IEC 62040-3

Edition 3.0 2021-04

INTERNATIONAL STANDARD

colour inside

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

IEC 62040-3:2021-04(en)

IEC Central Office
3, rue de Varembé
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 It also gives information on projects, replaced and withdrawn publications.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.

IEC 62040-3

Edition 3.0 2021-04

INTERNATIONAL STANDARD

colour inside

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

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

Term	Term number	Term	Term number	Term	Term number
manual	3.3.10	maximum input current	3.5.24	mechanical power switch	3.2.26
movable UPS	3.4.1	multiple normal mode UPS	3.3.7	nominal	3.5.3
non-linear load	3.2.34	non-sinusoidal output voltage	3.5.18	normal mode	3.3.6
output current	3.5.26	output frequency tolerance band	3.5.48	output voltage	3.5.15
output voltage tolerance band	3.5.16	overload capacity	3.5.38	parallel redundant UPS	3.2.7
parallel UPS	3.2.4	periodic output voltage modulation	3.5.22	phase angle	3.5.39
polyphase	3.2.10	port	3.2.11	power factor	3.5.40
rated apparent power of the equipment S_{equ}	3.5.32	rated current	3.5.13	rated frequency	3.5.44
rated frequency tolerance band	3.5.45	rated input current	3.5.23	rated load	3.2.32
rated output active power	3.5.36	rated output apparent power	3.5.35	rated	3.5.1
rated voltage	3.5.12	rating	3.5.2	recovery time	3.5.10
UPS rectifier rectifier	3.2.14	redundant UPS	3.2.5	reference non-linear load	3.2.35
reference test load	3.2.36	reliability integrity level RIL	3.3.19	restored energy time	3.5.54
RMS value RMS	3.5.7	RMS voltage variation	3.5.8	routine test	3.3.16
secondary battery	3.2.20	service life	3.3.17	short-circuit power S_{sc}	3.5.33
short-circuit ratio *Rsce*	3.5.34	single UPS	3.2.3	sinusoidal output voltage	3.5.17
standby redundant UPS	3.2.6	static bypass switch	3.2.30	stationary UPS	3.4.2
steady state	3.5.9	step load	3.2.37	stored energy mode	3.3.8
stored energy time	3.5.53	supply impedance	3.3.2	synchronization	3.3.12
synchronous transfer	3.3.13	tolerance band	3.5.4	total harmonic distortion THD	3.5.49
transfer switch	3.2.24	transient	3.5.6	type test	3.3.15
unbalance ratio	3.5.21	unbalanced load	3.5.20	uninterruptible power system UPS	3.2.1
UPS switch	3.2.23	UPS unit	3.2.2	voltage unbalance	3.5.19

3.2 Systems and components

3.2.1
uninterruptible power system
UPS
combination of **converters,** switches and **energy storage devices** (such as **batteries**), constituting a power system for maintaining **continuity of load power** in case of **AC input power failure**

3.2.2
UPS unit
assembly consisting of at least one of each of the following **UPS functional units**:

- **UPS inverter**;
- **UPS rectifier**, and/or a **charger;**
- **energy storage device** (or means for connection to one)

3.2.3
single UPS
UPS comprising only one **UPS unit**

3.2.4
parallel UPS
UPS comprising two or more **UPS units** operating together for the purpose of sharing the **load**

3.2.5
redundant UPS
UPS that has additional **UPS units** and/or additional **UPS functional units** for the purpose of improving the **continuity of load power**

3.2.6
standby redundant UPS
redundant UPS in which one or more **UPS unit(s)** or **UPS functional units** are held in reserve until one or more **UPS unit(s)** or **UPS functional unit(s)** fail

3.2.7
parallel redundant UPS
parallel UPS that is also a redundant UPS

3.2.8
AC input power
external electrical power supplied to the **UPS** and, subject to satisfying the **UPS** output specification, to any **bypass** circuits

Note 1 to entry: The **AC input power** is usually the **mains** or a private low-voltage power supply system.

3.2.9
mains
public low-voltage power supply system with characteristics as detailed in IEC 61000-2-2, or, for industrial applications, non-public industrial low-voltage power supply system with class 3 characteristics as detailed in IEC 61000-2-4

3.2.10
polyphase
<circuit> circuit comprising more than one phase conductor

Note 1 to entry: Typical **polyphase** circuits include three-phase, bi-phase, split-phase circuits.

3.2.11
port
access to a device or network where electromagnetic energy or signals may be supplied or received or where the device or network variables may be observed or measured

Note 1 to entry: Examples of **ports** include sockets and a group of terminals.

[SOURCE: IEC 60050-131:2002, 131-12-60, modified – Word "sockets" added to example in Note 1 to entry, which has also been rephrased.]

3.2.12
converter
convertor
<electronic power conversion> unit for electronic power conversion, comprising one or more electronic valve devices, transformers and filters if necessary and auxiliaries if any

Note 1 to entry: In English, the two spellings "converter" and "convertor" are in use, and both are correct.

[SOURCE: IEC 60050-551:1998, 551-12-01, modified – "(electronic) (power)" deleted from term, <electronic power conversion> added as domain.]

3.2.13
UPS functional unit
functional unit
UPS sub-system, for example, a **UPS rectifier**, a **UPS inverter** or a **UPS switch**

3.2.14
UPS rectifier
rectifier
converter that changes single-phase or **polyphase** alternating electric currents to unidirectional current

[SOURCE: IEC 60050-551:2001, 151-13-45, modified – Word "UPS" added to term and word "electric energy converter" replaced by "converter" in the definition.]

3.2.15
UPS inverter
inverter
converter that changes direct electric current to single-phase or **polyphase** alternating currents

[SOURCE: IEC 60050-551:2001, 151-13-46, modified – Word "UPS" added to term and word "electric energy converter" replaced by "converter".]

3.2.16
bidirectional converter
converter which has the functions of both a **rectifier** and an **inverter,** and which can reverse the flow of power from AC to DC and vice-versa

3.2.17
DC link
DC power interconnection between the **rectifier** and the **inverter functional units**

Note 1 to entry: The voltage of the **energy storage device** can differ from that of the **DC link**.

Note 2 to entry: The **DC link** can include **converters**.

3.2.18
energy storage device
system consisting of a single or multiple devices designed to provide power to the **UPS inverter** for the required **stored energy time**

Note 1 to entry: Examples of **energy storage devices** include, but are not limited to, **battery**, double-layer capacitor ("super" or "ultra" capacitor) and **flywheel energy storage systems**.

3.2.19
battery
set of electrochemical cells of the same type so connected as to act together

[SOURCE: IEC 60050-151:2001, 151-12-11, modified – Words "bank" and "off" deleted from the term, word "devices" replaced by "electrochemical cells" and note deleted.]

3.2.20
secondary battery
battery that is rechargeable by way of a reversible chemical reaction

3.2.21
charger
converter that provides DC power to an **energy storage device** for the purpose of increasing or maintaining the amount of stored energy

3.2.22
flywheel energy storage system
mechanical **energy storage device** wherein stored kinetic energy can be converted to electrical energy during **stored energy mode**

3.2.23
UPS switch
controllable switch used to interconnect or isolate power **ports** of **UPS units**, **bypass** or **load** for **continuity of load power**

Note 1 to entry: Annex C details **UPS switch** applications.

3.2.24
transfer switch
UPS switch used to convey power from one of two or more sources

3.2.25
electronic power switch
UPS switch comprising at least one controllable electronic valve device

Note 1 to entry: A **static bypass switch** is an example of an **electronic power switch**.

[SOURCE: IEC 60050-551:1998, 551-13-01, modified – Words "an operative unit for electronic power switching" replaced by "UPS switch" and Note 1 to entry added.]

3.2.26
mechanical power switch
UPS switch with physical separation between contacts

3.2.27
hybrid power switch
UPS switch with physical separation between contacts in combination with at least one controllable electronic valve device

3.2.28
maintenance bypass switch
UPS switch designed to maintain **continuity of load power** via an alternative path during maintenance activities

3.2.29
bypass
alternative power path provided to maintain **continuity of load power** when the normal path cannot be used

3.2.30
static bypass switch
electronic power switch, typically internal to the **UPS**, used to enable the **bypass mode**

3.2.31
load
device or condition intended to absorb power supplied by the **UPS** and defined by the equations

$$Z = U / I$$

$$S = U^2 / Z = Z \times I^2$$

where

Z is the **load** impedance [Ω];

S is the **apparent power** [VA];

U is the UPS output voltage [V];

I is the current flowing through the **load** [A]

3.2.32
rated load
value of **load** used for specification purposes, generally established by a manufacturer for a specified set of operating conditions of a component, device, equipment, or system

Note 1 to entry: The **rated load** is expressed in **apparent power** [VA] and **active power** [W] resulting in a **power factor** of the **rated load** that includes the effect of any applicable combination of **linear** and of **non-linear load**

3.2.33
linear load
load wherein the parameter Z (**load** impedance) is a constant

3.2.34
non-linear load
load wherein the parameter Z (**load** impedance) is a variable dependent on other parameters, such as voltage or time

3.2.35
reference non-linear load
non-linear load constructed, **rated** and applied in accordance with Annex E

3.2.36
reference test load
load at which the **UPS** delivers its **rated output active power**

Note 1 to entry: This definition permits, when in test-mode and subject to local regulations, the **UPS** output power to be returned to the **AC input power port**.

3.2.37
step load
instantaneous addition or removal of electrical **loads** to a power source

3.2.38
light load
load that, for practical and/or cost reasons, is limited to a low value when the load level is not relevant for performing a test, for example to 10 % of the **reference test load** value

3.3 Performance of systems and components

3.3.1
AC input power failure
variation in the **AC input power** which could cause the **UPS** to operate in **stored energy mode**

3.3.2
supply impedance
impedance of the power source supplying a **port** or a device

Note 1 to entry: Examples of **supply impedance** include that of **the AC input power source** supplying the input **port** of a **UPS** and that of a **converter** supplying the output **port** of a UPS.

3.3.3
high impedance failure
failure in which the power source is disconnected from the **port** or device it normally supplies

3.3.4
low impedance failure
failure in which the power source is short-circuited at the **port** or device it normally supplies

3.3.5
continuity of load power
set of electrical conditions required for proper operation of the **load** including

a) voltage **tolerance band**,
b) frequency **tolerance band**,
c) voltage distortion limit, and
d) power interruption time limit

3.3.6
normal mode
<UPS operation> stable mode of operation that the **UPS** attains under the following conditions:

a) **AC input power** is within the specified **tolerance band**;
b) **energy storage device** is connected and charged or is under recharge;
c) **load** is within the specified **rating**;
d) **bypass**, if applicable, is within the specified **tolerance band.**

3.3.7
multiple normal mode UPS
UPS that provides a **manually** selectable and/or **automatically** determined set of input dependency characteristics when operating in **normal mode**

Note 1 to entry: Typical sets of declared input dependency characteristics supported by a **multiple normal** mode **UPS** include: (VFD, VI, VFI), (VFD, VI), (VFD, VFI) and (VI, VFI).

3.3.8
stored energy mode
<UPS operation> stable mode of operation that the **UPS** attains under the following conditions:

a) **AC input power** is disconnected or is out of the specified **tolerance band**;
b) all power is derived from the **energy storage device**;
c) **load** is within the specified rating.

3.3.9
bypass mode
<UPS operation> temporary mode of operation that the **UPS** attains when the **load** is supplied via the **bypass,** resulting from abnormal conditions or a command

3.3.10
manual
<control> control of an operation by human intervention

[SOURCE: IEC 60050-441:1984, 441-16-04, modified – Word "control" deleted from term and added as domain.]

3.3.11
automatic
<control> control of an operation without human intervention, in response to the occurrence of predetermined conditions

[SOURCE: IEC 60050-441:1984, 441-16-05, modified – Word "control" deleted from term and added as domain.]

3.3.12
synchronization
adjustment of an AC power source to match another AC power source in frequency and **phase angle**

3.3.13
synchronous transfer
transfer within the voltage and frequency **tolerance bands** and **phase angle** difference as declared by the manufacturer

3.3.14
asynchronous transfer
transfer that is not a **synchronous transfer**

3.3.15
type test
conformity test made on one or more items representative of the production

[SOURCE: IEC 60050-151:2001, 151-16-16]

3.3.16
routine test
conformity test made on each individual item during or after manufacture

[SOURCE: IEC 60050-151:2001, 151-16-17]

3.3.17
service life
<of a **battery**> period of useful life of a **battery** under specified conditions

[SOURCE: IEC 60896-21:2004, 3.26, modified – Words "of a battery" added as domain.]

3.3.18
battery ripple current
superimposed effective (**RMS**) alternating component of the **battery** current

3.3.19
reliability integrity level
RIL
probability of **UPS** output power failure per hour in high demand or continuous mode of operation along with a discrete level for specifying the integrity requirements of the functions to be allocated to the **UPS**, where **RIL** level 1 has the lowest level of integrity and **RIL** level 4 has the highest

Note 1 to entry: The target failure rates for the four **reliability integrity levels** for **UPS** are specified in Annex K.

Note 2 to entry: High demand mode of operation means that the integrity is challenged more than once per year, for example **AC input power failure** is deemed to occur more than once per year. See Annex K.

3.4 Equipment mobility

3.4.1
movable UPS
UPS that is either 18 kg or less in mass and not a **fixed UPS**, or a **UPS** with wheels, castors or other means to facilitate movement as required to perform its intended use

3.4.2
stationary UPS
UPS that is not **movable UPS**

3.4.3
fixed UPS
UPS that is fastened or otherwise secured in a specific location

3.5 Specified values

3.5.1
rated
<value> value of a quantity used for specification purposes, generally established by a manufacturer for a specified set of operating conditions of a component, device, equipment, or system

[SOURCE: IEC 60050-151:2001, 151-16-08, modified – Word "value" deleted from term and added as domain, words "generally" and "by a manufacturer" added to the definition.]

3.5.2
rating
set of **rated** values and operating conditions

[SOURCE: IEC 60050-151:2001, 151-16-11]

3.5.3
nominal
<value> value of a quantity used to designate and identify a component, device, equipment, or system

Note 1 to entry: The **nominal** value is generally a rounded value.

[SOURCE: IEC 60050-151:2001, 151-16-09, modified – Word "value" deleted from term and added as domain.]

3.5.4
tolerance band
range of values of a quantity within limits specified by the manufacturer

3.5.5
deviation
difference between the actual value and the desired value of a variable quantity at a given instant

Note 1 to entry: This entry was numbered 351-21-04 in IEC 60050-351:2006.

[SOURCE: IEC 60050-351:2013, 351-41-04]

3.5.6
transient
behaviour of a variable quantity during transition between two consecutive **steady states**

Note 1 to entry: This entry was numbered 351-24-07 in IEC 60050-351:2006.

[SOURCE: IEC 60050-351:2013, 351-45-08, modified – Word "behaviour" deleted from term.]

3.5.7
RMS value
RMS
for a time-dependent quantity, positive square root of the mean value of the square of the quantity taken over a given time interval

Note 1 to entry: The root-mean-square value of a periodic quantity is usually taken over an integration interval the range of which is the period multiplied by a natural number.

Note 2 to entry: For a sinusoidal quantity $a(t)=\hat{A}\cos(\omega t+\vartheta_0)$, the root-mean-square value is $A_{eff} = \hat{A}/\sqrt{2}$.

Note 3 to entry: The root-mean-square value of a quantity may be denoted by adding one of the subscripts eff or rms to the symbol of the quantity.

Note 4 to entry: In electrical technology, the root-mean-square values of electric current $i(t)$ and voltage $u(t)$ are usually denoted I and U, respectively.

Note 5 to entry: The abbreviation RMS was formerly denoted as r.m.s. or rms, but these notations are now deprecated.

[SOURCE: IEC 60050-103:2017, 103-02-03, modified – Words "root-mean-square" and "effective value" deleted from term, and domains deleted.]

3.5.8
RMS voltage variation
difference between the **RMS** voltage and the corresponding previously undisturbed **RMS** voltage

3.5.9
steady state
state of a physical system in which the relevant characteristics remain constant with time

Note 1 to entry: A state under periodic conditions is often considered as a **steady state**.

[SOURCE: IEC 60050-103:2009, 103-05-01]

3.5.10
recovery time
time interval between a step change in one of the control or influence quantities and the instant when the stabilized output quantity returns to and stays within the **steady state tolerance band**

3.5.11
instantaneous voltage variation
difference between an instantaneous voltage and the previous instantaneous voltage one cycle prior divided by the peak voltage one cycle prior, expressed as a percentage

Note 1 to entry: Refer to Figure H.1 for an example.

3.5.12
rated voltage
input or **output voltage** assigned by the manufacturer for a specified operating condition

3.5.13
rated current
input or **output current** of the equipment assigned by the manufacturer for a specified operating condition

3.5.14
input voltage tolerance band
steady state AC input power voltage tolerance band for normal mode operation

3.5.15
output voltage
RMS value of the voltage at the AC output **port** of the **UPS**

Note 1 to entry: The **output voltage** is an **RMS value** unless otherwise specified for a particular test.

3.5.16
output voltage tolerance band
steady state output voltage tolerance band with the **UPS** operating in **normal mode** or in **stored energy mode**

3.5.17
sinusoidal output voltage
output voltage waveform complying with an applicable compatibility level for harmonic voltages in low-voltage power supply systems

Note 1 to entry: Refer to Table 3 and Table 4.

3.5.18
non-sinusoidal output voltage
output voltage waveform that is not a **sinusoidal output voltage**

3.5.19
voltage unbalance
<**polyphase** circuit> condition in which the **RMS values** of the phase voltages or the **phase angles** between consecutive phases are not all equal

[SOURCE: IEC 60050-161:1990, 161-08-09, modified – Words "voltage imbalance" deleted from term and "in a polyphase system" in the definition replaced by "polyphase circuit" as a domain.]

3.5.20
unbalanced load
load as seen by the supply, where the current or **power factor** differs between any of the phases

3.5.21
unbalance ratio
difference between the highest and the lowest **RMS values** of the fundamental components in a **polyphase** circuit, referred to the average between all phases of the **RMS values** of the fundamental components of the currents or voltages respectively

[SOURCE: IEC 60146-2:1999, 3.5.15, modified – Words "three-phase a.c. system" replaced by "polyphase circuit" and "three phases" replaced by "all phases".]

3.5.22
periodic output voltage modulation
periodic variation of the **RMS output voltage** amplitude at frequencies less than the fundamental output frequency

3.5.23
rated input current
<UPS> **RMS** current at the AC input **port** of the **UPS** while operating in **normal mode**, at **rated** input voltage, **rated load** and charging a fully depleted **energy storage device**

3.5.24
maximum input current
<UPS> **RMS** current at the AC input **port** of the **UPS** while operating in **normal mode**, at worst-case input voltage, **rated load** and charging a fully depleted **energy storage device**

3.5.25
inrush current
maximum peak value and time duration of the input current when the **UPS** transitions from **stored energy mode** to **normal mode** with no **load** connected

3.5.26
output current
RMS value of the current at the AC output **port** of the **UPS**

Note 1 to entry: The output current is an **RMS value** unless otherwise specified for a particular test.

