

INTERNATIONAL STANDARD



Uninterruptible power systems (UPS) – Part 3: Method of specifying the performance and test requirements



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2021 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 Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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 It also gives information on projects, replaced and withdrawn publications.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@iec.ch.

IEC online collection - oc.iec.ch

Discover our powerful search engine and read freely all the publications previews. 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 22 000 terminological entries in English and French, with equivalent terms in 18 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

Preview generated by EVS

INTERNATIONAL STANDARD



Uninterruptible power systems (UPS) – Part 3: Method of specifying the performance and test requirements

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 29.200

ISBN 978-2-8322-9670-7

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

CONTENTS

FOREWORD	6
1 Scope	8
2 Normative references	8
3 Terms and definitions	10
3.1 General	10
3.2 Systems and components	11
3.3 Performance of systems and components	15
3.4 Equipment mobility	18
3.5 Specified values	18
4 Environmental conditions	25
4.1 General – Test environment	25
4.2 Normal conditions	25
4.2.1 General	25
4.2.2 Operation	26
4.2.3 Storage and transportation	26
4.3 Unusual conditions	26
4.3.1 General	26
4.3.2 Operation	26
4.3.3 Storage and transportation	27
5 Electrical conditions, performance and declared values	28
5.1 General	28
5.1.1 UPS configuration	28
5.1.2 Markings and instructions	28
5.2 UPS input specification	28
5.2.1 Conditions for normal mode operation	28
5.2.2 Characteristics to be declared by the manufacturer	29
5.2.3 Characteristics and conditions to be identified by the purchaser	30
5.3 UPS output specification	30
5.3.1 Conditions for the UPS to supply a load	30
5.3.2 Characteristics to be declared by the manufacturer	31
5.3.3 Characteristics and conditions to be identified by the purchaser	32
5.3.4 Performance classification	32
5.4 Energy storage device specification	37
5.4.1 General	37
5.4.2 Battery	37
5.5 UPS switch specification	38
5.5.1 UPS switches supplied as an integral part of a UPS	38
5.5.2 UPS switches not supplied as an integral part of a UPS	38
5.6 Signal, control and communication ports	38
6 UPS tests	38
6.1 Summary	38
6.1.1 Venue, instrumentation and load	38
6.1.2 Routine testing	39
6.1.3 Site testing	39
6.1.4 Witness testing	39
6.1.5 Type testing	39

6.1.6	Schedule of tests	40
6.2	Routine tests	41
6.2.1	General	41
6.2.2	Electrical	41
6.3	Site tests	43
6.4	Type tests – Electrical	44
6.4.1	Input – AC input power compatibility	44
6.4.2	Output – Load compatibility	47
6.4.3	Stored and restored energy times	52
6.5	Type tests – Environmental	53
6.5.1	Transportation	53
6.5.2	Storage in dry heat, damp heat and cold environments	55
6.5.3	Operation in dry heat, damp heat and cold environments	55
6.5.4	Acoustic noise	56
6.6	UPS functional unit tests (where not tested as a complete UPS)	56
6.6.1	General	56
6.6.2	UPS rectifier tests	57
6.6.3	UPS inverter tests	57
6.6.4	UPS switch tests	57
6.6.5	Energy storage device tests	57
Annex A	(informative) Configurations – Uninterruptible power system (UPS)	58
A.1	General	58
A.2	Single output bus UPS	58
A.2.1	General	58
A.2.2	Basic single UPS	58
A.2.3	Single UPS with bypass	59
A.3	Parallel UPS	59
A.3.1	General	59
A.3.2	Parallel UPS with common bypass	60
A.3.3	Parallel UPS with distributed bypass	60
A.3.4	Standby redundant UPS	61
A.4	Dual bus UPS	62
A.4.1	Basic dual bus UPS	62
A.4.2	Standby redundant dual bus UPS	63
Annex B	(informative) Topologies – Uninterruptible power system (UPS)	64
B.1	General	64
B.2	Double conversion topology	64
B.3	Line-interactive topology	65
B.4	Standby topology	65
Annex C	(informative) Switch applications – Uninterruptible power systems (UPS)	67
C.1	General	67
C.2	Transfer switches, bypass transfer switches	67
C.3	Maintenance bypass switches	67
Annex D	(informative) Purchaser specification guidelines	69
D.1	General	69
D.2	Load to be supplied by the UPS	69
D.3	Energy storage device (battery – where applicable)	70
D.4	Physical and environmental requirements	70

