

Edition 1.0 2025-12

INTERNATIONAL STANDARD

Photovoltaic power generating systems connection with the grid - Testing of power conversion equipment -

power conversion equipment Part 3: Basic operations S://Standards.iteh.ai)

Document Preview

IEC 63409-3·2025

https://standards.iteh.ai/catalog/standards/iec/a61eb531-fe09-4148-a5bf-9b0a82f13603/iec-63409-3-2025



THIS PUBLICATION IS COPYRIGHT PROTECTED Copyright © 2025 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Secretariat Tel.: +41 22 919 02 11

3, rue de Varembé info@iec.ch CH-1211 Geneva 20 www.iec.ch

Switzerland About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

IEC publications search -

webstore.iec.ch/advsearchform

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, ...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished Stay up to date on all new IEC publications. Just Published

details all new publications released. Available online and once a month by email.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@jec.ch.

IEC Products & Services Portal - products.iec.ch

Discover our powerful search engine and read freely all the publications previews, graphical symbols and the glossary. With a subscription you will always have access to up to date content tailored to your needs.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 500 terminological entries in English and French, with equivalent terms in 25 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

Preview

IEC 63409-3:2025

https://standards.iteh.ai/catalog/standards/iec/a61eb531-fe09-4148-a5bf-9b0a82f13603/iec-63409-3-202

CONTENTS

INT		ION	
1	Scope		8
2	Normativ	/e references	8
3	Terms ar	nd definitions	8
4	General	requirements	11
4	1.1 Ge	neral conditions for testing	11
	4.1.1	Sequence of tests	
	4.1.2	Test equipment conditions	12
	4.1.3	Manufacturer's stated tolerance	12
	4.1.4	Required setting for EUT (equipment under test)	12
	4.1.5	PCE firmware used during the test	12
	4.1.6	Reporting the test results	12
4	1.2 Tes	st setup	12
4	1.3 Pai	rameters used in the tests	13
5	Test pro	cedures	15
5	5.1 Ste	eady state characteristics	15
	5.1.1	General	15
	5.1.2	Active power and reactive power	15
	5.1.3	Operable voltage	16
	5.1.4	Reactive power capability for low DC voltage Operable frequency	18
	5.1.5	Operable frequency	19
	5.1.6	Power factor	
5		ansient-response characteristics	21
	5.2.1	General	21
	5.2.2	Active power control	21
	5.2.3		
	5.2.4	Grid voltage variation	
	5.2.5	Grid voltage phase angle variation	
	5.2.6	Grid voltage unbalance	
	5.2.7	Grid frequency variation	
Ann	ex A (nor	mative) Summary of test items	29
Ann	ex B (nor	mative) Format for recording test results	32
Е	3.1 Ge	neral	32
Е	3.2 Ste	eady state characteristics	32
	B.2.1	Active power and reactive power (see 5.1.2)	32
	B.2.2	Operable voltage (see 5.1.3) and reactive power capability for low DC voltage (see 5.1.4)	33
	B.2.3	Operable frequency (see 5.1.5)	34
	B.2.4	Power factor (see 5.1.6)	34
E	3.3 Tra	ansient-response characteristics	35
	B.3.1	Active power control (see 5.2.2)	
	B.3.2	Reactive power control (see 5.2.3)	
	B.3.3	Grid voltage variation (see 5.2.4)	
	B.3.4	Grid voltage phase angle variation (see 5.2.5)	
	B.3.5	Grid voltage unbalance (see 5.2.6)	39

B.3.6 Grid frequency variation (see 5.2.7)	40
Annex C (informative) Examples of testing environments	42
C.1 General	42
C.2 Recommended specification of power supplies	44
C.3 Recommended specification of measuring instruments	45
Annex D (normative) Supplemental information for settling time measurement	
Annex E (normative) Sign conventions for measurements of voltage, current and	
power	
E.1 General	
E.2 Reference polarity and direction	
E.2.1 Reference polarity of voltage	
E.2.2 Reference direction of current	
E.2.3 Sign conventions for measurements of voltage, current and power	
E.3 Reference frame of active and reactive power	
E.4 Physical meanings of the power flows of generators in regional standards	54
Annex F (normative) Grid voltage unbalance – test condition	56
F.1 General	56
F.2 Causes and definitions of unbalanced grid voltage	56
F.3 Test conditions	56
Annex G (informative) Phase angle variation of grid voltage – alternative test setup	
G.1 General	
G.2 Alternative test setup and test procedure	57
Annex H (informative) Fundamental principle of reactive power reduction with lower	07
DC voltage	58
H.1 General	
H.2 Controllability limit	50
Annex I (informative) Grid support functions covered in IEC 63409 series	
IFC (2400.2.2025	
Annex J (informative) Influence of MPPT control and PV simulator to the test results	63 ,3409-3-2(
s://standards.iteh.ai/catalog/standards/iec/a61eb531-fe09-4148-a5bf-9b0a82f13603/iec-6 J.1 General	
J.2 DC power supply and MPPT control of PCE	
J.2.1 DC power supply	63
J.2.2 MPPT control	
J.3 Influence of the PV simulator	63
Bibliography	66
Figure 1 – Scopes of IEC 63409 series	7
Figure 2 – Example of step response	11
Figure 3 – Example of a test setup	13
Figure 4 – Example operational parameters in P-Q capability curve of PCE in Producer Reference Frame (PRF)	
Figure 5 – Example of settling time measurement for grid voltage variation test	
Figure 6 – Example of settling time measurement for grid frequency variation	
Figure B.1 – P-Q capability curve showing active power and reactive power test results and power factor test results (example)	
Figure B.2 – Active power control test waveform example when active power setpoint was changed from 100 %	36
Figure B.3 – Reactive power control test waveform example when reactive power	-
setpoint was changed from 52,7 % to 0 %	37