3.5.27
current limit
<control> function that prevents a current from exceeding its specified value

3.5.28
inverter current limit
ratio of the **UPS output current** supplied by the **inverter** to the **rated UPS output current** when a short-circuit is applied to the output **port** of the **UPS**

3.5.29
charger current limit
value of the **charger** DC output current when the **charger** is connected to a fully depleted **energy storage device**

3.5.30
active power
P
under periodic conditions, mean value, taken over one period T, of the instantaneous power p:

$$P = \frac{1}{T}\int_0^T p \, \mathrm{d}t$$

Note 1 to entry: Under sinusoidal conditions, the **active power** is the real part of the complex **power** $\underline{S}$. Thus P = Re $\underline{S}$.

Note 2 to entry: The SI unit for **active power** is watt, W.

[SOURCE: IEC 60050-131:2013, 131-11-42]

3.5.31
apparent power
S
product of the RMS voltage U between the terminals of a two-terminal element or two-terminal circuit and the RMS electric current I in the element or circuit

$$S = U \times I$$

Note 1 to entry: Under sinusoidal conditions, the **apparent power** is the modulus of the complex power $\underline{S}$, thus $S = |\underline{S}|$.

Note 2 to entry: The coherent SI unit for **apparent power** is voltampere, VA.

[SOURCE: IEC 60050-131:2013, 131-11-41]

3.5.32
rated apparent power of the equipment
S_{equ}
value calculated from the **rated** line current I_{equ} of the equipment stated by the manufacturer and the **rated voltage** U_p (single phase) or U_i (interphase) as follows:

a) $S_{equ} = U_p \times I_{equ}$ for single-phase equipment and the single-phase part of hybrid equipment;

b) $S_{equ} = U_i \times I_{equ}$ for interphase, for example bi-phase or split-phase equipment;

c) $S_{equ} = \sqrt{3}\ U_i \times I_{equ}$ for balanced three-phase equipment and the three-phase part of hybrid equipment;

d) $S_{equ} = 3\ U_p \times I_{equ\ max}$ for unbalanced three-phase equipment, where $I_{equ\ max}$ is the maximum of the **RMS** currents flowing in any one of the three phases

Note 1 to entry: In the case of a voltage range, U_p or U_i is the **nominal** system voltage according to IEC 60038 (for example: 120 V or 230 V for single-phase or 400 V line-line for three-phase).

3.5.33
short-circuit power
S_{sc}
value of the three-phase short-circuit power calculated from the **nominal** interphase system voltage $U_{nominal}$ and the line impedance Z of the system at the PCC:

$$S_{sc} = U^2{}_{nominal} / Z$$

where

Z is the system impedance at the power frequency

Note 1 to entry: PCC means point of common coupling, see IEC 60050-161:1990, 161-07-15.

[SOURCE: IEC 61000-3-12:2011, 3.10, modified – Note 1 to entry added.]

3.5.34
short-circuit ratio
R_{sce}
impedance relation between a **UPS** and its **AC input power**, defined as follows:

a) $R_{sce} = S_{sc} / (3\ S_{equ})$ for single-phase **UPS**;

b) $R_{sce} = S_{sc} / (2\ S_{equ})$ for bi-phase or split-phase **UPS**;

c) $R_{sce} = S_{sc} / S_{equ}$ for all three-phase **UPS**

3.5.35
rated output apparent power
apparent power available at the AC output **port** of the **UPS** as declared by the manufacturer

3.5.36
rated output active power
active power available at the AC output **port** of the **UPS** as declared by the manufacturer

3.5.37
load sharing
simultaneous supply of power to a **load** from two or more **UPS units**

Note 1 to entry: The share of power provided by each **UPS unit** is not necessarily equal.

3.5.38
overload capacity
highest **load** which a **UPS** can maintain during a short period of time with the **output voltage** remaining within applicable limits

Note 1 to entry: The **overload capacity** is expressed as the ratio of **output current,** over a given time, to **rated output current**.

Note 2 to entry: **Overload capacity** is typically required for **load** energisation purposes wherein the **power factor** is lower than the **power factor** at **rated load**.

3.5.39
phase angle
angle between reference points on one or more AC waveforms

Note 1 to entry: The **phase angle** is usually expressed in electrical degrees or radians.

3.5.40
power factor
under periodic conditions, ratio of the absolute value of the **active power** P to the **apparent power** S:

$$\lambda = \frac{|P|}{S}$$

Note 1 to entry: Under sinusoidal conditions, the power factor is the absolute value of the active factor.

[SOURCE: IEC 60050-131:2002, 131-11-46]

3.5.41
displacement power factor
ratio of the **active power** of the fundamental wave to the **apparent power** of the fundamental wave

3.5.42
input power factor
power factor at the AC input **port** of the **UPS**, while operating in **normal mode**, at **rated** input voltage, supplying the **reference test load** and with a fully charged **energy storage device** connected

3.5.43
load power factor
power factor of the **load** assuming it is supplied with an ideal sinusoidal voltage

3.5.44
rated frequency
input or output frequency of the equipment assigned by the manufacturer for a specified operating condition

3.5.45
rated frequency tolerance band
steady state input or output frequency tolerance band

3.5.46
frequency variation
variation of the input or output frequency

3.5.47
input frequency tolerance band
steady state input frequency tolerance band for normal mode operation

3.5.48
output frequency tolerance band
steady state output frequency tolerance band

3.5.49
total harmonic distortion
THD
ratio of the **RMS value** of the sum of the **harmonic components** X_h of orders 2 to 40 to the **RMS value** of the fundamental component X_1

$$THD = \sqrt{\sum_{h=2}^{40} \left(\frac{X_\mathrm{h}}{X_1} \right)^2}$$

Note 1 to entry: In this context, X_h refers to harmonic current or voltage components.

3.5.50
individual harmonic distortion
ratio of the **RMS value** of a specific **harmonic component** X_h of orders 2 to 40 to the **RMS value** of the fundamental component X_1

3.5.51
harmonic component
component of the **harmonic content** as expressed in terms of the order and **RMS value** of the Fourier series terms describing the periodic function

3.5.52
harmonic content
quantity obtained by subtracting the fundamental component from an alternating quantity

[SOURCE: IEC 60050-161:1990, 161-02-21]

3.5.53
stored energy time
minimum time during which the **UPS**, under specified operational conditions, will ensure **continuity of load power**, during an **AC input power failure**

3.5.54
restored energy time
maximum time required to, under **normal mode** of operation and with the charging capacity installed, recharge the **energy storage device** of the **UPS** so that the **stored energy time** can again be achieved

3.5.55
cut-off voltage
voltage at which the **energy storage device**, during **stored energy mode**, under specified operational conditions, is considered to be fully depleted

3.5.56
ambient temperature
temperature of the air or other medium where the equipment is to be used

[SOURCE: IEC 60050-826:2004, 826-10-03, modified – Words "average temperature" replaced by "temperature", words "in the vicinity of the equipment" replaced by "where the equipment is to be used", and Note to entry deleted.]

3.5.57
efficiency
<UPS> ratio of output **active power** to input **active power** or the ratio of output energy to input energy under specified test conditions

Note 1 to entry: Test conditions for **UPS efficiency** are found in Annex J.

4 Environmental conditions

4.1 General – Test environment

The **UPS** shall be capable of operating as **rated** in an environment with pollution degree 2 of IEC 60664-1 and under the normal conditions in 4.2.

Other conditions may be agreed upon between manufacturer/supplier and purchaser.

NOTE 1 Pollution degree is a characteristic of an environment and detailed in IEC 60664-1 from where the following is derived.

– Pollution degree 1 applies where there is no pollution or only dry, non-conductive pollution.
– Pollution degree 2 applies where there is only non-conductive pollution that might temporarily become conductive due to occasional condensation.
– Pollution degree 3 applies where a local environment within the equipment is subject to conductive pollution, or to dry non-conductive pollution that could become conductive due to expected condensation.
– Pollution degree 4 applies when the pollution generates persistent conductivity caused for example by conductive dust or rain or snow.

NOTE 2 It is assumed that the applicable safety and EMC conformity assessments are coordinated with any other conditions agreed upon between manufacturer/supplier and purchaser.

4.2 Normal conditions

4.2.1 General

4.2 lists the default environmental conditions applicable to the operation, storage and transportation of **UPS**.

4.2.2 Operation

4.2.2.1 Ambient temperature and relative humidity

A **UPS** shall perform as **rated** when operating within the following ambient ranges:

- temperature +15 °C to +30 °C;
- relative humidity 10 % to 75 % (non-condensing).

The temperature and relative humidity ranges above are verified in accordance with IEC TR 60721-4-3 when performed as described in 6.5.3.

NOTE A requirement for the **UPS** to perform when operating beyond the ambient ranges is considered an unusual condition. See 4.3.

4.2.2.2 Altitude

A **UPS** conforming to this document shall be designed to operate as **rated** from sea-level up to and including 1 000 m above sea level.

4.2.3 Storage and transportation

UPS equipment conforming to this document shall accept stationary storage within a building and shall be transportable in its manufacturer provided shipping packaging by a pressurised aircraft, by ship or by truck, within the following ambient ranges:

- temperature –25 °C to +55 °C;
- relative humidity 10 % to 95 % (non-condensing).

The temperature and relative humidity ranges above are verified as described in 6.5.2.

Packaging not designed for wet (condensing) ambient conditions shall be marked by warning labels.

Shock and free-fall withstand requirements are verified when performed as described in 6.5.1.

Unless otherwise declared by the **UPS** manufacturer, **UPS** equipment conforming to this document shall not be stored or transported at an altitude with equivalent air pressure lower than 70 kPa.

NOTE 1 The air pressure at an altitude of 3 000 m above sea level is approximately 70 kPa.

NOTE 2 Certain **energy storage devices** require other storage and transportation conditions; for example for a **battery,** the duration of high or low **ambient temperature** can affect the **battery** life. The **energy storage device** manufacturer typically provides instructions for **battery** transportation, storage and recharging.

4.3 Unusual conditions

4.3.1 General

4.3 lists conditions that, subject to an agreement between the manufacturer and the purchaser, may require special design and/or special protection features. The purchaser shall identify any requirements that deviate from the normal conditions in 4.2.

4.3.2 Operation

Unusual operating conditions to be identified include the following:

- pollution degree in excess of 2 (see Note 1 in 4.1);
- temperature and relative humidity conditions exceeding the ranges listed in 4.2.2.1;
- altitude conditions exceeding those listed in 4.2.2.2;

NOTE 1 Table 2 is provided for guidance. It is an example of power derating required by altitude.

- exposure to vibration, shocks, tilting;

NOTE 2 Examples include a UPS installed in a vehicle or in an industrial environment.

- exposure to earthquakes;

NOTE 3 More details are given in IEC 60068-3-3.

- electromagnetic immunity exceeding the applicable requirements of IEC 62040-2;
- radioactive immunity to radiation levels exceeding those of the natural background;
- any of the following: moisture, steam, fungus, insects, vermin, dust, abrasive dust, corrosive gases, salt laden air or contaminated cooling refrigerant, damaging fumes, explosive mixtures of dust or gases, restriction of ventilation (for **UPS** and/or **battery**), radiated or conducted heat from other sources.

Any change in performance affected by an unusual condition specified shall be declared by the manufacturer.

Table 2 – Example of power derating factors for use at altitudes above 1 000 m

Altitude		Derating factor	
m	feet	Convection cooling	Forced air cooling
1 000	3 300	1,000	1,000
1 200	4 000	0,994	0,990
1 500	5 000	0,985	0,975
2 000	6 600	0,970	0,950
2 500	8 300	0,955	0,925
3 000	10 000	0,940	0,900
3 500	11 600	0,925	0,875
3 600	12 000	0,922	0,870
4 000	13 200	0,910	0,850
4 200	14 000	0,904	0,840
4 500	15 000	0,895	0,825
5 000	16 500	0,880	0,800
This table is derived from ANSI C57.96:2013 for loading of dry-type distribution and power transformers. Values are generally calculated by interpolation for altitudes not listed.			

NOTE 4 The maximum altitude declared by the manufacturer according to this document is assumed consistent with the maximum value declared for safety purpose according to IEC 62040-1.

4.3.3 Storage and transportation

Any unusual storage and transportation condition shall be identified including situations different from those normally applied to electronic equipment and **batteries**. The following is a list of unusual conditions:

- temperature and relative humidity conditions exceeding the ranges listed in 4.2.3;
- altitude conditions exceeding those listed in 4.2.3;
- exposure to abnormal vibration, shocks, tilting and earthquake acceleration forces;
- special transportation and equipment handling requirements.

5 Electrical conditions, performance and declared values

5.1 General

5.1.1 UPS configuration

The **UPS** manufacturer/supplier shall declare and describe the **UPS** configuration, including

- the quantity of **UPS units** and their topology,
- the redundancy configuration as applicable, and
- any **UPS switches** necessary for connection, interruption, transfer, **bypass** or isolation.

The declaration and its description may reference the applicable subclauses and figures in Annex A, Annex B and Annex C and may be contained in a technical data sheet. Annex D provides an example of a technical data sheet. This data sheet may be included in the **UPS** user manual.

5.1.2 Markings and instructions

Any markings and instructions required in addition to those specified in IEC 62040-1 shall be provided in the user manual, and the **UPS** shall be marked as applicable.

NOTE Examples include instructions necessary for performance related user customisation.

5.2 UPS input specification

5.2.1 Conditions for normal mode operation

A **UPS** conforming to this document shall remain in **normal mode** when connected to an **AC input power** presenting characteristics as follows:

a) **rated voltage** with **input voltage tolerance band** ±10 % of **rated voltage**;

b) **rated** frequency with **input frequency tolerance band** ±2 % of **rated** frequency;

c) for **polyphase** input, voltage unbalance with an **unbalance ratio** of 5 %;

d) **total harmonic distortion** of voltage:

  – for **UPS** intended for connection to the public low-voltage supply:

  ≤ 8 % with maximum levels of **individual harmonic distortion** of voltages not exceeding those in Table 3;

  – for **UPS** intended for connection to industrial plants and non-public networks:

  ≤ 12 % with maximum levels of **individual harmonic distortion** of voltages not exceeding those in Table 4;

e) **transient** voltages, superimposed high-frequency voltages and other electrical noise such as that caused by lightning or capacitive or inductive switching; within the electromagnetic immunity levels specified in IEC 62040-2.

Table 3 – Compatibility levels for individual harmonic distortion of voltage in public low-voltage power supply systems

Odd harmonics non-multiple of 3		Odd harmonics multiple of 3 [a]		Even harmonics	
Harmonic order *n*	**Harmonic voltage** %	**Harmonic order** *n*	**Harmonic voltage** %	**Harmonic order** *n*	**Harmonic voltage** %
5	6	3	5	2	2
7	5	9	1,5	4	1
11	3,5	15	0,4	6	0,5
13	3	21	0,3	8	0,5
$17 \le n \le 37$	$2,27 \times (17/n) - 0,27$	$21 \le n \le 39$	0,2	$10 \le n \le 40$	$0,25 \times (10/n) + 0,25$

NOTE 1 All of the harmonic levels in this table are assumed not to occur simultaneously.

NOTE 2 Table 3 is an extract from the compatibility levels in Table 1 of IEC 61000-2-2 and IEC 61000-2-2:2002/AMD1:2017.

[a] The levels given for odd harmonics that are multiples of three apply to zero sequence harmonics. Also, on a three-phase network without a neutral conductor or without **load** connected between line and ground, the values of the 3rd and 9th harmonics may be much lower than the compatibility levels, depending on the unbalance of the system.

Table 4 – Compatibility levels for individual harmonic distortion of voltage in industrial plants and non-public low-voltage power supply systems

Odd harmonics non-multiple of 3		Odd harmonics multiple of 3 [a]		Even harmonics	
Harmonic order *n*	**Harmonic voltage** %	**Harmonic order** *n*	**Harmonic voltage** %	**Harmonic order** *n*	**Harmonic voltage** %
5	8	3	6	2	3
7	7	9	2,5	4	1,5
11	5	15	2	6	1
13	4,5	21	1,75	8	1
$17 \le n \le 39$	$4,5 \times (17/n) - 0,5$	$21 \le n \le 39$	1	$10 \le n \le 40$	1

NOTE 1 All of the harmonic levels in this table are assumed not to occur simultaneously.

NOTE 2 Table 4 is derived from Class 3 compatibility levels in Table 2, Table 3 and Table 4 of IEC 61000-2-4:2002.

NOTE 3 In some cases where part of an industrial network is dedicated to large non-linear **loads**, the compatibility levels for that part of the network may be 1,2 times the above values.

[a] The levels given for odd harmonics that are multiples of three apply to zero sequence harmonics. Also, on a three-phase network without a neutral conductor or without **load** connected between line and ground, the values of the 3rd and 9th harmonics may be much lower than the compatibility levels, depending on the unbalance of the system.

5.2.2 Characteristics to be declared by the manufacturer

The manufacturer shall declare the applicable characteristics for each AC input **port**. In addition to those covered in 5.2.1, the following characteristics shall be declared:

a) number of phases;

b) neutral requirements;

c) **rated input current**;

d) **input power factor**;

e) **inrush current**;

f) **maximum input current**;

g) input current at **overload capacity** (where applicable, the curve of current versus time);

h) **total harmonic distortion** of current;

i) minimum **short-circuit power** (S_{sc}) capacity required from the **AC input power** for compliance with the maximum harmonic current distortion levels permitted in IEC 61000-3-2 (UPS ≤ 16 A) or IEC 61000-3-12 (16 A < UPS ≤ 75 A), where applicable. Where none of the standards mentioned apply, **individual harmonic distortion** of input current levels ($n \leq 40$) measured or calculated at **rated input current** shall be declared when supplied with a voltage source of negligible distortion;

j) earth leakage current characteristics (where in excess of 3,5 mA). Excludes contribution from the **load,** if any;

k) AC power distribution system compatibility (TN, TT or IT as defined in IEC 60364-1);

l) **rated input voltage** and **input voltage tolerance band**;

m) **rated input frequency** and **input frequency tolerance band**.

NOTE The declaration generally takes the form of a technical data sheet. Annex D provides an example of a technical data sheet.

5.2.3 Characteristics and conditions to be identified by the purchaser

The purchaser shall identify any conditions and characteristics that are more severe than those declared by the manufacturer. Further, the purchaser shall identify any particular conditions that may be required by national and local regulations and any adverse or special service conditions including

a) pre-existing harmonic voltage distortion when in excess of those listed in Table 3 or Table 4, as applicable,

b) requirements for compatibility with characteristics of protective devices of the **AC input power**,

c) requirements for all-pole isolation of the **UPS** from the **AC input power**, and

d) standby generator characteristics, if any.