D.5	UPS technical data sheet – Manufacturer's declaration	71
Annex E (normative)	Reference non-linear load	77
E.1	General.....	77
E.2	Apparent power rating of the reference non-linear load	77
E.3	Circuit design.....	77
E.4	Adjustment.....	78
Annex F (informative)	Multiple normal mode UPS – Guidance for testing	79
F.1	General.....	79
F.2	UPS presenting automatic change of classification	79
Annex G (normative)	AC input power failure – Test method	80
G.1	General.....	80
G.2	Test G.1 – High impedance AC input power failure	80
G.3	Test G.2 – Low impedance AC input power failure	80
Annex H (informative)	Dynamic output performance – Measurement techniques	81
H.1	General.....	81
H.2	Validation method for RMS measurements.....	81
H.3	Validation method for instantaneous measurements.....	81
H.4	Example.....	82
Annex I (normative)	UPS efficiency values.....	84
I.1	General.....	84
I.2	Equipment covered	84
I.3	Minimum weighted UPS efficiency	84
Annex J (normative)	UPS efficiency and no load losses – Methods of measurement.....	86
J.1	General.....	86
J.2	Measurement conditions	86
J.2.1	Environmental conditions.....	86
J.2.2	Operational and electrical conditions	86
J.2.3	Instrumentation.....	87
J.3	Measurement method	87
J.3.1	Standard method	87
J.3.2	Alternative method.....	88
J.4	Test report	88
Annex K (informative)	UPS availability	90
K.1	General.....	90
K.2	Downstream distribution failures in the AC output of UPS	90
K.3	Reliability integrity levels	90
K.4	Availability calculation.....	91
K.5	Industry practice	92
Bibliography	93
Figure 1	– Typical characteristic Y output voltage waveform	34
Figure 2	– Dynamic output performance class 1.....	35
Figure 3	– Dynamic output performance class 2.....	36
Figure 4	– Dynamic output performance class 3.....	36
Figure 5	– Load configuration for testing transient conditions.....	50
Figure A.1	– Basic single UPS	58
Figure A.2	– Single UPS with bypass	59

Figure A.3 – Parallel UPS with common bypass	60
Figure A.4 – Parallel UPS with distributed bypass	61
Figure A.5 – Standby redundant UPS	62
Figure A.6 – Dual bus UPS	62
Figure A.7 – Standby redundant dual bus UPS	63
Figure B.1 – Double conversion topology	64
Figure B.2 – Line-interactive topology	65
Figure B.3 – Standby topology	66
Figure C.1 – Bypass transfer switch	67
Figure C.2 – Internal maintenance bypass switch	68
Figure C.3 – External maintenance bypass switch	68
Figure E.1 – Reference non-linear load ≤ 8 kVA	77
Figure G.1 – Connection of test circuit	80
Figure H.1 – Validation example of a transient response complying with UPS dynamic output performance class 3	83
Figure K.1 – Reliability % over time	92
Figure K.2 – Maintainability % over time	92
Table 1 – Alphabetical list of terms	10
Table 2 – Example of power derating factors for use at altitudes above 1 000 m	27
Table 3 – Compatibility levels for individual harmonic distortion of voltage in public low-voltage power supply systems	29
Table 4 – Compatibility levels for individual harmonic distortion of voltage in industrial plants and non-public low-voltage power supply systems	29
Table 5 – UPS test schedule	40
Table 6 – Free fall testing	54
Table D.1 – UPS technical data – Manufacturer's declaration	71
Table I.1 – Efficiency weighting factors for UPS	85
Table I.2 – Minimum weighted UPS efficiency values (%)	85
Table K.1 – Reliability integrity levels for UPS	91

INTERNATIONAL ELECTROTECHNICAL COMMISSION

UNINTERRUPTIBLE POWER SYSTEMS (UPS) –

Part 3: Method of specifying the performance and test requirements

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 62040-3 was prepared by subcommittee 22H: Uninterruptible power systems (UPS), of IEC technical committee 22: Power electronic systems and equipment. It is an International Standard.

