Transient-response characteristics

Test procedures to confirm PCE's response against a change of operational condition will be described.

Transient-response characteristics to be confirmed are response behaviours against;

- Active power set point change and reactive power set point change
- Grid voltage change, phase angle change, voltage unbalance and frequency change

This standard only considers the changes within normal (continuous) operational ranges. Therefore, the behaviours against abnormal changes and grid support functions are out of the scope and will be covered in other parts of this series of International Standard.

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

3 Terms and definitions

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

EUT

Equipment under test

3.2**Grid support functions**

PCE's functions which controls active power and / or reactive power output according to pre-defined characteristics or set point command to support stabilizing power quality of the grid which the PCE is connected.

3.3**Maximum power point tracking****MPPT**

PCE's control function which tracks the maximum input DC power point in the PV module's power generation characteristics.

3.4**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]

3.5**response time**

elapsed time from the start of a step change or start of event until the observed value first time enters the predefined tolerance band of the target value

Note: See Figure 2.

[SOURCE: IEC 61400-21-1: 2019]

3.6**settling time**

elapsed time from the start of a step change event until the observed value continuously stays within the predefined tolerance band of the target value

Note: See Figure 2.

[SOURCE: IEC 61400-21-1: 2019]

3.7**rise time**

time from when the observed value reaches 10% of the step change until the observed value reaches 90% of the step change

Note: See Figure 2.

[SOURCE: IEC 61400-21-1: 2019]

3.8**overshoot**

difference between the maximum value of the response and the steady-state final value

Note: See Figure 2.

[SOURCE: IEC 61400-21-1: 2019]

3.9**reaction time**

elapsed time from test command issued until the change in amplitude reaches 10% of the measured output variable of the step height

Note: See Figure 2.

[SOURCE: IEC 61400-21-1: 2019]

3.10 tolerance band
acceptable deviation range of measured signal from the defined target value
[SOURCE: IEC 61400-21-1: 2019]

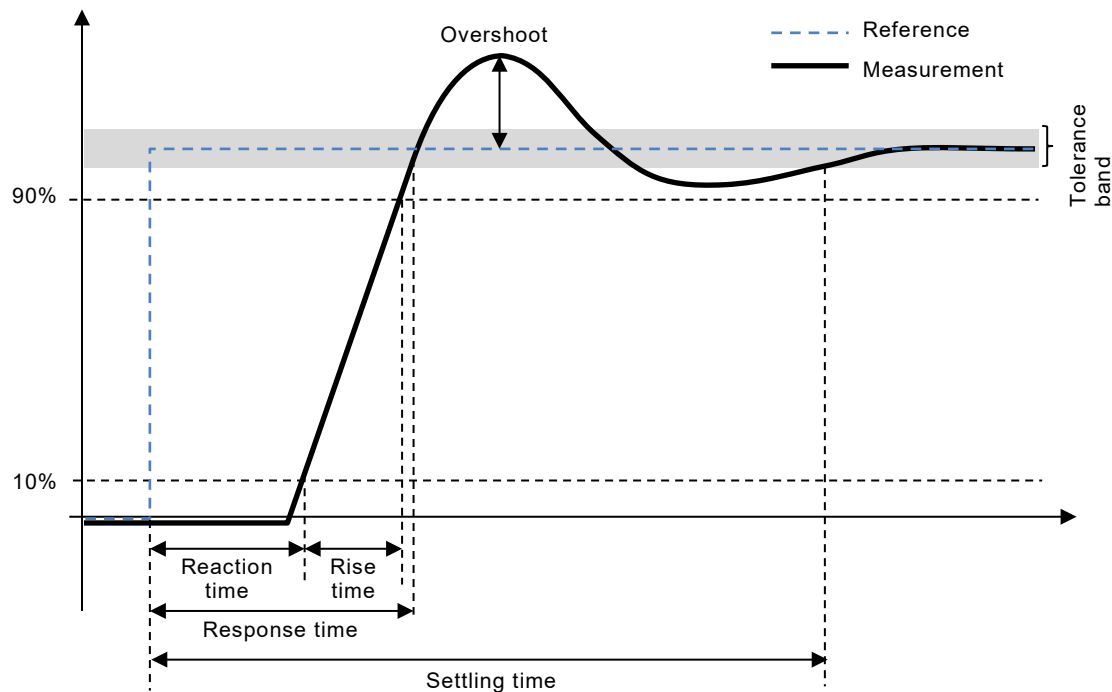


Figure 2 – Example of step response

4 General requirements

4.1 General conditions for testing

4.1.1 Sequence of tests

The sequence of the tests is optional unless otherwise specified in this standard. The same sample need not be used for all tests unless otherwise specified in this standard.

4.1.2 Test equipment conditions

Requirements on the test equipment such as external test sources and test instruments are described in IEC 63409-2.

4.1.3 Manufacturer's stated accuracy

The manufacture of the PCE under evaluation shall state the accuracy of ac voltage, frequency, active power, reactive power and time measurements.

4.1.4 Required setting for EUT

All the grid support functions covered in Part 6 of this series of standard shall be disabled throughout the test. If any one of the grid support functions is essential to perform the test, it is permissible to enable it. In that case, it shall be written in the test report as remarks that the specific function was enabled during the test because it was essential to complete the test.

MPPT control shall be disabled as written in Cl. 4.2.