NOTE IEC 60034-22 provides characteristics for internal combustion engine driven generating sets.

Such service conditions and **deviations** may require special design and/or protection features.

UPS designed for industrial applications or for separately generated **AC input power** supplies may be required to meet more severe conditions. The purchaser should specify such conditions as applicable. In the absence of such information, the manufacturer/supplier may apply their experience as to the compatibility of the design for the intended installation.

5.3 UPS output specification

5.3.1 Conditions for the UPS to supply a load

Subject to either

- the input conditions of 5.2.1 being satisfied, or
- the **energy storage device** being available,

a **UPS** conforming to this document shall be capable of supplying **loads** (single or **polyphase**, as applicable) that are compatible with the output characteristics of the **UPS** as declared by the manufacturer.

5.3.2 Characteristics to be declared by the manufacturer

The manufacturer shall declare the applicable characteristics, including

a) the performance classification (V_ _ _ _ _ _ in accordance with 5.3.4) and, for **multiple normal mode UPS**, the declared sets of input dependency characteristics in accordance with 3.3.7 and the corresponding performance classifications,

b) the **rated output voltage** and **RMS output voltage tolerance band**,

c) the **rated frequency** and free-running **output frequency tolerance band** (non-synchronized),

d) the **output frequency tolerance band** accepted by the **UPS inverter** for **synchronization** with an external source, for example **bypass** and maximum **phase angle** between the **inverter** output voltage and external source voltage waveforms,

e) the rate of change of frequency (slew-rate) when synchronizing,

f) the number of phases available,

g) the neutral availability,

h) the AC power distribution system compatibility (TN, TT or IT as defined in IEC 60364-1),

i) the **total harmonic distortion** of voltage
   - in **normal mode**, and
   - in **stored energy mode**,

j) the **rated output active power, rated output apparent power** and **rated output current**,

k) the **overload capacity** including, if applicable, the effect on the **RMS output voltage tolerance band** declared in b)
   - in **normal mode**,
   - in **stored energy mode**. and
   - in **bypass mode**, where applicable,

l) the minimum **inverter current limit** and minimum sustaining time,

m) the fault clearing capacity expressed as
   - the maximum **load** protective device rating with which the **UPS** can co-ordinate under fault conditions, and
   - the applicable class 1, 2 or 3 of Figure 2, Figure 3, or Figure 4 that the **output voltage** will comply with while clearing the fault; or the time it takes to clear the protective device;

n) the **load power factor** at **rated load**,

o) the permissible **displacement power factor tolerance band** of the **load** (cos Φ)[1],

p) the **voltage unbalance** resulting from 100 % **load unbalance ratio** (**polyphase UPS** only),

q) the **UPS efficiency** (in accordance with Annex I and Annex J),

r) the no **load** losses (in accordance with Annex J),

s) the **parallel redundant UPS** failure performance as the applicable class 1, 2 or 3 of Figure 2, Figure 3, or Figure 4, and

t) the **rated output active power** and **rated output apparent power** for a system consisting of two **UPS units** operating in parallel (if applicable).

Characteristics j), m), n) and o) shall also be declared also for the **bypass transfer switch** when included with a single or **parallel UPS**.

NOTE 1 The characteristics declared are valid with a fully charged **energy storage device**, if not otherwise agreed to.

NOTE 2 The declaration generally takes the form of a technical data sheet. Annex D provides an example of a technical data sheet.

NOTE 3 Some manufacturers include particular performance characteristics under abnormal conditions in the declaration, for example transfer time from **UPS** to **bypass** under non-synchronized conditions.

5.3.3 Characteristics and conditions to be identified by the purchaser

The purchaser shall identify any characteristics and conditions that are more severe than those declared by the manufacturer and any particular condition that may be required by national and local regulations and any adverse or special **load** condition, including:

a) **loads** generating harmonic currents, in particular even harmonic currents, except for **loads** complying with the maximum levels permitted in IEC 61000-3-2 (**load** ≤ 16 A), IEC 61000-3-12 (16 A < **load** ≤ 75 A), or IEC TS 61000-3-4 (**load** > 75 A),

b) asymmetric **loads** requiring circulation of a DC current, for example half-wave,

c) requirement for independent earthing of the output neutral,

d) requirements for output power distribution including characteristics of protective devices for coordination purposes,

e) requirements for all-pole isolation of the **UPS** from the output power distribution,

f) future extension/expansion requirements,

g) standby generator characteristics,

h) availability (see Annex K) and degree of redundancy (see Annex A), and

i) output overvoltage protection.

5.3.4 Performance classification

5.3.4.1 General

The manufacturer shall classify **UPS** complying with this document in accordance with the coding AAA BB CC as detailed in 5.3.4.

NOTE 1 The objective of classifying **UPS** by performance is to provide a common base on which all **UPS** manufacturer's/supplier's data are evaluated. This enables purchasers, for similar **UPS** power ratings, to compare different manufacturer's products under the same measurement conditions.

NOTE 2 This classification is performance-based and does not exclude any specific technology or topology as the means for achieving compliance with such classification.

NOTE 3 Refer to Annex B for examples of applicable UPS topologies.

5.3.4.2 Input dependency AAA

5.3.4.2.1 General

The input dependency AAA is a set of characters describing to which extent, for operation in **normal mode**, the **load** power depends on the quality of the **AC input power**. The set of characters takes form of either VFD, VI or VFI as described in the following subclauses.

5.3.4.2.2 VFD (voltage and frequency dependent)

UPS classified VFD shall protect the **load** from a complete loss of **AC input power**.

The output of the VFD **UPS** is dependent on changes in voltage and frequency of the **AC input power** and is not intended to provide additional voltage corrective functions, such as those arising from the use of tapped transformers.

VFD classification is verified when performing the test described in 6.2.2.7.

5.3.4.2.3 VI (voltage independent)

UPS classified VI shall protect the **load** as required for VFD and also from

- under-voltage applied continuously to the input, and
- over-voltage applied continuously to the input.

The **output voltage** of the VI **UPS** shall remain within declared voltage limits (provided by voltage corrective functions, such as those arising from the use of active and/or passive circuits). The manufacturer shall declare an **output voltage tolerance band** narrower than the **input voltage tolerance band**.

NOTE The **energy storage device** does not discharge when the **AC input power** is within the **input voltage tolerance band.**

VI classification is verified when performing the tests described in 6.4.1.2.

5.3.4.2.4 VFI (voltage and frequency independent)

UPS classified VFI is independent of **AC input power** voltage and **frequency variations** as specified and declared in 5.2 and shall protect the **load** against adverse effects from such variations without discharging the **energy storage device**.

VFI classification is verified when performing the tests described in 6.4.1.3.

5.3.4.3 Output voltage waveform BB

5.3.4.3.1 General

The output voltage waveform BB is a set of characters describing the **steady state** waveform of the **output voltage** when operating in:

– **normal mode** (1st character);

– **stored energy mode** (2nd character),

where each character takes the form of either S, X or Y as described in the following subclauses.

5.3.4.3.2 Waveform S

Sinusoidal output voltage waveform compatible with **load** equipment intended for connection to public low-voltage power supply systems, presenting under **linear load** and **reference non-linear load** conditions:

– **harmonic distortion** ≤ 8 %, and

– **individual harmonic distortion** within limits of Table 3.

5.3.4.3.3 Waveform X

Sinusoidal output voltage waveform compatible with **load** equipment intended for connection in industrial plants dedicated to large non-linear **loads**, presenting under **linear load** and **reference non-linear load** conditions:

– **total harmonic distortion** ≤ 12 %, and

– **individual harmonic distortion** within limits of Table 4.

5.3.4.3.4 Waveform Y

Non-sinusoidal output voltage waveform presenting

– peak voltage U_P ≤ **rated voltage** × $\sqrt{2}$, and

– rise/fall rates $d_U/d_t \leq 10$ V/µs.

Figure 1 represents a typical characteristic Y waveform.

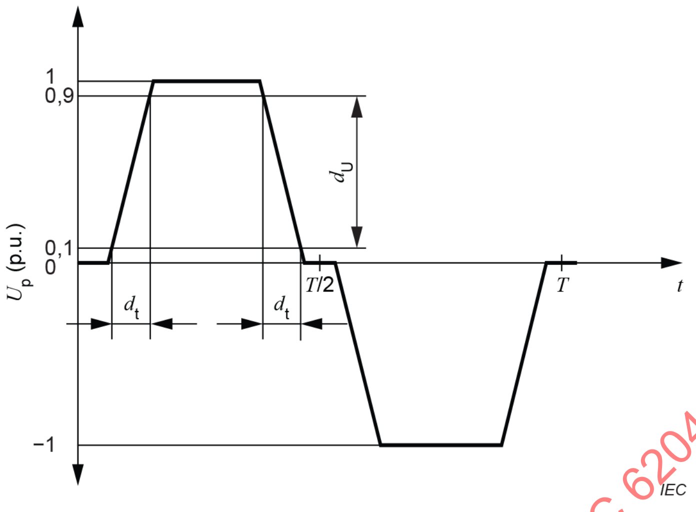


Figure 1 – Typical characteristic Y output voltage waveform

The voltage waveform classification is verified by performing the applicable steady state electrical type tests described in 6.4.2.2 and 6.4.2.4.

NOTE **Non-linear loads** such as switch mode power supplies tolerate non-sinusoidal voltage waveforms, generally for a limited time. Subject to requirements from the **load** equipment manufacturer, this time is the **stored energy time** (typically 5 min to 30 min).

5.3.4.4 Dynamic output performance CC

5.3.4.4.1 General

The dynamic output performance CC is a set of characters describing the voltage variation caused by

- the change of mode of operation (1st character), and
- the **step load** application (2nd character),

where each character takes form of either 1, 2 or 3 as described in the following subclauses.

The dynamic output performance is verified by performing the electrical type tests in 6.4.2.10.2, 6.4.2.10.3, 6.4.2.10.4 (for the 1st character) and in 6.4.2.10.5 (for the 2nd character).

NOTE 1 **Linear loads** are generally tolerant of single **transient deviations** not exceeding 100 % of **nominal** peak voltage for less than 1 ms. **Linear loads**, often containing magnetic components, are however generally sensitive, on a half-cycle by half-cycle basis, to loss or gain in volt-time area. The validation method for **RMS** measurements described in Clause H.2 is deemed an adequate technique to measure the latter.

NOTE 2 **Non-linear loads** of the type represented by the **reference non-linear load** of Annex E are generally tolerant of loss or gain in the volt-time area during at least one complete half-cycle. The capacitor of the **reference non-linear load** draws current only when the **UPS** voltage exceeds the **load** capacitor voltage and as such is affected only if the **UPS** peak voltage decreases substantially for a length of time. Dynamic performance considerations for this type of **load** is generally limited to ensuring the maintenance of the **load** capacitor voltage within stated limits during **transient** testing.

NOTE 3 Purchasers are reminded that due to the diversity of **load** types, **UPS** manufacturers' data are based on industry standard test **loads** that simulate typical **load** applications.

NOTE 4 The actual performance in a given application is subject to variation under **transient** conditions since actual **load** ratings, individual sequencing, and start currents are likely to differ from standardized test situations.

NOTE 5 Cord connected **UPS** designed to be installed by the operator for use in an office environment, either desk or floor-mounted, and/or intended to be marketed by a third party without reference to the manufacturer, are, within the **UPS** rating, expected to be capable of accepting any **load** suitable for connection to a public low-voltage power system, unless any limitations are stated by the manufacturer within the user instructions.

NOTE 6 Refer to Annex H for guidance on measurement techniques.

5.3.4.4.2 Class 1

The **UPS output voltage** remains within the limits of Figure 2.

NOTE Such performance is required by sensitive critical loads.

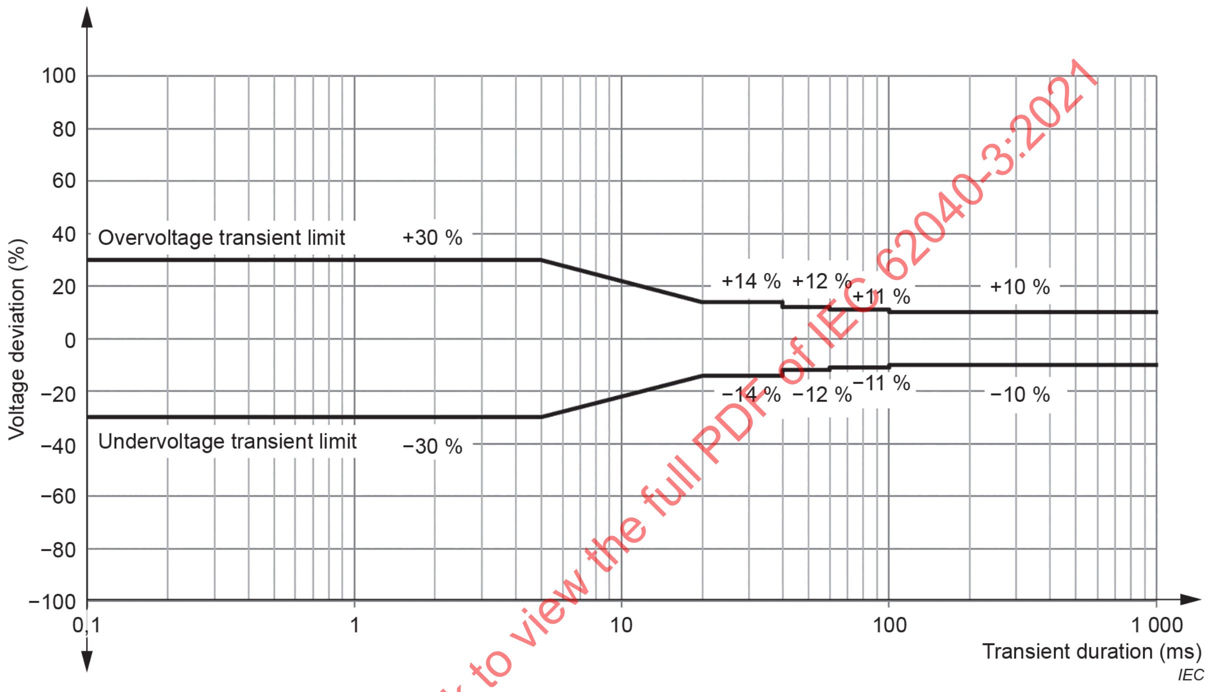


Figure 2 – Dynamic output performance class 1

5.3.4.4.3 Class 2

The **UPS output voltage** remains within the limits of Figure 3.

NOTE Such performance is accepted by most types of critical load.

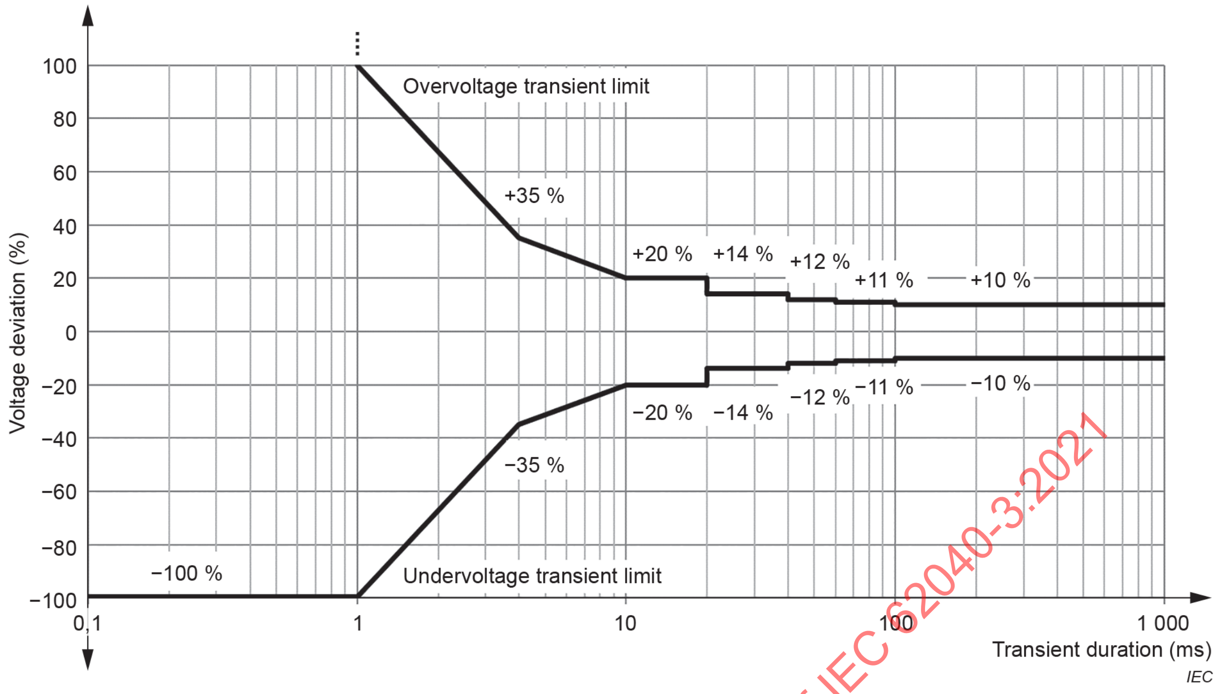


Figure 3 – Dynamic output performance class 2

5.3.4.4.4 Class 3

The **UPS output voltage** remains within the limits of Figure 4.

NOTE Such performance is accepted by most types of general-purpose IT loads, for example switched-mode power supplies.