This third edition cancels and replaces the second edition published in 2011 and constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) environmental conditions aligned with IEC 62040-1:2017 (UPS safety requirements);
- b) compliance requirements included in all sub-clauses referenced in Table 5 UPS test schedule;
- c) non-linear step load is no longer a type test and was removed from 6.4 in consistency with requirements for switch mode power supplies incorporating inrush current controls; this resulted in the performance classification coding being shortened from 8 to 7 characters (see 5.3.4);
- d) free-fall test aligned with ISO 4180 (see 6.5.1.3);

- e) multiple normal mode UPS test requirements introduced;
- f) non-linear load requirements relaxed in Annex E in consistency with requirements for switch mode power supplies complying with the applicable limits for harmonic current in IEC 61000-3-2 and IEC 61000-3-12;
- g) minimum UPS efficiency values referenced in Annex I became normative and are based on active output power rating and utilisation of weighting factors rather than on allowances related to isolation transformers, input harmonic current filters and input voltages.

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

FDIS	Report on voting
22H/267/FDIS	22H/270/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.

This document has been drafted in accordance with the 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.

In this document, the following print types are used:

- requirements proper and normative annexes: in roman type;
- compliance statements and test specifications: *in italic type*;
- notes and other informative matter: in smaller roman type;
- normative conditions within tables: in smaller roman type;
- terms that are defined in Clause 3: **bold**.

A list of all parts of the IEC 62040 series, published under the general title *Uninterruptible power systems (UPS)*, can be found on the IEC website.

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.

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.

UNINTERRUPTIBLE POWER SYSTEMS (UPS) –

Part 3: Method of specifying the performance and test requirements

1 Scope

This part of IEC 62040 establishes the performance and test requirements applied to **movable, stationary and fixed electronic uninterruptible power systems (UPS)** that

- are supplied from AC voltage not exceeding 1 000 V,
- deliver AC **output voltage** not exceeding 1 000 V,
- incorporate an **energy storage device** not exceeding 1 500 V DC, and
- have a primary function to ensure **continuity of load power**.

This document specifies performance and test requirements of a complete **UPS** and, where applicable, of individual **UPS functional units**. Requirements for the individual **UPS functional units** found in IEC publications listed in the Bibliography apply so far that they are not in contradiction with this document.

UPS are developed for a wide range of power, from less than hundred watts to several megawatts, to meet requirements for availability and quality of power to a variety of **loads**. Refer to Annex A and Annex B for information on typical **UPS** configurations and topologies.

This document also includes **UPS** performance and test requirements related to **UPS switches** that interact with **UPS functional units** to maintain **continuity of load power**.

This document does not cover

- conventional AC and DC distribution boards and their associated switches,
- stand-alone static transfer systems covered by IEC 62310-3,
- rotary UPS covered by IEC 88528-11, and
- DC UPS covered by IEC 62040-5-3.

NOTE 1 This document recognises that **continuity of load power** to information technology (IT) equipment represents a major **UPS** application. The **UPS** output characteristics specified in this document are therefore also aimed at ensuring compatibility with the requirements of IT equipment. This, subject any limitation stated in the manufacturer's declaration, includes requirements for **steady state** and **transient** voltage variation as well as for the supply of both **linear** and **non-linear load** characteristics of IT equipment.

NOTE 2 Test **loads** specified in this document simulate both **linear** and **non-linear load** characteristics. Their use permits verification of the performance declared by the manufacturer while minimising complexity and energy consumption during the tests.

NOTE 3 This document is aimed at 50 Hz and 60 Hz applications but does not exclude other frequency applications within the domain of IEC 60196. This is subject to an agreement between manufacturer and purchaser with respect to any particular requirements arising.