changed from 100 % to 110 %	38
Figure B.5 – Phase angle of grid voltage change test waveform example (10-degree step change was applied to AC voltages for illustrative purpose)	39
Figure B.6 – Grid voltage unbalance test waveform example when negative sequence voltage was applied to AC voltages	40
Figure B.7 – Grid frequency variation test waveform example when AC frequency was changed from 50 Hz to 50,5 Hz	41
Figure C.1 – Example of a testing environment	42
Figure D.1 – Example of settling time measurement for grid voltage variation in case the settled power is different from the original steady state	47
Figure E.1 – Reference polarity of voltage	48
Figure E.2 – Reference polarity of current	48
Figure E.3 – Reference polarity and direction for the measurements for DER	49
Figure E.4 – Reference polarity and direction for the measurements for load	49
Figure E.5 – Rotating vector voltage and current for load	50
Figure E.6 – Rotating vector voltage and current for DER	50
Figure E.7 – Complex power for load	52
Figure E.8 – Complex power for DER	52
Figure E.9 – Power quadrants for load	
Figure E.10 – Power quadrants for DER	53
Figure G.1 – Configuration of an alternative test setup	
Figure H.1 – Basic configuration of a power conversion equipment	58
Figure H.2 – EUT voltage and current vector diagram and operating point depicted in the PQ curve with sufficient $U_{\rm ac}$ (over-excited)	
Figure H.3 – EUT voltage and current vector diagram and operating point depicted in the PQ curve with small $U_{\rm ac}$ (over-excited) 3.409.3.2025	60
Figure H.4 – EUT voltage and current vector diagram and operating point depicted in the PQ curve with small $U_{\rm ac}$ (under-excited)	
Figure H.5 – EUT voltage and current vector diagram and operating point depicted in the PQ curve during inflexion operating point (over-excited)	61
Figure J.1 – PV simulator characteristics examples	63
Figure J.2 – Active power control test waveform with constant DC voltage source and no MPPT	64
Figure J.3 – Active power control test waveform with PV simulator and MPPT enabled	65
Figure J.4 – Examples of operational point movement of a PCE during Active power control tests	65
Table 1 – Parameters defined for the tests	14
Table 2 – Test conditions for operable voltage test	18
Table 3 – Test conditions for operable frequency test	20
Table 4 – Test cases for grid voltage unbalance	27
Table A.1 – Test items for steady state characteristics (example)	29
Table A.2 – Test items for transient-response characteristics (example)	30
Table B.1 – Record of active power and reactive power test (example)	32
Table B.2 – Record of operable voltage test (example)	34

Table B.3 – Record of operable frequency test (example)	34
Table B.4 – Record of power factor test (example)	35
Table B.5 – Record of active power control test (example)	35
Table B.6 – Record of reactive power control test (example)	36
Table B.7 – Record of grid voltage variation test (example)	37
Table B.8 – Record of grid voltage phase angle variation test (example)	38
Table B.9 – Record of grid voltage unbalance test (example)	39
Table B.10 – Record of grid frequency variation test (example)	40
Table C.1 – Required functions for power supplies	43
Table C.2 – Electrical quantity measured with measuring instruments or devices	43
Table C.3 – Recommended specifications for power supplies	44
Table C.4 – Recommended specifications of power quality measurement	45
Table C.5 – Recommended specifications of waveform monitoring and recording device	46
Table E.1 – Physical meanings of the power flows of loads	53
Table E.2 – Physical meanings of the power flows of generators	54
Table E.3 – Physical meanings of the power flows of generators in Japan	54
Table E.4 – Physical meanings of the power flows of generators in IEEE 1547.1	54
Table E.5 – Physical meanings of the power flows of generators in EN 50549-10	54
Table E.6 – Physical meanings of the power flows of generators in AS/NZS 4777.2	55
Table I.1 – Grid support functions covered in IEC 63409 series	62

Document Preview

IEC 63409-3:2025

https://standards.iteh.ai/catalog/standards/iec/a61eb531-fe09-4148-a5bf-9b0a82f13603/iec-63409-3-2025

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) IEC draws attention to the possibility that the implementation of this document may involve the use of (a) patent(s). IEC takes no position concerning the evidence, validity or applicability of any claimed patent rights in respect thereof. As of the date of publication of this document, IEC had not received notice of (a) patent(s), which may be required to implement this document. However, implementers are cautioned that this may not represent the latest information, which may be obtained from the patent database available at https://patents.iec.ch. IEC shall not be held responsible for identifying any or all such patent rights.

IEC 63409-3 has been prepared by IEC technical committee 82: Solar photovoltaic energy systems. It is an International Standard.

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

Draft	Report on voting
82/2456/FDIS	82/2525/RVD

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 International Standard is English.