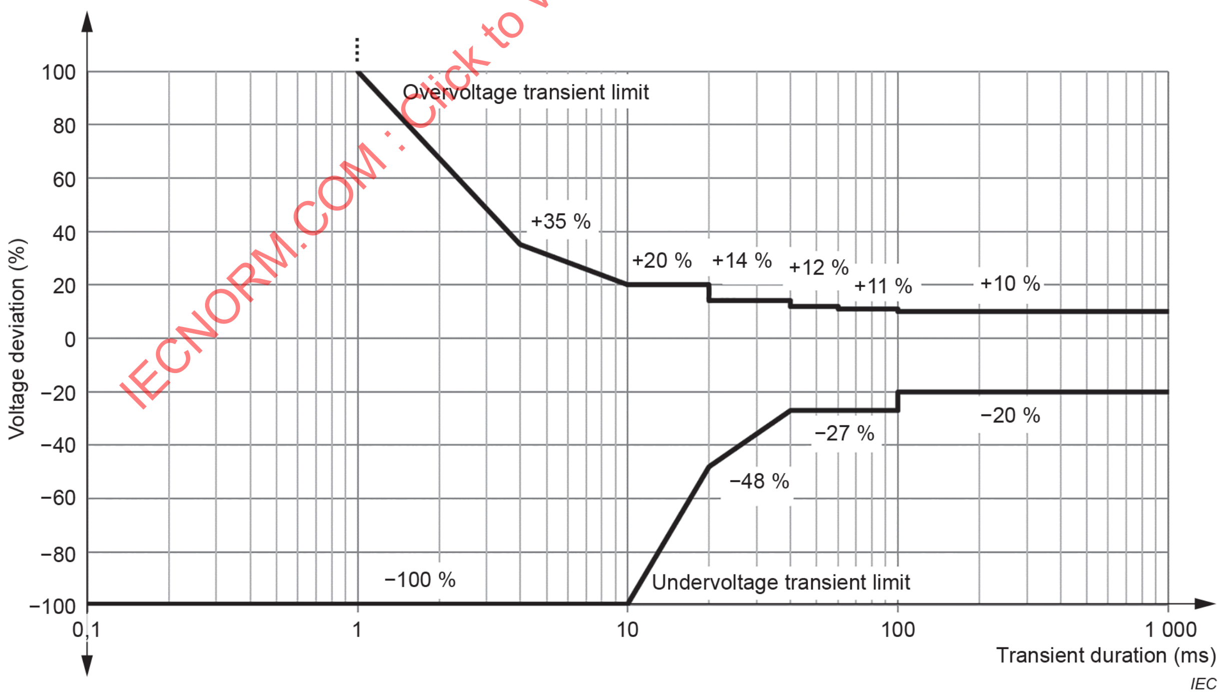


Figure 4 – Dynamic output performance class 3

5.4 Energy storage device specification

5.4.1 General

5.4 specifies details that apply to a **secondary battery**, presently the most common technology utilised to provide energy storage for use during **AC input power failure**.

It is recognised that other technologies, for example **flywheel energy storage systems**, may replace the need for a **battery** system. Such technologies may be fully compatible with **UPS** characteristics primarily intended for **batteries**. With this in mind, subject to an agreement between the manufacturer/supplier and the purchaser and where applicable, 5.4 may be used to specify other energy storage technologies.

5.4.2 Battery

5.4.2.1 Requirements for all batteries

A **battery** intended to serve as an **energy storage device** for a **UPS** complying with this document shall comply with the IEC 62040-1 requirements for location, ventilation, marking and protection of a **battery**.

5.4.2.2 Characteristics to be declared by the manufacturer

The manufacturer shall declare the following **battery** characteristics, for example in the user manual or in the **UPS** technical data sheet (see Clause D.5):

a) service life;

b) quantity of blocks or cells and of paralleled strings if more than one string;

c) nominal string voltage;

d) battery technology (e.g. vented or valve-regulated lead-acid, NiCd, NiMH, Li-Ion);

e) nominal capacity of total battery and reference discharge rate, for example discharge rate C10;

f) **stored energy time** at **reference test load**;

g) **restored energy time**;

h) **ambient temperature** at which **battery** performance is rated;

i) earth condition of DC port /isolation of DC port from input and/or output (only applicable for remote battery);

j) Battery ripple current during normal mode operation (if exceeding 5 % of the numerical Ah capacity [C10 discharge rate]).

When a remote **battery** is part of the **UPS** installation, and the remote **battery** cabling and/or protection is not provided by the manufacturer/supplier, the following additional characteristics shall be declared:

k) discharge current at nominal **battery** string voltage while in **stored energy mode** and supplying **rated load**;

l) DC fault current rating;

m) cable voltage drop recommendation;

n) protection requirements.

The manufacturer/supplier shall supply the following additional information if requested by the purchaser:

o) charging regime, for example constant voltage, constant current, boost or equalization capability, two-state charging;

p) charging voltage and **tolerance band**;

q) **cut-off voltage**;

r) **charger current limit** and range (if adjustable), and **tolerance band**.

5.4.2.3 Characteristics and conditions to be identified by the purchaser

The purchaser shall identify any requirements, characteristics and conditions that deviate or are more severe than those listed in 5.4.2.1 and 5.4.2.2. This includes any particular conditions required by national and local regulations and any adverse or special service conditions including when a **battery** is supplied by a third party.

NOTE National and local regulations can specify a minimum **stored energy time** and define the type of **energy storage device** to be used.

5.5 UPS switch specification

5.5.1 UPS switches supplied as an integral part of a UPS

UPS switches supplied as an integral part of a **UPS** are covered by the specified electrical service conditions and performance requirements in Clause 5 and need not to be specified separately.

5.5.2 UPS switches not supplied as an integral part of a UPS

Switches supplied separately and intended to operate in conjunction with the **UPS** shall be compatible with the applicable electrical service conditions and performance requirements of the **UPS** and shall comply with their own product performance standard.

NOTE Examples of product standards that apply to particular switches are:

– static transfer systems (STS): IEC 62310-3;
– **automatic** transfer systems (ATS): IEC 60947-6-1;
– **manual** isolation, tie and **transfer switches**: IEC 60947-3.

5.6 Signal, control and communication ports

The manufacturer shall provide adequate instructions for use and installation of any communication and signalling circuits supplied as an integral part of the **UPS** and intended to be connected to information technology equipment, for example programmable logic computers, local area networks (LAN) or to telecommunication networks.

6 UPS tests

6.1 Summary

6.1.1 Venue, instrumentation and load

6.1.1.1 Test venue

A **UPS** shall be tested in accordance with Table 5, generally at the manufacturer's premises.

If testing of a **UPS** requires facilities either not available at the manufacturer's premises and/or not economically justified within the scope of a particular situation, the manufacturer may then elect to:

a) use a third-party competent body to carry out compliance testing on the manufacturer's behalf. Evidence of third party certification shall be deemed sufficient to prove compliance with the relevant clauses; or

b) demonstrate by calculation or by experience and/or testing of similar designs or sub-assemblies in similar conditions and through compilation of a technical construction file that the design is compliant. Evidence through a technical construction file shall be deemed sufficient to prove compliance with the relevant clauses; or

c) subject to an agreement with the purchaser, defer applicable tests to be performed on site.

Tests may be performed on the **UPS** in its complete form or, alternatively, on a **UPS functional unit** or on a subassembly prior to delivery on site. When such necessity arises, the **UPS functional unit** test of 6.6 applies and the manufacturer/supplier and the purchaser should agree on conditions for final site testing. The manufacturer's recommendation should be followed in this respect.

6.1.1.2 Test instrumentation

Instruments used for the measurement of electrical parameters shall have sufficient bandwidth to accurately measure true **RMS value** on waveforms which may be other than a fundamental sinewave, i.e. may present considerable **harmonic content**. Whichever type of instrumentation is used, its accuracy shall be in relation to the characteristic being measured and regularly calibrated in accordance with applicable standards. Refer to IEC 61000-4-30 for guidance on selection of instrumentation.

6.1.1.3 Test load

Tests are performed with **reference test load** where not otherwise specified in the relevant test clause.

UPS capable of parallel operation may be tested as individual **UPS units**, except for the **load sharing** test in 6.4.2.6. In particular cases, a special **load**, including the actual site **load**, may be used if agreed upon between the manufacturer/supplier and the purchaser.

6.1.2 Routine testing

The **routine tests** listed in Table 5 shall be performed on every **UPS** and where not otherwise specified in the relevant test clause, with the **AC input power** in accordance with 5.2.1.

Testing of characteristics other than those covered by **routine tests** are subject to an agreement between the manufacturer/supplier and the purchaser.

6.1.3 Site testing

Uninterruptible power systems covered by this document include large multi-module **UPS** that may be delivered as separate **functional units** intended for final assembly and wiring on site. Such large **UPS** may require their final performance testing to be completed on site. Refer to 6.3 for more details.

6.1.4 Witness testing

In addition to the **routine tests** performed by the manufacturer, the purchaser may wish their representative to witness testing of selected items of Table 5 and/or of other specific items.

Witness tests are subject to an agreement between the manufacturer/supplier and the purchaser.

The purchaser should evaluate the need for witness testing taking into account the manufacturer's/supplier's quality assurance status.

6.1.5 Type testing

Type tests shall be performed on a **UPS** that represents a series of substantially identical products. **Type tests** are intended to assure that such identical products are compliant with their full specifications when produced under relevant quality standards and after having passed the **routine tests** detailed in 6.2. The **UPS** used for type testing is not necessarily supplied to any purchaser. **Type tests** are listed in Table 5 and detailed in 6.4 and 6.5.

For **UPS** in ongoing production, some of the **type tests** should be repeated at specified intervals on production samples to verify that the quality of the product is maintained.

6.1.6 Schedule of tests

Tests shall be performed in accordance with Table 5.

Multiple normal mode UPS shall be tested in each declared set of input dependency characteristics. See 3.3.7.

NOTE 1 Annex F provides guidance for testing of **multiple normal mode UPS**.

Table 5 – UPS test schedule

Test description	Routine test	Type test	Subclause
Cable and interconnection check	x	x	6.2.2.2
Light load and functional test	x	x	6.2.2.3
No load	x	x	6.2.2.4
Full load	x	x	6.2.2.5
Synchronization	x	x	6.2.2.6
AC input power failure, VFD test	x	x	6.2.2.7
AC input power return	x	x	6.2.2.8
Transfer to bypass mode	x	x	6.2.2.9
Input – supply compatibility:			
Input voltage tolerance, VI test		x	6.4.1.2
Combined input voltage and frequency tolerance, VFI test		x	6.4.1.3
Rated input current		x	6.4.1.4
Maximum input current			6.4.1.5
Inrush current		x	6.4.1.6
Total harmonic distortion of input current		x	6.4.1.7
Input power factor		x	6.4.1.8
Efficiency		x	6.4.1.9
No load losses		x	6.4.1.10
Standby generator compatibility		x	6.4.1.11
Output – load compatibility:			
Normal mode		x	6.4.2.2
Stored energy mode		x	6.4.2.3
Unbalanced load		x	6.4.2.4
DC voltage off-set		x	6.4.2.5
Load sharing		x	6.4.2.6
Output overvoltage		x	6.4.2.7
Periodic output voltage modulation		x	6.4.2.8
Overload capacity		x	6.4.2.9.1
Fault clearing capacity		x	6.4.2.9.2
Inverter current limit		x	6.4.2.9.3
Dynamic output performance:			
Normal mode to stored energy mode		x	6.4.2.10.2

Test description	Routine test	Type test	Subclause
Stored energy mode to normal mode		x	6.4.2.10.3
Normal mode to bypass mode – Overload		x	6.4.2.10.4
Step load		x	6.4.2.10.5
Parallel redundant UPS failure		x	6.4.2.10.6
Energy storage device:			
Stored energy time		x	6.4.3.1
Restored energy time		x	6.4.3.2
Battery ripple current		x	6.4.3.3
Restart test		x	6.4.3.4
Charger current limit		x	6.4.3.5
Environmental:			
Shock during transportation		x	6.5.1.2
Free fall during transportation		x	6.5.1.3
Storage in dry heat, damp heat and cold environments		x	6.5.2
Operation in dry heat, damp heat and cold environments		x	6.5.3
Acoustic noise		x	6.5.4
UPS functional unit tests (where not tested as a complete **UPS**):			
UPS rectifier		x	6.6.2
UPS inverter		x	6.6.3
UPS switch(es)		x	6.6.4
Energy storage device		x	6.6.5

6.2 Routine tests

6.2.1 General

The **routine tests** detailed in 6.2 are electrical only. No environmental **routine tests** are required.

6.2.2 Electrical

6.2.2.1 General

The requirements in 6.2.2 apply to both **routine** and **type tests**. See Table 5.

6.2.2.2 Cable and interconnection check

The **UPS** shall be inspected in accordance with the manufacturer's installation and wiring diagrams to determine that the **AC input power**, the **energy storage device** (as applicable), the **load** and any communication circuits are connected as required.

Compliance is verified by inspection.

6.2.2.3 Light load and functional test

With the **UPS** in **normal mode** and **light load** applied; operation of the following shall be verified:

a) all control switches and other means to activate **UPS** operation;

b) protective devices (refer to 7.5.3 of IEC 60146-1-1:2009);

c) auxiliary devices, such as contactors, fans, outlets, annunciators and communication devices;

d) supervisory, monitoring and remote signalling devices (if any);

e) **automatic** transfer to **stored energy mode** and back to **normal mode** by failing and subsequently restoring the **AC input power**;

NOTE 1 This test can be performed in conjunction with AC fail/return tests of 6.2.2.7 and 6.2.2.8.

f) for **UPS** so equipped, **automatic** transfer to **bypass mode** or isolation of the **inverter** from the common AC output bus (as applicable) and back to **normal mode** by failing and subsequently restoring the **inverter** AC **output voltage**;

NOTE 2 This test can be performed in conjunction with transfer to **bypass** test of 6.2.2.9 or **parallel redundant UPS** failure test of 6.4.2.10.6 as applicable

g) for UPS so equipped, **manual** transfer to **bypass mode** or isolation of the **inverter** from the common AC output bus and back to **normal mode** (as applicable) by operating appropriate switches and/or controls.

*Compliance is verified by observation that the devices and functions intended to control, protect, supervise, measure and signal **UPS** activities perform as expected and that the **load** voltage remains within specified values during the **manual** and **automatic** transfers.*

6.2.2.4 No load

The **UPS** shall remain in **normal mode** of operation and its **output voltage** shall remain within the declared values with no load connected.

Compliance is verified by measurement that the output voltage does not exceed the steady state variation declared for the rated voltage. See 5.3.2 b).

6.2.2.5 Full load

The **UPS** shall remain in **normal mode** of operation and its **output voltage** shall remain within the declared values while supplying the **reference test load**.

Parallel UPS may be **load** tested by testing the individual **UPS units** separately or together.

*Compliance is verified by measurement that the **output voltage** does not exceed the **steady state** variation declared for the **rated voltage**. See 5.3.2 b).*

6.2.2.6 Synchronization

This test shall be performed when **synchronization** to an external source is required. The test shall be performed in **normal mode** and at **light load**. The voltage and frequency of the external source, for example the **bypass**, shall be that prevailing at the test site and shall be stable and within the characteristics specified in 5.2.1.

This test may be performed in conjunction with another test if it is more convenient.

*Compliance is verified when, in **steady state**, the measured **phase angle** between the **inverter** output voltage and the external source voltage waveforms is equal to or less than that declared in 5.3.2 d).*

6.2.2.7 AC input power failure and VFD input dependency

The **UPS** shall operate in **normal mode** at **light load** and with the **energy storage device** or another appropriate energy source connected. The **AC input power failure** shall be tested as specified in Annex G for **high impedance failure**.

This test may be performed in conjunction with the **light load** test of 6.2.2.3 e).

Compliance is verified when, following the input AC failure, the ***UPS*** *operates in* ***stored energy mode*** *within* ***steady state output voltage*** *and frequency limits declared in 5.3.2 b) and 5.3.2 c).*

6.2.2.8 AC input power return

The **UPS** shall operate in **stored energy mode** at **light load** and with the **energy storage device** or another appropriate energy source connected and with the **AC input power** disconnected. The **AC input power** shall then be returned, and the resulting **AC output voltage** and **frequency variations** shall be measured.

Additionally, for type testing only, the procedure above shall be repeated except that the **AC input power** shall be returned with improper phase rotation. This test may be performed in conjunction with the **light load** test of 6.2.2.3 e).

Compliance is verified when:

a) *following the return of* ***input AC power*** *with proper phase rotation, the* ***UPS*** *operates in* ***normal mode*** *within* ***steady state output voltage*** *and frequency limits specified in 5.3.4; and*
b) *for type testing only, following the return of* ***input AC power*** *with improper phase rotation, the* ***UPS*** *does not get damaged.*

6.2.2.9 Transfer to bypass mode

This test shall only be performed for **UPS** featuring **automatic bypass** capability.

The **UPS** shall operate in **normal mode.**

By failure simulation or output overload, the **load** shall be transferred to the **bypass automatically** and then back to the **UPS** either **automatically** or **manually** when the failure simulation or output overload is removed.

The **output voltage transient** shall be measured and the **phase angle** between the **bypass** input voltage and the **inverter** output voltage shall also be measured while transferring to and from the **bypass**.

This test may be performed in conjunction with the full **load** test of 6.2.2.5.

Compliance is verified when, throughout the process described above, the ***UPS output voltage*** *remains within the* ***tolerance bands*** *declared in 5.2.1 a) or 5.3.2 b), whichever is the widest, and when the measured* ***phase angle*** *is equal or less than the value declared in 5.3.2 d).*

6.3 Site tests

UPS that are delivered as separate **UPS functional units** intended for final on-site assembly and wiring require their final performance tests to be completed on site. The site test procedure generally consists of the manufacturer's commissioning procedure and of completion of any **routine** and **type tests** of Table 5 that were not otherwise completed prior to delivery.

The purchaser may, subject to an agreement with the **UPS** manufacturer, formulate a specific site acceptance test (SAT) schedule as part of a purchase contract.

The purchaser should, for economic reasons and to avoid unnecessary stress to the **UPS**, confine the site-test schedule to verify essential characteristics not otherwise verified.

6.4 Type tests – Electrical

6.4.1 Input – AC input power compatibility

6.4.1.1 General

The **AC input power** shall

- comply with the applicable requirements in 5.2.1,
- present the applicable power distribution characteristics declared in 5.2.2 k), and
- be capable of providing a variable frequency and voltage as declared in 5.2.1 a) and 5.2.1 b). In the absence of a variable frequency/voltage generator, alternative test methods are permitted.

6.4.1.2 Steady state input voltage tolerance and VI input independency

With the **UPS** operating in **normal mode** and with the AC input voltage and frequency set to **nominal** values, the input voltage shall be adjusted first to the minimum value and then to the maximum value of the **input voltage tolerance band** declared by the manufacturer in 5.2.1 a) (or 5.2.2 l) if wider).The voltage shall remain at each value for at least 1 min.

The **UPS output voltage** shall be measured and recorded at **nominal**, minimum and maximum input voltages. The test shall be performed both under **reference test load** and under no **load** conditions.

a) *Compliance with the **steady state input voltage tolerance** is verified when, under both **load** conditions,*
   - *the **UPS output voltage** remains within the **RMS output voltage tolerance band** declared in 5.3.2 b), and*
   - *the **UPS** remains in **normal mode**.*

b) *Compliance with VI input independency, if applicable, is verified when, in addition to a), the boundaries of the output **RMS output voltage tolerance band** declared in 5.3.2 b) are narrower than those of the **input voltage tolerance band** declared in 5.2.1 a) (or 5.2.2 l) if wider).*

6.4.1.3 Combined input voltage/frequency tolerance and VFI input independency

With the **UPS** operating in **normal mode** and the input voltage and frequency set at the minimum values of their declared **tolerance bands**, simultaneously adjust both to the maximum values of their declared **tolerance bands**. See 5.2.1 a) (or 5.2.2 l) if wider) and 5.2.1 b) (or 5.2.2 m) if wider).