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 cited edition applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60038:2009, *IEC standard voltages*

IEC 60068-2-1:2007, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2:2007, *Environmental testing – Part 2-2: Tests – Test B: Dry heat*

IEC 60068-2-27:2008, *Environmental testing – Part 2-27: Tests – Test Ea and guidance: Shock*

IEC 60068-2-78:2012, *Environmental testing – Part 2-78: Tests – Test Cab: Damp heat, steady state*

IEC 60146-1-1:2009, *Semiconductor converters – General requirements and line commutated converters – Part 1-1: Specification of basic requirements*

IEC 60146-2:1999, *Semiconductor converters – Part 2: Self-commutated semiconductor converters including direct d.c. converters*

IEC 60364-1, *Low-voltage electrical installations – Part 1: Fundamental principles, assessment of general characteristics, definitions*

IEC 60364-5-52, *Low-voltage electrical installations – Part 5-52: Selection and erection of electrical equipment – Wiring systems*

IEC 60664-1:2020, *Insulation coordination for equipment within low-voltage supply systems – Part 1: Principles, requirements and tests*

IEC TR 60721-4-3:2001, *Classification of environmental conditions – Part 4-3: Guidance for the correlation and transformation of environmental condition classes of IEC 60721-3 to the environmental tests of IEC 60068 – Stationary use at weatherprotected locations*
IEC TR 60721-4-3/AMD1:2003

IEC 61000-2-2:2002, *Electromagnetic compatibility (EMC) – Part 2-2: Environment – Compatibility levels for low-frequency conducted disturbances and signaling in public low-voltage power supply systems*

IEC 61000-2-2:2002/AMD1:2017

IEC 61000-2-2:2002/AMD2:2018

IEC 61000-3-2:2018, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*

IEC TS 61000-3-4:1998, *Electromagnetic compatibility (EMC) – Part 3-4: Limits – Limitation of emission of harmonic currents in low-voltage power supply systems for equipment with rated current greater than 16 A*

IEC 61000-3-12:2011, *Electromagnetic compatibility (EMC) – Part 3-12: Limits – Limits for harmonic currents produced by equipment connected to public low-voltage systems with input current > 16 A and ≤ 75 A per phase*

IEC 62040-1:2017, *Uninterruptible power systems (UPS) – Part 1: Safety requirements*

IEC 62040-2:2016, *Uninterruptible power systems (UPS) – Part 2: Electromagnetic compatibility (EMC) requirements*

ISO 3744:2010, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Engineering methods for an essentially free field over a reflecting plane*

ISO 3746:2010, *Acoustics – Determination of sound power levels and sound energy levels of noise sources using sound pressure – Survey method using an enveloping measurement surface over a reflecting plane*

ISO 4180:2019, *Packaging – Complete, filled transport packages – General rules for the compilation of performance test schedules*

3 Terms and definitions

3.1 General

For the purposes of this document, the following terms and definitions 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>

NOTE In this document, IEC 60050 definitions are referenced wherever possible, particularly those of IEC 60050-551. When an existing IEC 60050 definition needs amplification or additional information, this is indicated by adding the word "modified" after the IEC 60050 reference.

Table 1 provides an alphabetical cross-reference listing of terms.

Table 1 – Alphabetical list of terms

Term	Term number	Term	Term number	Term	Term number
AC input power	3.2.8	AC input power failure	3.3.1	active power P	3.5.30
ambient temperature	3.5.56	apparent power S	3.5.31	asynchronous transfer	3.3.14
automatic	3.3.11	battery	3.2.19	battery ripple current	3.3.18
bidirectional converter	3.2.16	bypass	3.2.29	bypass mode	3.3.9
charger	3.2.21	charger current limit	3.5.29	continuity of load power	3.3.5
converter convertor	3.2.12	current limit	3.5.27	cut-off voltage	3.5.55
DC link	3.2.17	deviation	3.5.5	displacement power factor	3.5.41
electronic power switch	3.2.25	efficiency	3.5.57	energy storage device	3.2.18
fixed UPS	3.4.3	flywheel energy storage system	3.2.22	frequency variation	3.5.46
UPS functional unit functional unit	3.2.13	harmonic component	3.5.51	harmonic content	3.5.52
high impedance failure	3.3.3	hybrid power switch	3.2.27	individual harmonic distortion	3.5.50
input frequency tolerance band	3.5.47	input power factor	3.5.42	input voltage tolerance band	3.5.14
inrush current	3.5.25	instantaneous voltage variation	3.5.11	UPS inverter inverter	3.2.15
inverter current limit	3.5.28	light load	3.2.38	linear load	3.2.33
load	3.2.31	load power factor	3.5.43	load sharing	3.5.37
low impedance failure	3.3.4	mains	3.2.9	maintenance bypass switch	3.2.28