Where the **UPS** output frequency is synchronized to the input frequency, the range of **synchronization** shall be checked compliant with the maximum **phase angle** between the **inverter** output voltage and input voltage waveforms while the input frequency is varied at maximum slew-rate. See 5.3.2 d) and 5.3.2 e).

NOTE A decrease in frequency is assumed not to coincide with an increase in line voltage, and vice versa.

The test shall be performed at no **load** and then repeated with **reference test load** connected to the **UPS** output.

a) *Compliance with the combined input voltage/frequency tolerance is verified when under both **load** conditions:*
   - *the **output voltage** and frequency remain within the **tolerance bands** declared in 5.3.2 b) and 5.3.2 d) while input voltage and frequency are moved over the declared input voltage and frequency **tolerance bands**;*
   - *the **UPS** remains in **normal mode**.*

b) *Compliance with VFI input independency, if applicable, is verified when, in addition to a), the boundaries of the declared **output voltage** and frequency **tolerance bands** are narrower than those of the declared input voltage and frequency **tolerance bands**.*

6.4.1.4 Rated input current

The value of the **rated input current** shall be obtained from test 5.2.3.102 in IEC 62040-1:2017.

Compliance is verified when the value obtained is equal or less than that declared by the manufacturer in 5.2.2 c).

6.4.1.5 Maximum input current

The **UPS** shall operate in **normal mode**, at worst-case declared AC input voltage, at **rated load** and with a fully depleted **energy storage device**, and the value of the AC input current shall be measured.

Compliance is verified when the measured input current is equal or less than that declared by the manufacturer. See 5.2.2 f).

6.4.1.6 Inrush current

The **UPS** shall operate at no **load** in **normal mode**. The **AC input power** shall then be switched off for 5 min and restored. The resulting **inrush current** and its duration shall be measured.

For the purpose of determining the maximum **inrush current** value, the test shall be repeated 10 times except that the duration of the **AC input power** interruption shall be randomly varied between 1 s and 5 s.

For the purpose of this test, initial current surges attributable to energization of RFI capacitors in input filters with a time duration of less than 1 ms shall be disregarded.

The **AC input power** shall be capable of providing a prospective short-circuit current so that the **short-circuit ratio** R_{sce} is at least 33. Testing at a R_{sce} lower than 33 is permitted when the test result is corrected by an appropriate calculation.

*Compliance is verified when the measured **inrush current** and its duration do not exceed those declared by the manufacturer in 5.2.2 e).*

6.4.1.7 Total harmonic distortion of input current

The **UPS** shall operate in **normal mode**, at **rated** input voltage, with the **reference test load** applied and with a fully charged **energy storage device**. The **total harmonic distortion** of the current at the input **port** shall be measured.

Where the **reference test load** is implemented by means of returning the output power to the **UPS** input **port**, the harmonic distortion to be measured is that of the input current actually drawn by the **UPS** input (as opposed to that drawn from the **AC input power**).

*Compliance is verified when the measured **total harmonic distortion** of the current at the input **port** is equal or less than that declared by the manufacturer in 5.2.2 h).*

6.4.1.8 Input power factor

The **UPS** shall operate in **normal mode**, at **rated** input voltage and frequency, with the **reference test load** applied and with a fully charged **energy storage device**. The **input power factor** shall be measured.

Where the **reference test load** is implemented by means of returning the output power to the **UPS** input, the **input power factor** to be measured is that of the input current actually drawn by the **UPS** (as opposed to that drawn from the **AC input power**).

*Compliance is verified when the measured **input power factor** is equal to or greater than that declared by the manufacturer in 5.2.2 d).*

6.4.1.9 Efficiency

The **efficiency** shall be measured at 100 %, 75 %, 50 % and 25 % **load** as specified in Annex J.

Where a **UPS** is designed to operate at multiple **rated voltages** and/or **rated frequencies**, the **UPS** shall be tested at the most applicable **rated voltage** and **rated frequency** combination as found in IEC 60038.

UPS designed for compliance with specific customer requirements impacting **efficiency** are not required to comply with the **efficiency** values in Annex I.

Specific customer requirements typically arise from particular industry segments (for example oil and gas, health care, offshore platforms and power plants).

Specific customer requirements impacting **efficiency** include widening of environmental conditions, lowering of the DC voltage of the **energy storage device**, input/**output voltages** and/or frequencies not listed in IEC 60038, additional isolation, special cooling, additional overload, additional fault clearing capacity, additional input or output filtering, additional ingress protection, etc.

*Compliance is verified when the calculated **efficiency** values are equal to or greater than those declared by the manufacturer in 5.3.2 q).*

6.4.1.10 No load losses

The **AC input power** shall be measured at no **load** as specified in Annex J.

Where a **UPS** is designed to operate at multiple **rated voltages** and/or **rated frequencies**, the **UPS** shall be tested at the most applicable **rated voltage** and **rated frequency** combination as found in IEC 60038.

Compliance is verified when the measured loss value is equal to or lower than that declared by the manufacturer in 5.3.2 r).

6.4.1.11 Standby generator compatibility

For the purpose of demonstrating **UPS** compatibility with a standby generator, all **routine tests** listed in Table 5, with the exception of 6.2.2.3, shall be performed as a **type test** using the output of a standby generator as the **AC input power**.

When performing test 6.2.2.7 and 6.2.2.8, a **reference test load** shall be used.

The characteristics of the standby generator used for this **type test** shall be provided by the manufacturer of the **UPS.**

Subject to an agreement between the manufacturer/supplier and the purchaser, this test may be performed on site.

NOTE 1 This test is generally performed in conjunction with the input voltage and frequency tolerance tests (see 6.4.1.2 and 6.4.1.3).

NOTE 2 IEC 60034-22 provides characteristics for internal combustion engine driven generating sets.

6.4.2 Output – Load compatibility

6.4.2.1 Load power factor

Where the manufacturer/supplier declares in 5.3.2 o) a permissible **displacement power factor tolerance band** for the **load** that can be connected to the **UPS** output **port**, the tests in 6.4.2 shall be performed with a nominal **load power factor** as per 5.3.2 n) and repeated using **loads** at each extreme of the permissible **displacement power factor tolerance band.**

6.4.2.2 Normal mode

With the **UPS** operating in **normal mode** and at no **load**, measure the **total harmonic distortion**, the **individual harmonic distortion** and the **RMS value** of the **output voltage**.

Repeat the test but with **reference test load** connected to the output of the **UPS**.

Repeat the test but with **reference non-linear load** connected to the output of the **UPS**.

Measurement of the harmonic values is unnecessary for **UPS** whose output in **normal mode** is connected directly and solely through a switching device to the **AC input power**.

*Compliance is verified when, under all **load** conditions,*

– *the measured **output voltage total harmonic distortion** and **individual harmonic distortion** values remain within the waveform characteristics declared in 5.3.2 a) (see 5.3.4.3, 1st character), and*

– *the measured **output voltage** remains within the **RMS output voltage tolerance band** declared in 5.3.2 b).*

6.4.2.3 Stored energy mode

With the UPS operating in stored energy mode and at no load, measure under steady state conditions the total harmonic distortion, the individual harmonic distortion and the RMS value of the output voltage

- at the beginning of **stored energy mode**, and
- just prior to when the **UPS** shuts down at **cut-off voltage** of the **energy storage device**.

Repeat the test but with **reference test load** connected to the output of the **UPS**.

Repeat the test but with **reference non-linear load** connected to the output of the **UPS**.

It is permissible to terminate the no **load** test at the end of the declared **stored energy time** rather than when the **UPS** shuts down.

For **UPS** with a **stored energy time rated** less than 10 min, it is permissible to connect an additional **energy storage device** to enable testing and to stabilise measurements.

NOTE This test can be performed in conjunction with **stored energy time** tests of 6.4.3.1.

*Compliance is verified when, under all **load** conditions,*

– *the measured **total harmonic distortion** and **individual harmonic distortion** values remain within the waveform characteristics declared in 5.3.2 a) (see 5.3.4.3, 2nd character), and*

– *the measured **output voltage** remains within the **RMS output voltage tolerance band** declared in 5.3.2 b).*

6.4.2.4 Unbalanced load (polyphase UPS only)

With the **UPS** operating in **normal mode** and with all output phases supplying 100 % **load** except for one phase that shall be at no **load** (unless otherwise specified by the manufacturer/supplier), measure the phase-to-neutral **output voltages** (or phase-to-phase voltages if a neutral does not exist) and calculate the **output voltage unbalance ratio**.

*Compliance is verified when the calculated **output voltage unbalance ratio** is equal to or less than the declared **output voltage unbalance ratio.** See 5.3.2 p).*

6.4.2.5 DC voltage off-set

With the **UPS** operating in **normal mode** and at no **load**, measure the 10 s average DC voltage at the AC output **port** of the **UPS**.

*Compliance is verified when the measured DC voltage at the AC output **port** is equal to or less than 0,1 % of the **rated output voltage**.*

6.4.2.6 Load sharing (parallel UPS only)

With two **UPS units** operating in parallel and in **normal mode** while supplying a **load** equal to the **rated output active power** and the **rated output apparent power** declared in 5.3.2 t), measure the output **active power** and the output **apparent power** at the output **port** of each **UPS unit**.

Repeat the test in **stored energy mode**.

*Compliance is verified when, in both modes of operation, the measured power values do not exceed the applicable **rated output active power** and **rated output apparent power** of each **UPS unit** as declared by the manufacturer in 5.3.2 j).*

6.4.2.7 Output overvoltage

With the **UPS** operating in **normal mode** and at **light load**, simulate an **output voltage** beyond the upper limits in Figure 2, Figure 3 or Figure 4, as applicable.

Repeat the test but with the **UPS** operating in **stored energy mode**.

*Compliance is verified when, in both modes of operation, following the simulation, the **UPS automatically** performs corrective action so that the overvoltage ceases to be supplied to the **load.***

6.4.2.8 Periodic output voltage modulation

Only when, subject to a specific agreement between the purchaser and the manufacturer, this test is specified, it shall be checked by voltage recording at different **loads** and operating conditions.

*Compliance is verified when, under all **load** and operating conditions, the **UPS output voltage** remains within the limits of Figure 2, Figure 3 or Figure 4, as applicable.*

6.4.2.9 Overload capacity and fault clearing capacity

6.4.2.9.1 Overload capacity

With the **UPS** operating in **normal mode** at **light load** and with an **ambient temperature** between 20,0 °C to 30,0 °C, apply a **load** which shall result in the **UPS** supplying its declared **overload capacity**. See 5.3.2 k).

Repeat the test but with the **UPS** operating in **stored energy mode** with a fully charged **energy storage device**, and if applicable, in **bypass mode**.

NOTE In some cases, the **UPS** will change mode of operation to **bypass mode** where so declared by the manufacturer.

Compliance is verified when

– *the **UPS output voltage** remains within the **RMS output voltage tolerance band** declared in 5.3.2 b) or, if **current limiting**, as otherwise declared by the manufacturer or supplier,*
– *the **UPS** is not damaged or showing signs of over-heating as a result of the test, and*
– *the **UPS** is able to function correctly after removal of the overload.*

6.4.2.9.2 Fault clearing capacity

With the **UPS** operating in **normal mode** and at **light load**, a short-circuit shall be applied through a suitable fuse or circuit-breaker of a current rating in accordance with the manufacturer or supplier's stated protective device clearing capability. See 5.3.2 m).

If the **UPS** is **rated** for operation at multiple input and **output voltages**, the short-circuit test shall be performed at the highest **nominal rated** input and **output voltages**.

The manufacturer or supplier shall declare the dynamic output performance class with which the **UPS output voltage** will comply during the fault clearing and whether a **static bypass switch** takes part in the fault clearing. Otherwise, the manufacturer shall declare the time it takes to clear the protective device.

The manufacturer may specify conditions for compliance, provided that such conditions represent realistic site conditions. Typical conditions include a lower limit for the impedance of cables connecting the **UPS** output to the protective device and to the short-circuit.

The test shall be repeated with the **UPS** operating in **stored energy mode**, unless the manufacturer or supplier states that the **UPS** cannot co-ordinate with external protective devices in this mode of operation.

If the **UPS** is declared capable of co-ordinating with external protective devices in **stored energy mode**, the manufacturer shall substantiate by calculation that worst-case clearing requirements are supported.

Compliance is verified when, throughout the event, the UPS output voltage remains within the limits of Figure 2, Figure 3 or Figure 4, as applicable.

6.4.2.9.3 Inverter current limit

With the **UPS** operating in **stored energy mode,** at **light load** and with the **bypass** input disconnected, if any, short-circuit(s) shall be applied at the **UPS** output **port**, and the applicable **steady state** short-circuit current(s) and the time sustained shall be measured.

The following short-circuit conditions shall be considered:

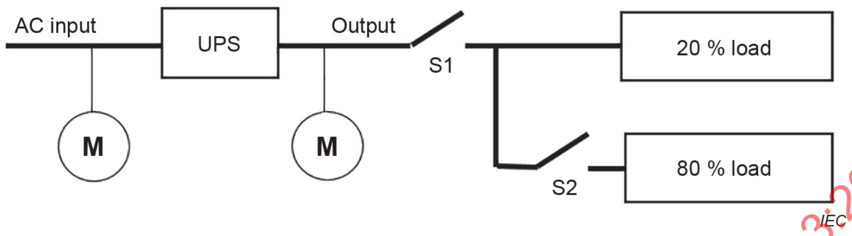
- phase to neutral (resulting in short-circuit current ik1);
- phase-to-phase (resulting in short-circuit current ik2);
- three-phase without short-circuit connection to neutral (resulting in short-circuit current ik3).

Compliance is verified when the values measured are equal or greater than the values declared in 5.3.2 l).

6.4.2.10 Dynamic performance

6.4.2.10.1 Load configuration

For the purpose of determining the dynamic performance of the **UPS** output during **transient** conditions arising from change of mode of operation or from step loading, the **UPS output voltage** waveform shall be observed in conjunction with the **output current** waveform to determine the voltage variation and time duration of the **transient**.



Key

S1 switch

S2 switch

M meter for recording voltage and/or current

Figure 5 – Load configuration for testing transient conditions

a) Configuration for change of mode of operation

Using the test circuit of Figure 5, initiate the change of mode of operation under conditions specified in the relevant test procedure. While initiating the change of mode, record the **UPS** input and **output voltages** until **steady state** conditions occur.

b) Configuration for **step load**

Using the test circuit of Figure 5, apply the specific **step load** under conditions specified in the relevant test procedure. While initiating the **step load**, record the **UPS output voltage** and current until **steady state** conditions occur.

6.4.2.10.2 Normal mode to stored energy mode

With the **UPS** initially operating in **normal mode**, the **AC input power** shall be interrupted as specified in Annex G for high and for low impedance **AC input power failure** and shall remain interrupted for a minimum of 1 s, starting at each of the following conditions independently:

a) where the input voltage waveform passes through zero;

b) at the peak of the input voltage waveform.

At each of these conditions, the measurements shall be performed as described in 6.4.2.10.1 a).

The tests shall be performed at least three times to ascertain repeatability. Alternatively, conditions a) and b) may be ignored if compliance is achieved when conducting each test sequentially 10 times at a random **phase angle**.

For **UPS** requiring **polyphase AC input power**, observation of the input voltage waveform of any of the phases is permitted.

*Compliance is verified when the **output voltage** measured remains within the limits of Figure 2, Figure 3 or Figure 4, as applicable.*

6.4.2.10.3 Stored energy mode to normal mode

With the **UPS** initially operating in **stored energy mode**, the input supply shall be reconnected (at any angular position on the input supply waveform) and measurements shall be performed as described in 6.4.2.10.1 a).

Where **synchronization** is a feature of the **UPS**, during a time interval covering the transition back to **normal mode**, the input and **output voltage** waveforms shall be checked to ensure that, at the point of transition, the **phase angle** between the input supply voltage waveform and **output voltage** waveform does not exceed any limits stated.

NOTE The time required by the **UPS** to synchronize is variable. This test therefore requires instrumentation that can capture a delayed time event. In some cases, communication signals from the **UPS** or trigger signals within the **UPS** can generally assist in this test. Where this is not possible, the test is done by comparison of both waveforms in time intervals.

*Compliance is verified when, throughout the event, the **output voltage** measured remains within the limits of Figure 2, Figure 3 or Figure 4, as applicable, followed by the **steady state** values declared in 5.3.2 b).*

6.4.2.10.4 Normal mode to bypass mode – Overload

Where the **UPS** has a **bypass mode** of operation that is **automatic** under conditions of output overload, the **overload capacity** test 6.4.2.9.1 shall be repeated to force **bypass mode** of operation due to overload. The input and **output voltage** waveforms shall be observed during transitions from **normal mode** to **bypass mode**, and vice versa. Where in addition the manufacturer declares that **automatic** change to **bypass mode** is inhibited if the **bypass** voltage or frequency is out of tolerance (except under certain fault conditions), the input supply voltage and frequency shall be adjusted beyond the specified range to demonstrate compliance with the **UPS** specification beyond which the **UPS** operation in **bypass mode** is inhibited.

*Compliance is verified when the **output voltage** measured remains within the limits of Figure 2, Figure 3 or Figure 4, as applicable.*

6.4.2.10.5 Step load

With the **UPS** operating in **normal mode** at no **load**, apply a 100 % **reference test load** step and measure the dynamic performance of the **UPS output voltage**.

Reduce the **load** to 20 % of **rated output active power** by switching off the 80 % **load** and measure the dynamic performance of the **UPS output voltage**.

Refer to Figure 5 for **load** configuration and to Annex H for measurement techniques.

Repeat the test but with the **UPS** operating in **stored energy mode**.

The test shall be performed with the **step load** applied to the output of the **UPS** at the peak voltage within a **tolerance band** of ±10°.

For **polyphase UPS**, the **reference test load** shall be applied to all output phases while any output phase is at peak voltage with respect to neutral, or to another phase if neutral is not available at the **UPS** output **port**. Voltage measurement of all output phases is required.

NOTE A typical test procedure consists of repeating the **step load** application at random until such time that the required peak voltage condition is achieved.

*Compliance is verified when the **output voltage(s)** measured remain within the limits of Figure 2, Figure 3 or Figure 4, as applicable.*

6.4.2.10.6 Parallel redundant UPS failure

This test is required for **UPS** incorporating **parallel redundancy**. The test shall be conducted with **rated load** applied to the **UPS**. By failure simulation, the **redundant UPS functional units** or **UPS units** shall be made to fail (e.g. **inverter** semiconductor failure). The **output voltage transients** and frequency shall be measured and shall comply with the manufacturer's declared limits. Both **high** and **low impedance failures** in **redundant UPS** shall be considered.

NOTE **Low impedance failure** is typically simulated by shorting an appropriate power semiconductor in the **redundant UPS**. **High impedance failure** is typically simulated by opening the connection to an appropriate power semiconductor in the **redundant UPS**.

The manufacturer or supplier declare the dynamic output performance class with which the **UPS output voltage** will comply while the fault simulation is performed.

*Compliance is verified when the **output voltage** measured remains within the limits of Figure 2, Figure 3 or Figure 4, as applicable.*

6.4.3 Stored and restored energy times

6.4.3.1 Stored energy time

Before carrying out this test, operate the **UPS** at no **load** in **normal mode** for a period in excess of the **restored energy time** declared in 5.4.2.2 g).

Measure the temperature of the **energy storage device** immediately prior to the test for the purpose of calculating any applicable adjustment to the **stored energy time** declared in 5.4.2.2 f).

Assuming that the **energy storage device** is a **battery**, subject to any particular agreement between the purchaser and the **UPS** manufacturer, the reference temperature of the **battery** shall be 25 °C.

NOTE 1 Similar consideration apply for other stored energy technologies.

Apply **reference test load** to the **UPS** output and disconnect the **AC input power**.

Measure the voltage of the **energy storage device** while the **UPS** operates in **stored energy mode.**

*Compliance is verified when the **UPS** has operated in **stored energy mode** for a period equal to the **stored energy time** declared in 5.4.2.2 f) and when the measured voltage of the **energy storage device** has not fallen below the **cut-off voltage** declared 5.4.2.2 q).*

NOTE 2 New batteries often do not provide full capacity and a number of charge/discharge cycles can be necessary before full **stored energy time** is achieved.

6.4.3.2 Restored energy time (to 90 % capacity)

At the cessation of **stored energy time** test of 6.4.3.1, reapply **AC input power** to the **UPS** and operate in **normal mode**, at **nominal AC input power** voltage and **reference test load**.

After the **restored energy time** declared in 5.4.2.2 g) has elapsed, the test of 6.4.3.1 shall be repeated to obtain the new value of **stored energy time.**

Worst-case consideration should apply where the charging capacity, in **normal mode** of operation, is affected by the amount of **load** applied to the **UPS** output.

NOTE Stored energy and **restored energy times** are influenced by **ambient temperature** and the values stated by the manufacturer for **restored energy time** is the time to restore 90 % of **rated** capacity unless otherwise stated.

*Compliance is verified when the **UPS** has operated in **stored energy mode** for a period equal to at least 90% of the **stored energy time** declared in 5.4.2.2 f) and when the measured voltage of the **energy storage device** has not fallen below the **cut-off voltage** declared 5.4.2.2 q).*

6.4.3.3 Battery ripple current

The AC component (**RMS value**) of the **battery** current shall be measured. The **UPS** shall operate in **normal mode** and the **battery** shall be fully charged. Balanced and **unbalanced load** conditions shall be measured. See 6.4.2.4. Worst-case ripple current shall be reported.

NOTE In the absence of a specific **battery** manufacturer specification, recommended ripple current limits for lead-acid, NiCd and NiMH batteries are given in IEC 62485-2 (e.g. for lead-acid batteries 0,05 C under float charge).

*Compliance is verified when the ripple current measured is equal to or less than that specified by the **battery** manufacturer.*

6.4.3.4 Restart test

Automatic or other restart means shall be tested after a complete shutdown of the **UPS**.

*Compliance is verified when the **normal mode** of **UPS** operation is returned per manufacturer's design criteria.*

6.4.3.5 Charger current limit

With the **UPS** operating in **normal mode** with **reference test load** applied and with a fully depleted **energy storage device** or a suitable DC **load** connected to the **port** intended for the **energy storage device**, the charging current shall be measured. Repeat the test at minimum and maximum settings if adjustable.

This test is only required for **UPS** capable of supporting external **energy storage devices.**

*Compliance is verified when the values measured are within the **tolerance bands** declared in 5.4.2.2 r).*

6.5 Type tests – Environmental

6.5.1 Transportation

6.5.1.1 General

The following tests are intended to simulate the environmental transportation requirements the **UPS** is designed to meet. The transportation-related tests assess the construction of the **UPS** in the shipping container against resistance to damage by normal handling operations during transportation.

6.5.1.2 Shock

The following steps shall be carried out on a complete **UPS** with a mass less than 50 kg, excluding the transportation packaging and in the chronological order below.

a) As initial measurements, perform the **light load** and functional test (see 6.2.2.3).

b) Ensure the **UPS** is non-operational and pack it in its normal shipping state for transportation.

c) Subject the packaged **UPS** to two 15 g_n half-sine shock pulses of 11 ms **nominal** duration in all three planes, in accordance with IEC 60068-2-27.

NOTE No electrical measurements are taken during the test.

d) As final inspection after the above tests, unpack the **UPS** and check for signs of physical damage or distortion to component parts.

e) As final measurements, perform the **light load** and functional test. See 6.2.2.3.

Final measurements and requirements may be combined with those of the free fall test. See 6.5.1.3.

Consideration should be given to any test result consequences that may require dielectric tests to be applied in accordance with the relevant safety standard.

Compliance is verified when the requirements of items d) and e) are satisfied.

6.5.1.3 Free fall

The following free fall test steps shall be performed in the chronological order below.

a) As initial measurements, perform the **light load** and functional test. See 6.2.2.3.

b) Ensure the **UPS** is non-operational and packed in its normal shipping state for transportation.

c) Test the **UPS** by allowing it to fall freely from a point of suspension onto a solid surface. The surface of the package which impacts the solid surface through the fall is the surface on which the package normally rests.

   The following test conditions shall be met.

   1) The test shall be carried out twice.
   2) The test shall be made with the UPS in its integral transport case or shipping state for transportation.
   3) The height of fall shall be in accordance with Table 6.
   4) The height of fall shall be measured from the part of the UPS nearest to the test surface.

d) As final inspection after above tests, unpack the UPS and check for signs of physical damage or distortion to component parts.

e) As final measurements, perform the **light load** and functional test. See 6.2.2.3.

Table 6 – Free fall testing

Mass of packed UPS (kg)	**Drop height** (mm)
< 10	600
10,1 to 20	450
20,1 to 30	300
30,1 to 40	250
40,1 to 50	200
50,1 to 100	150

Table 6 is derived from level 3 of ISO 4180 (number of transhipments and level of external force are considered to be general). For other levels and for masses greater than 100 kg, the free-fall testing shall be governed by ISO 4180.

Consideration should be given to any test result consequences that may require dielectric tests to be applied in accordance with the relevant safety standard.

Compliance is verified when the requirements of d) and e) are satisfied.

6.5.2 Storage in dry heat, damp heat and cold environments

The following storage test steps shall be performed in the chronological order below.

a) As initial measurements, perform the **light load** and functional test. See 6.2.2.3. Before carrying out these tests, charge any internal **energy storage device** for the period defined in the manufacturer's instructions.

b) Ensure the **UPS** is not operational, but packed in its normal shipping state for transportation and storage with controls in shipping state.

c) Conduct tests as follows.

   1) Dry heat as per the normal environmental conditions: +55 °C ± 2 °C for a duration of 16 h using the test method Bb of IEC 60068-2-2.

   2) Damp heat as per the normal environmental conditions: +40 °C ± 2 °C at a humidity between 90 % to 95 % for a duration of 96 h using test method Cab of IEC 60068-2-78.

   3) Cold as per the normal environmental conditions: –25 °C ± 3 °C for a duration of 16 h where practicable using test method Ab of IEC 60068-2-1.

   NOTE No electrical measurement are required during the tests.

d) As final inspection after the tests, unpack the **UPS**, inspect for signs of physical damage or distortion to components and for corrosion of metallic parts.

e) As final measurements, allow the **UPS** to return to normal **ambient temperature** and pressure and perform the **light load** and functional test. See 6.2.2.3.

Compliance is verified when the requirements of d) and e) are satisfied.

6.5.3 Operation in dry heat, damp heat and cold environments

The following operation test steps shall be performed in the chronological order below.

a) Perform the **light load** and functional test. See 6.2.2.3.

b) Ensure the **UPS** works in **normal mode** at **rated** input voltage and **rated** output power.

c) Conduct tests in the following sequence.

   1) Dry heat as per the normal environmental conditions or as per the manufacturer's stated maximum value for a duration of 16 h using test method Bd of IEC 60068-2-2.

   2) Damp heat at +30 °C ± 2 °C at a humidity between 72 % and 78 % for a duration of 96 h using test method Cab IEC 60068-2-78. This test only applies when the manufacturer's stated maximum temperature is above +30 °C.

   3) Cold as per the manufacturer's stated minimum temperature for a duration of 2 h using test method Ab or method Ad of IEC 60068-2-1, as applicable. This test only applies when the manufacturer's stated minimum temperature is +5 °C or lower.

   4) Repeat the damp heat after the cold if both damp heat and cold apply.

   Separate tests are permitted when the declared environmental conditions of the **UPS** and the **energy storage device** differ.

d) Take measurements during testing as applicable to check that the **UPS** continues to function according to this document in **normal** and **stored energy modes** of operation.

e) Repeat step a) after the **UPS** has returned to ambient conditions to confirm normal operation.

f) As final requirements after the tests, perform the **light load** and functional test (see 6.2.2.3) and check the **UPS** for signs of physical damage or distortion and that it continues to perform in accordance with the initial characteristics.

Compliance is verified when the requirements of e) and f) are satisfied.

6.5.4 Acoustic noise

The **UPS** manufacturer shall declare the acoustic noise level in the technical documentation.

NOTE The declaration generally takes the form of a technical data sheet. Annex D provides an example of a technical data sheet.

The acoustic noise level shall be determined in accordance with the method of measurement specified in ISO 3746, or as an alternative, ISO 3744, and governed by the normal positioning expected in use (for example, table-top, wall-mounted or free-standing).

Values shall be measured when the **UPS** operates at **reference test load** under the following conditions:

- **normal mode**, at normal input voltage;
- **stored energy mode**.

The acoustic noise level to be declared is the A-weighted emission sound pressure level, $L_{\mathrm{pA,m}}$ expressed in dB (20 µPa) at bystander positions as follows.

The bystander positions shall be at a horizontal distance of 1,00 m ± 0,03 m from the sides of the **UPS** and at a vertical distance of 1,50 m ± 0,03 m above the floor. Four bystander positions are centred horizontally at the front, rear, right and left sides of the **UPS**. If the length of any side of the **UPS** exceeds 2,0 m, additional bystander positions at 1,0 m intervals should be used. For wall-mounted **UPS** or for **UPS** placed against the wall, three bystander positions are centred at the front, right, and left sides of the **UPS**.

The acoustic noise from audible alarms shall not be included in the values stated.

The acoustic noise from fans required to operate under any **rated** condition shall be included in the values stated.

*Compliance is verified when the values determined from the measurements are within the values declared by the **UPS** manufacturer.*

6.6 UPS functional unit tests (where not tested as a complete UPS)

6.6.1 General

The **UPS** manufacturer shall design a **UPS** test program if submitting selected **UPS functional units** to performance tests prior to their final assembly and wiring into the **UPS.**

Any test result from **UPS functional units** shall be considered in conjunction with the **routine** or **type tests** listed in Table 5. This is to decide and substantiate whether any of these tests may be simplified or waived due to **UPS functional unit** tests having been performed**.** The objective is to prove compliance of the complete **UPS** with the requirements of the applicable tests listed in Table 5.

Consideration shall be given to prove compliance through adequate calculation, for example calculation of the **efficiency** of the complete **UPS** is facilitated when the **efficiency** or losses of the **UPS functional unit** are known.

If previous **type tests** have been performed on a **UPS functional unit**, the original manufacturer's specifications shall be acceptable and no further **type tests** will be required for that unit.

Subclauses 6.6.2, 6.6.3, 6.6.4 and 6.6.5 provide **UPS functional unit** test guidance for consideration of the manufacturer.

*Compliance is verified when all applicable requirements of the tests listed in Table 5 have been satisfied following final assembly and wiring of the complete **UPS**.*

NOTE Subclause 6.1.3 provides additional information for completion and testing of a **UPS** intended for final assembly and wiring on site.

6.6.2 UPS rectifier tests

Line-commutated **UPS rectifiers** shall be tested in accordance with the applicable tests in Table 13 of IEC 60146-1-1:2009, i.e. all tests listed except safety and EMC tests 7.2, 7.4.2, 7.6 a) and 7.6 b) that are not part of the scope of this document.

Self-commutated **UPS rectifiers** shall be tested as **UPS inverters** in accordance with 6.6.3.

*Compliance is verified when the **UPS rectifier** successfully passes all of the applicable tests (for **UPS type test**) or 7.3.1 of IEC 60146-1-1:2009 (for **UPS routine test**) and when the compliance condition in* 6.6.1 *is satisfied.*

6.6.3 UPS inverter tests

UPS inverter tests shall be performed in accordance with the applicable tests in Table 4 of IEC 60146-2:1999, i.e. all tests listed except safety and EMC tests 7.3.3, 7.3.8, 7.3.18, 7.3.20, 7.3.21 that are not part of the scope of this document.

*Compliance is verified when the **UPS inverter** successfully passes all of the applicable tests (for **UPS type test**) or passes 7.3.1, 7.3.2, 7.3.4 and 7.3.5 of IEC 60146-2:1999 (for **UPS routine test**) and when the compliance condition in 6.6.1 is satisfied.*

6.6.4 UPS switch tests

UPS switches that are integral to the **UPS** are tested in conjunction with the **UPS.**

UPS switches supplied separately may be tested during a **UPS site test**. See 6.3.

An external **maintenance bypass switch** is an example of a **UPS switch** that may be supplied separately. See Figure C.3.

*Compliance with the requirements in this document characterises compliance of **UPS switches** that are integral to the **UPS** and no additional tests are required.*

6.6.5 Energy storage device tests

Energy storage devices, for example batteries, shall be tested in accordance with their own product standard.

Unless otherwise specified in the purchase contract, any additional **UPS functional unit** performance tests on an **energy storage device** shall include, if deemed necessary by the **UPS** manufacturer, tests to verify the performance of the **battery** under any special charging and discharging regimes specified by the **energy storage device** manufacturer.

Stored energy time and **restored energy time** and any additional on-site testing shall be a matter of agreement between the **UPS** manufacturer or supplier, and the purchaser.

*Compliance is verified when the **energy storage device** has been tested compliant to its own product standard and when the compliance condition in 6.6.1 is satisfied.*

Annex A
(informative)

Configurations – Uninterruptible power system (UPS)

A.1 General

The uninterruptible power system (**UPS**), as described in this document, is an electronic power system. Its primary function is to provide specified continuity and quality of power to a user's equipment in the event of a partial or total failure of the **AC input power**, which is usually the public low-voltage power supply system. This is accomplished by supplying power from the **AC input power** and/or from the **energy storage device** to the user's equipment.

The user's equipment, typically referred to as the critical or protected **load**, may consist of one or many pieces of equipment located in a room or a building. This is the equipment that the user has determined needs to be provided with power that has a better continuity and quality than that power which is normally available. The critical **load** is predominantly some form of data processing equipment, although it may be other equipment such as lighting, instrumentation, pumps or communication equipment. The stored energy to support this **load**, usually in the form of batteries, may be needed to supply power to the equipment for a specified time which may be momentary or for many hours. The time interval is commonly referred to as **stored energy time** or back-up time.

A variety of **UPS** have been developed to meet the user's requirements for continuity and quality of power to different types of **loads** over a wide range of power from less than one hundred watts to several megawatts.

The following text outlines the variation of **UPS** configurations ranging from a single unit to more complex systems for added availability of **load** power.

Various **UPS** configurations are used to achieve different degrees of availability of **load** power and/or to increase output power rating.

Annex A presents the characteristics of typical arrangements in use.

A.2 Single output bus UPS

A.2.1 General

A **single UPS** comprises an **energy storage device** and one or more static power **converter(s)**, for example a **rectifier/battery charger** and an **inverter** and performs in accordance with **UPS** manufacturer's declaration. See 5.3.4. A **single UPS** generally presents an availability consistent with equipment requiring **reliability integrity level** 1 (**RIL**-1 – see Annex K).

A.2.2 Basic single UPS

A basic **single UPS** is a **UPS unit** that contains no alternative circuit path for the purpose of ensuring **continuity of load power**. See Figure A.1.

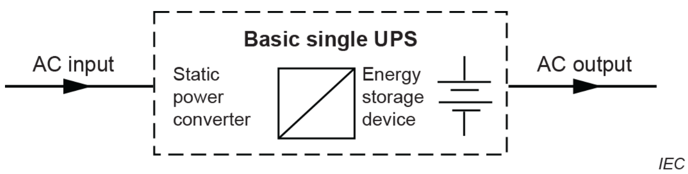


Figure A.1 – Basic single UPS

In the case of an **AC input power failure**, the **energy storage device**, for example a **battery**, will supply the power at a decreasing DC voltage until it is too low for satisfactory output of the **inverter**. The type and capacity of the **battery** will determine the length of time the system can operate without **AC input power**.

NOTE 1 Double conversion, line-interactive and standby **UPS** topologies, as detailed in Annex B, represent examples of a basic **single UPS**.

NOTE 2 It is acknowledged that some applications require, in addition to the AC output, a source of uninterruptible DC power. Subject to an agreement between the **UPS** manufacturer and the purchaser, the DC power can be derived from the **DC link**. Such DC requirements are excluded from the scope of this document.

A.2.3 Single UPS with bypass

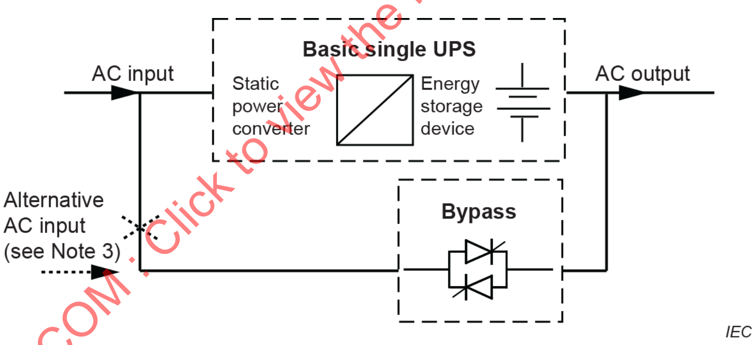
A **single UPS** with bypass (see Figure A.2), is a basic **single UPS** to which a bypass is added for the purpose of ensuring **continuity of load power** upon

a) failure of the basic single UPS, and

b) load current transients (overload, inrush or fault currents) exceeding the overload capacity of the basic single UPS and not exceeding capacity of the bypass.

Subject to compatibility of the **AC input power** with the requirements for AC output, the addition of a bypass increases the availability of **load** power.

The physical implementation of the bypass may consist of semiconductors (e.g. thyristor, triac, transistors) and/or of electro-mechanical devices (e.g. relay, contactor), provided that the bypass control and activation design is compatible with the requirements specified for the **UPS** in Clause 5.



NOTE 1 The input and output frequency is normally the same and, if the voltage levels are different, a bypass transformer is used. For some **loads**, the **UPS** and the bypass AC input are synchronized to maintain **continuity of load power**.

NOTE 2 A **UPS switch** is used to connect or disconnect the basic **single UPS** to or from the AC output.

NOTE 3 Separate AC input feeds for the static power **converter** and for the **bypass** can be used subject to compatibility requirements, if any, to be disclosed by the **UPS** manufacturer.

NOTE 4 An overall **maintenance bypass switch** can be added to the **bypass** for servicing purposes.

NOTE 5 The use of **bypass** introduces the possibility of an AC input disturbance affecting the **load**.

Figure A.2 – Single UPS with bypass

A.3 Parallel UPS

A.3.1 General

A **parallel UPS** comprises two or more **UPS units** with AC outputs connected to a common AC output bus. The **energy storage device**(s) in a **parallel UPS** are either dedicated to each **UPS unit** or shared between several **UPS units**.

NOTE **UPS switches** can be used in **parallel UPS** applications to connect or disconnect **UPS units** to or from the common AC output bus.

The total quantity of **single UPS units** in a **parallel UPS** equals

$$n + r$$

where

n is the quantity of **single UPS units** required to support the **load**;

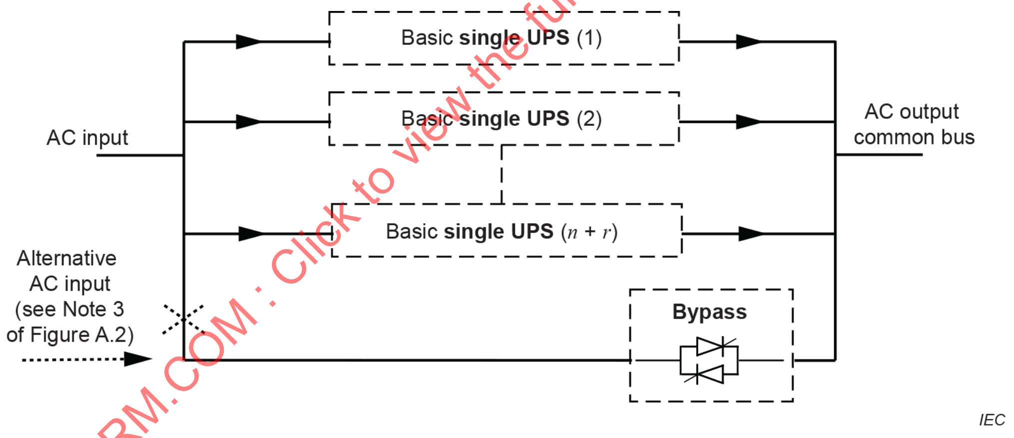
r is the quantity of **redundant UPS units**.

A **parallel redundant UPS** contains at least one **redundant UPS unit** ("n + 1") and presents an availability higher than that of the corresponding basic **single UPS** because any **UPS unit** may be isolated in case of failure or for maintenance procedures without affecting the continuity of power to the **load**.

A parallel capacity **UPS** contains no **redundant UPS unit** ("n + 0") and presents an availability lower than that of the corresponding basic **single UPS** because the failure of any **UPS unit** may affect the **continuity of load power**.

A.3.2 Parallel UPS with common bypass

This configuration consists of a paralleled basic **single UPS** with one common overall **bypass** fitted. See Figure A.3.

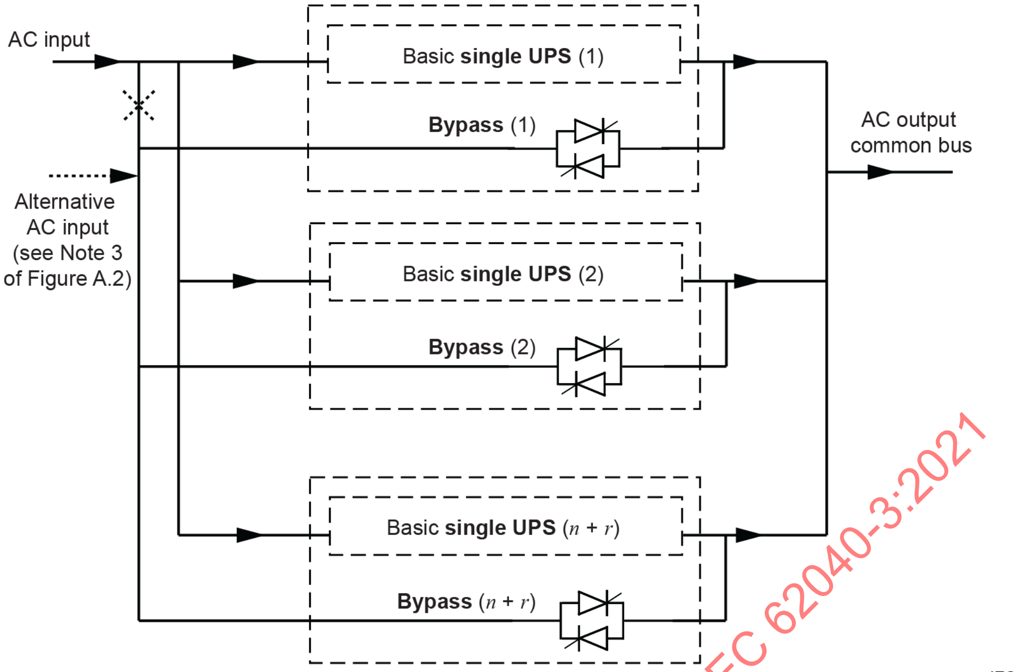


NOTE Notes 1 to 5 of Figure A.2 apply.

Figure A.3 – Parallel UPS with common bypass

A.3.3 Parallel UPS with distributed bypass

This configuration consists of **paralleled UPS** with **bypass** designed to ensure that, when the **UPS** operates in **bypass mode**, the **rated load** current flows through the distributed **bypass** units without overloading any of them. See Figure A.4.

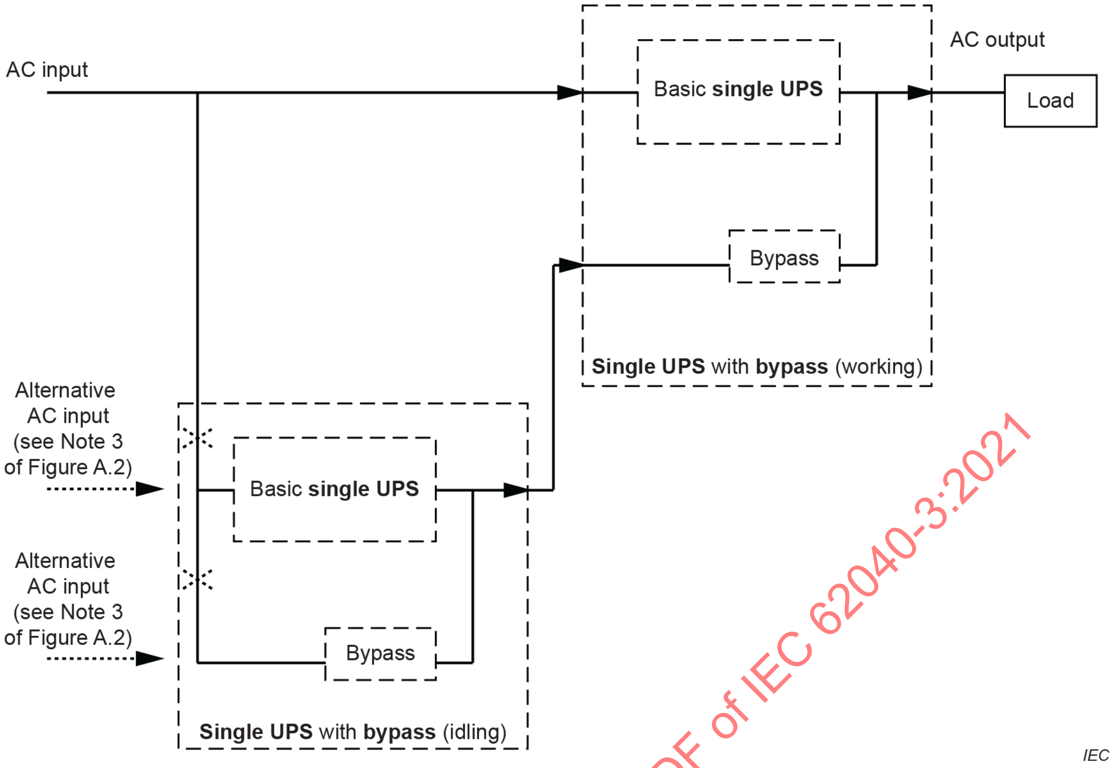


NOTE Notes 1 to 5 of Figure A.2 apply.

Figure A.4 – Parallel UPS with distributed bypass

A.3.4 Standby redundant UPS

The **standby redundant UPS** configuration comprises a minimum of two **single UPS** with bypass configuration. The **bypass** input of the working **UPS** (that supplies power to the critical **load**), is fed by the AC output of the idling **UPS**. Usually the basic **single UPS** of the working **UPS** supplies power to the **load** and transfers the **load** to the idling **UPS** in case of failure of the working **UPS**. See Figure A.5.



NOTE Notes 1 to 5 of Figure A.2 apply.

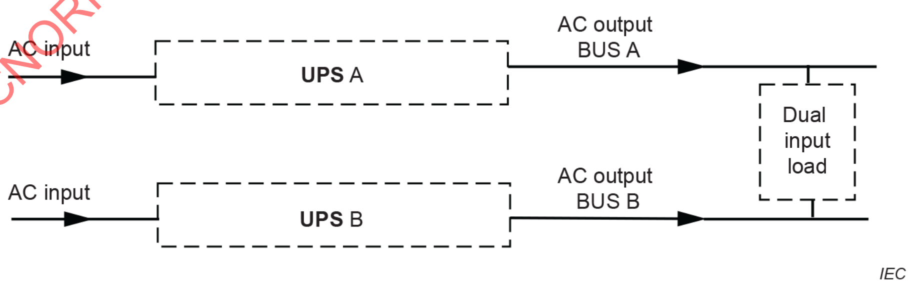
Figure A.5 – Standby redundant UPS

A variation of the **standby redundant UPS** configuration consists of two or more working **UPS** connected to one idling **UPS**.

A.4 Dual bus UPS

A.4.1 Basic dual bus UPS

A basic dual bus **UPS** comprises any two **UPS** configurations of Annex A whose AC outputs are connected to separate buses. See Figure A.6.



NOTE Notes 1 to 5 of Figure A.2 apply.

Figure A.6 – Dual bus UPS

Dual bus configuration is primarily intended to supply **loads** that accept dual input supply.

A basic dual bus configuration **UPS** is normally designed with redundancy so that any of the two buses is capable of supplying the total **load** ("2*n*"). The redundant dual bus **UPS** presents an availability higher than that corresponding a **parallel redundant UPS** configuration with the same quantity of **UPS units**. This is a result of the fault tolerant AC output configuration where, in addition to supply redundancy, a fault on one bus does not affect the other bus.

NOTE Dual bus configuration requires duplicated supply wiring to the **load**.

A.4.2 Standby redundant dual bus UPS

Dual bus configuration intended to supply **loads** that accept only a single input supply may be implemented with the use of a fault tolerant transfer system. The transfer system ensures that power from only one of the two buses is supplied to the **load** and transfers the **load** to the idling bus in case of a source-initiated failure. See Figure A.7. See 5.5 for references to transfer systems.

NOTE Some **loads** require **UPS** A and **UPS** B to be synchronized for the purpose of maintaining **continuity of load power** during the transfer of supply.

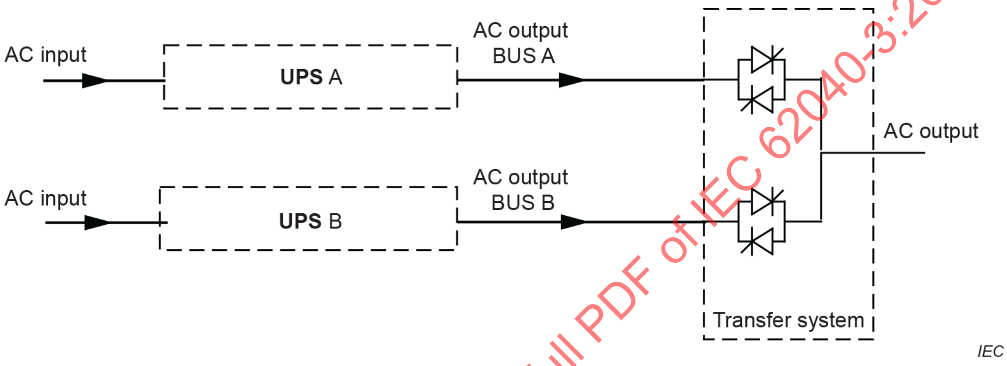


Figure A.7 – Standby redundant dual bus UPS

Annex B
(informative)

Topologies – Uninterruptible power system (UPS)

B.1 General

Annex B describes popular **UPS** topologies in use and the mode of operation of each of these in form of a block diagram. The **energy storage device** is commonly a **battery** and has been symbolised as such throughout Annex B. But other forms of **energy storage devices** are equally possible. See 5.4.1.

Additional circuits and components such as filters (**transient** and EMC) and isolation transformers may be required depending on the topology, the **load** requirements and the AC power distribution system. These details are omitted for simplicity. The technical merits are not discussed, and the purchaser should verify with the vendor the suitability of any system for the intended **load** equipment.

B.2 Double conversion topology

Double-conversion topology comprises an AC to DC **converter**, generally a **rectifier**, and a DC to AC **converter**, generally an **inverter**. See Figure B.1.

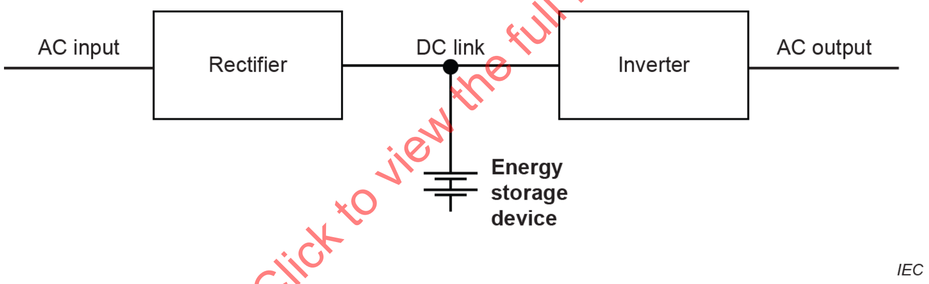


Figure B.1 – Double conversion topology

In **normal mode** of operation, the **load** is continuously supplied by the **rectifier/inverter** combination.

The **DC link** may be directly connected to the **energy storage device** or through a DC to DC **converter**, a switch or a semiconductor. Recharge of the **energy storage device** may be provided by the **rectifier** or by other means, for example by a dedicated **charger**.

When the **AC input power** is out of **UPS** pre-set tolerances, the **UPS** enters **stored energy mode** of operation where the **battery/inverter** combination continues to support the **load** for the duration of the **stored energy time** or until the AC input returns to **UPS** design tolerances, whichever is the sooner.

The double conversion topology is often referred to as an "on-line **UPS**" meaning the **load** is always supplied by the **inverter**. The term "on-line" also means "on-the-mains". To prevent confusion in definition, the term "on-line" should be avoided and the term "double conversion" used.

NOTE A double conversion **UPS** is an example of a **UPS** providing VFI performance (see 5.3.4).

B.3 Line-interactive topology

Line-interactive topology comprises bidirectional AC to DC power conversion, generally through a **bidirectional converter** and an AC power interface. See Figure B.2.

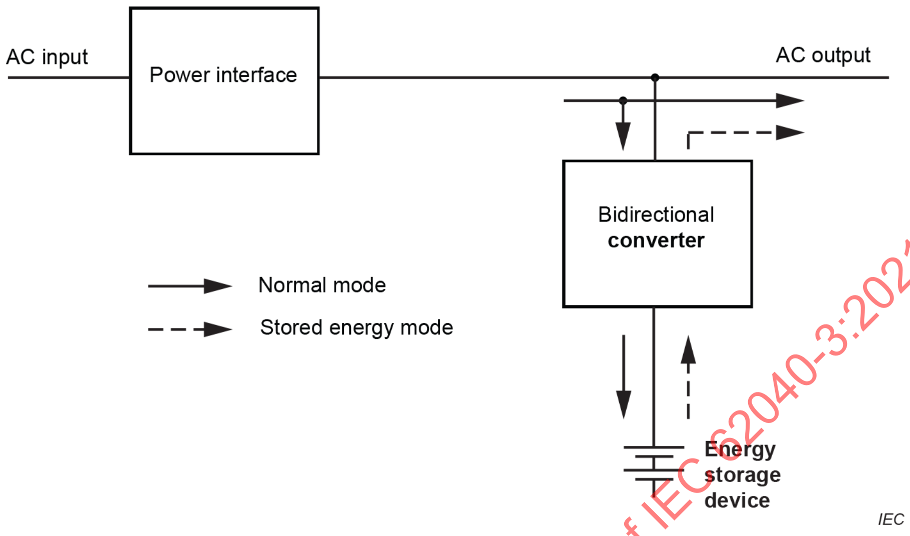


Figure B.2 – Line-interactive topology

In **normal mode** of operation, the **load** is supplied with conditioned power via a parallel connection of the AC input and the **bidirectional converter**. The **converter** or the power interface is operating to provide **output voltage** conditioning and/or **battery** charging. The output frequency is dependent upon the AC input frequency.

When the **AC input power** voltage or frequency is out of **UPS** pre-set tolerances, the **converter** and **battery** maintain **continuity of load power** in **stored energy mode** of operation and the AC power interface disconnects the **AC input power** from the **bidirectional converter**.

The unit runs in **stored energy mode** for the duration of the **stored energy time** or until the **AC input power** returns within **UPS** design tolerances, whichever is the sooner.

NOTE 1 The nature of this design requires an impedance between the **AC input power** and the **converter.**

NOTE 2 The **converter** is either of bidirectional design as described above, and the **AC input power** interface generally consists of a passive impedance. Alternatively, the **converter** is unidirectional, and the **AC input power** interface consists of a power conditioner. In this case, a separate **charger** for the **energy storage device** is incorporated.

NOTE 3 A line-interactive **UPS** is an example of a **UPS** providing VI performance (see 5.3.4).

B.4 Standby topology

Standby topology comprises a **battery charger**, a DC to AC **converter**, generally a uni-directional **inverter** and a **UPS switch**. See Figure B.3.

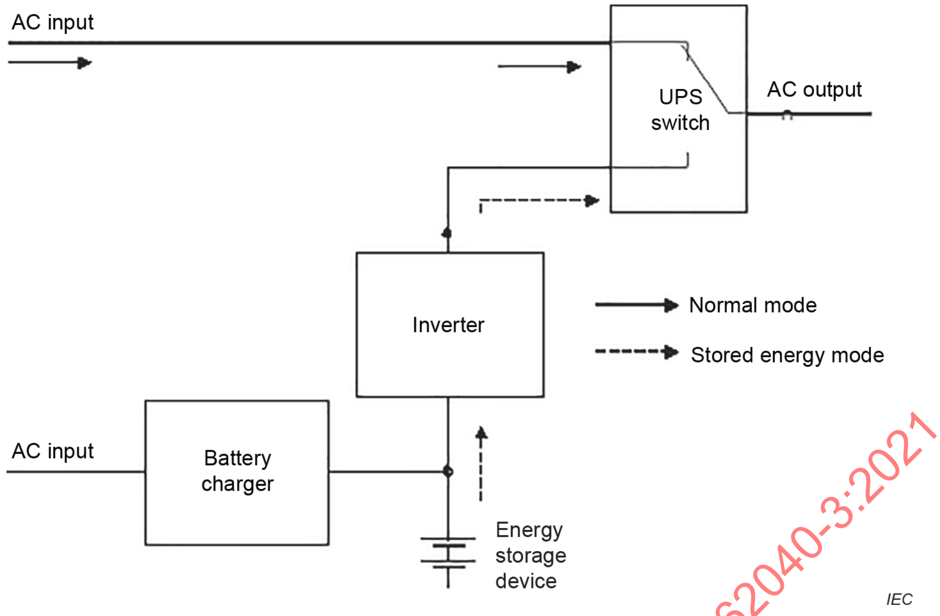


Figure B.3 – Standby topology

In **normal mode** of operation, the **load** is supplied with **AC input power** via the **UPS switch**. When the **AC input power** is out of **UPS** pre-set tolerances, the **UPS unit** enters **stored energy mode** of operation, and the **load** is transferred to the **inverter** directly or via the **UPS switch**.

The **battery/inverter** combination maintains **continuity of load power** for the duration of the **stored energy time** or until the **AC input power** returns to within **UPS** pre-set tolerances and the **load** is transferred back, whichever is the sooner.

In active standby operation, the **inverter** is normally operating at no **load**.

In passive standby operation, the **inverter** is normally not operating but activated upon **AC input power failure**.

Standby topology is often referred to as an "off-line **UPS**", meaning electronically conditioned power is fed to the **load** when the **AC input power** is out of tolerance. The term "off-line" also means "not-on-the-**mains**" when in fact the **load** is fed from the **mains** in **normal mode** of operation. To prevent confusion, the term "off-line" should be avoided and the term "passive standby" used.

NOTE 1 The **UPS transfer switch** can be electro-mechanical or electronic (see Clause C.2) depending on the **load** requirements.

NOTE 2 A standby **UPS** is an example of a **UPS** providing VFD performance. See 5.3.4.

NOTE 3 Incorporation of additional devices to provide conditioning of the **AC input power**, for example a ferro-resonant transformer or an **automatic** tap-changer, turns a passive standby **UPS** into a line-interactive **UPS**.

Annex C
(informative)

Switch applications – Uninterruptible power systems (UPS)

C.1 General

Annex C describes the general characteristics and applications of **UPS switches** that are integral to a **UPS**.

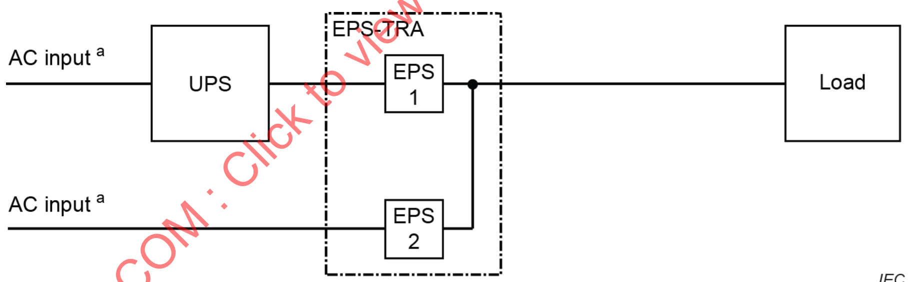
These switches interact with **UPS functional units** for the purpose of maintaining **continuity of load power** under specified conditions, including fault and maintenance conditions. Other switches or breakers, encountered in conventional electrical distribution boards, such as **rectifier** input switches, **battery** disconnect switches and general-purpose breakers or switches are not included in this discussion.

NOTE 1 Stand-alone static transfer systems (STS) that are not integral part of a **UPS** are excluded from the scope of this document. STS test and performance requirements are covered in IEC 62310-3.

NOTE 2 The **UPS switches** shown in the diagrams of Annex C are represented as separate units. In practice, a **UPS switch** can be contained within a **UPS unit**.

C.2 Transfer switches, bypass transfer switches

Figure C.1 shows a **transfer switch** (EPS-TRA) that connects the **load** either to the output of a **UPS** or to an alternative supply, for example the **bypass**. A **transfer switch** typically employs two **electronic power switches** (EPS1 and EPS2).



[a] AC inputs may be tied.

Figure C.1 – Bypass transfer switch

A **bypass transfer switch** is used to protect the load against power disturbances or interruption arising from inrush or fault currents that would otherwise overload the UPS or from unavailability of power during UPS failure or maintenance.

NOTE 1 Depending on the conditions prior to a transfer occurring, either **synchronous transfer** or **asynchronous transfer** occurs.

NOTE 2 Typical **transfer switch** characteristics include

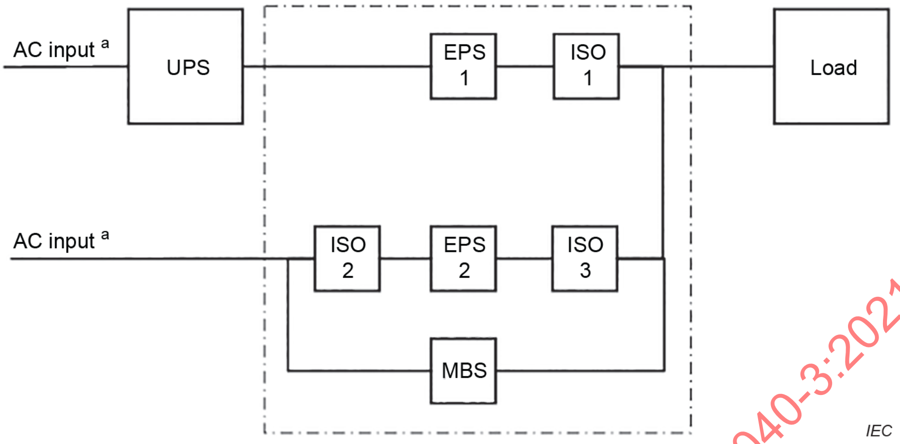
– **electronic power switches** – very fast opening and closing times,

– **mechanical power switches** – air-gap isolation when open and high **overload capacity** when closed, and

– **hybrid power switches** – very fast closing time and high **overload capacity** when closed.

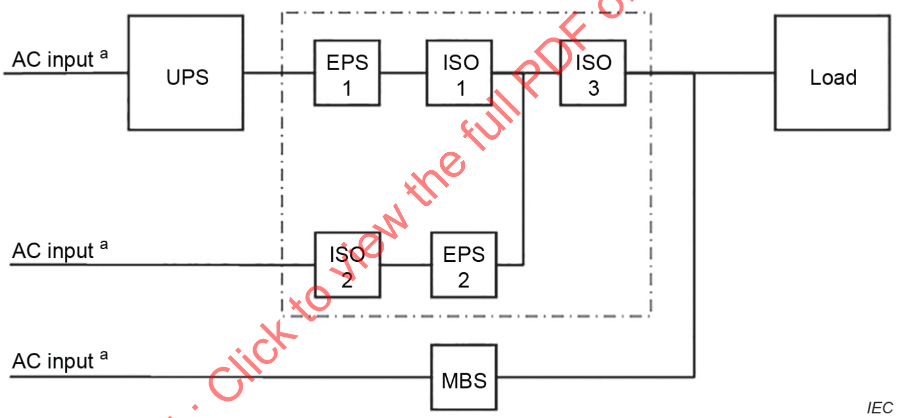
C.3 Maintenance bypass switches

For the purpose of ensuring **continuity of load power** during maintenance activities, a **UPS maintenance bypass switch** (MBS) provides an alternative supply path to the **load** that otherwise is supplied from the **UPS** through **electronic power switches** (EPS) and their associated **mechanical power switch(es)** for isolation (ISO). Figure C.2 and Figure C.3 show examples of **UPS maintenance bypass switches**.



[a] AC inputs may be tied.

Figure C.2 – Internal maintenance bypass switch



[a] AC inputs may be tied.

Figure C.3 – External maintenance bypass switch

Annex D
(informative)

Purchaser specification guidelines

D.1 General

A variety of **UPS** are available to meet the user requirements for continuity and quality of power to different types of **loads** over a wide range of power from less than one hundred watts to several megawatts.

Annex D has been compiled to assist purchasers to formalise criteria important to their application and/or to confirm agreement with conditions declared by the manufacturer/supplier.

For an explanation of typical **UPS** configurations, modes of **UPS** operation and topologies, the reader's attention is drawn to Annex A, Annex B and Annex C.

The **UPS** technical data sheet contained in Annex D presents a summary of the normal and unusual environmental and electrical conditions to be considered. This data sheet also references the specific subclause of concern. The reader's attention is drawn to Clause 4 (environmental conditions) and Clause 5 (electrical conditions).

The following additional topics should also be considered.

D.2 Load to be supplied by the UPS

The diversity of types of **load** equipment and their relevant characteristics are always changing with technology. For this reason, the **UPS** output performance is characterized by loading with passive reference **loads** to simulate, as far as practical, the expected **load** types, but it cannot be taken that these are totally representative of the actual **load** equipment in a given application.

The **UPS** industry has generally specified **UPS** output characteristics under conditions of **linear loading**, i.e. resistive or resistive/inductive. Under present technology, many **loads** present a **non-linear** characteristic due to power supplies of the rectifier capacitor type either single or poly-phase. See Annex E.

The effect on the output of the **UPS** by **non-linear loads** both in **steady state** and dynamic is, in many cases, to cause deviation from the output characteristic specified by the manufacturer/supplier where these are quoted under **linear load** conditions.

Due to the higher peak to **RMS steady state** current ratios, the output total harmonic voltage distortion may be increased beyond the stated limit. **Load** compatibility with higher levels of total harmonic voltage distortion is a matter of agreement between the manufacturer/supplier and the purchaser.

Application of **non-linear load** steps may result in a **deviation** from the linear dynamic voltage characteristics due to high transient inrush currents relative to **steady state**, especially where the **UPS** employs electronic **current limiting** in **normal mode** of operation.

These effects of high **transient** inrush currents on the **load** voltage may be tolerable where these **loads** are the first to be energized or have no deteriorative effect on the **loads** already connected. This effect applies to switching of transformers or other magnetic devices subject to magnetic remanence and to **loads** containing capacitors.

Some **UPS** topologies utilise a **static bypass switch** to support high inrush current to permit economic sizing of the **UPS**. While single units may not support high inrush currents when the **bypass** is unavailable, **redundant UPS** often can.

Where the **load** is sensitive to **frequency variation** beyond typical public low-voltage power supply system limits or is sensitive to voltage variation or distortion of the supply waveform, the choice of the best **UPS** topology for these applications should be investigated.

The advice of the manufacturer/supplier should be sought in respect of these matters.

Examples of **loads** that should be identified by the purchaser include IT equipment in general, motors, saturating transformer power supplies, diode rectifiers, thyristor rectifiers, switched mode power supplies.

Examples of special features or requirements of **loads** include their operating duty, any unbalance between phases, **non-linearity** (generation of harmonic currents), branch-circuit fuse and breaker ratings, maximum **step load** and **load** profile, required method of connection of **loads** to **UPS** output.

D.3 Energy storage device (battery – where applicable)

The **energy storage device** is generally recommended by the manufacturer/supplier for compatibility with the **UPS** design. The purchaser may nevertheless identify requirements related to the following:

a) type of **battery**/batteries and construction;
b) **nominal** voltage, number of cells, ampere hour capacity (if supplied by purchaser);
c) **rated stored energy time**;
d) **rated restored energy time**;
e) **service life** required;
f) presence of other **loads** on **battery** and their voltage tolerances;
g) availability of separate **battery** rooms;
h) protection and isolation devices;
i) special requirements regarding, for example, **battery ripple current**;
j) operating temperature;
k) cut-off voltage;
l) temperature compensated charging voltage/boost or equalization requirements.

D.4 Physical and environmental requirements

If physical and environmental requirements are other than those of Clause 4 and Clause 5, the purchaser should specify the following:

a) **efficiency** at specified **load** conditions;
b) **ambient temperature** range of operation;
c) cooling system (**UPS** and **battery** installation);
d) instrumentation (local/remote);
e) signal, control and communication **ports**;
f) special environmental conditions: equipment exposed to fumes, moisture, dust, salt, air, heat, etc.;

g) special mechanical conditions: exposure to vibration, shocks or tilting, special transportation, installation or storage conditions, limitations to space or weight;

h) performance limitations regarding, for example, electrical and audible noise;

i) future extensions of the **UPS** system.

D.5 UPS technical data sheet – Manufacturer's declaration

A recommended format for the test report is provided in Table D.1.

Table D.1 – UPS technical data – Manufacturer's declaration

Subclause description [test item]	Declared characteristic	Units/Value	Manufacturer's declared value [default value]
	General		
	Model	Manufacturer's designation	
3.5.35 5.3.2 j)	Rated output apparent power	VA	
3.5.36 5.3.2 j)	Rated output active power	W	
	Performance, configuration and topology		
5.3.2 a) [6.2.2.7] [6.4.1.2] [6.4.1.3]	Performance classification	VFD BB CC VI BB CC VFI BB CC	
3.3.7 [Annex F]	**Multiple normal mode UPS** If yes, applicable set of input dependency characteristics	Yes/no (VFD, VI, VFI), (VFD, VI), (VFD, VFI) (VI, VFI)	
5.1.1 Annex A	Configuration	Single Parallel Redundant Dual bus Bypass	
5.1.1 Annex B	Topology	Double-conversion Line-interactive Standby	
	Operating conditions – Environmental		
	Dimensions in use/installed (height × width × depth)	H x W x D mm	
	Mass in use/installed (with energy storage device if integrated)	kg	
4.1, 4.3.2	Pollution degree		[PD2]
4.2.2.1, 4.3.2 [6.5.3]	Ambient temperature range, operating	°C	[+15 °C to +30 °C]
4.2.2.1, 4.3.2 [6.5.3]	Relative humidity, ambient range, operating	% (non-condensing)	[10 % to 75 %]
4.2.2.2, 4.3.2	Altitude, maximum operating – without output power derating	m	[sea-level to 1 000 m]
4.3.2, Table 2	– with output power derating	m at …. % power	[3 000 m] at 90 % power
4.3.2	Other unusual operating conditions	yes (details), no	

Subclause description [test item]	Declared characteristic	Units/Value	Manufacturer's declared value [default value]
6.5.4, [6.5.4]	Acoustic noise: A-sound pressure ($L_{pA,m}$) at 1 m – in normal mode	dB (20 µPa)	
	– in stored energy mode	dB (20 µPa)	
Storage and transportation conditions – Environmental			
4.2.3, 4.3.3 [6.5.2]	Ambient temperature range	°C	[–25 °C to +55 °C]
4.2.3, 4.3.3 [6.5.2]	Relative humidity, ambient range	% (non-condensing)	[10 % to 95 %]
4.2.3, 4.3.3	Altitude, maximum permitted or Ambient air pressure, minimum permitted	M kPa	[3 000 m] or [70 kPa]
4.2.3, 4.3.3	Energy storage device, specific storage or transportation conditions	yes (details), no	
4.3.3	Other unusual storage and transportation conditions	yes (details), no	
5.2 UPS input specification			
5.2.2 a)	Number of phases		
5.2.2 b)	Neutral requirements		
5.2.2 c) [6.4.1.4]	Rated input current	A	
5.2.2 d) [6.4.1.8]	Input power factor		
5.2.2 e) [6.4.1.6]	Inrush current	% s	
5.2.2 f) [6.4.1.5]	Maximum input current	A	
5.2.2 g) [6.4.2.9.1]	Input current at overload capacity (where applicable curve of current against time)	% s	
5.2.2 h), [6.4.1.7]	Total harmonic distortion of current	%	
5.2.2 i)	Minimum short-circuit power (S_{sc}) capacity required from the AC input power	VA	
5.2.2 j)	Earth leakage current	mA	[< 3,5 mA]
5.2.2 k)	AC power distribution system compatibility	TN; TT; IT	
5.2.2 m) [6.4.1.3]	Rated input voltage Input voltage tolerance band	V + %, – %	[± 10 %]
5.2.2 m) [6.4.1.3]	Rated input frequency Input frequency tolerance band	Hz + %, – %	[± 2 %]
5.2.3 a)	UPS compatibility with unusual input harmonic voltage distortion	yes (details), no	
5.2.3 b)	UPS compatibility with specific input supply protective devices	yes (details), no	
5.2.3 c)	UPS compatibility with all-pole isolation from the AC input power	yes, no	
5.2.3 d)	UPS compatibility with a specific standby generator	yes (details), no	

Subclause description [test item]	Declared characteristic	Units/Value	Manufacturer's declared value [default value]
5.3 UPS output specification			
5.3.2 b)	Rated output voltage RMS output voltage tolerance band	V + %, – %	
5.3.2 j)	Rated output current	A	
5.3.2 l), [6.4.2.9.3]	Minimum inverter current limit (ik1, ik2, or ik3 as applicable) (% of rated current or actual current (A) and sustaining time)	% or A_{RMS} s	
5.3.2 c)	Rated frequency Free-running output frequency tolerance band (non-synchronized)	Hz + %, – %	
5.3.2 d), [6.4.1.3]	Output frequency tolerance band accepted by the UPS inverter for synchronization with an external source Maximum phase angle between the inverter and external source voltage waveforms;	(min) to (max) Hz degrees	
5.3.2 e), [6.4.1.3]	Rate of change of frequency (slew-rate) when synchronizing	Hz/s	
5.3.2 f)	Number of phases available		
5.3.2 g)	Neutral availability	yes, no	
5.3.2 h)	AC power distribution system compatibility	TN, TT or IT	[AC input power system declared in 5.2.2 k)]
5.3.2 i) [6.4.2.2] [6.4.2.3]	Total harmonic distortion of voltage: – normal mode (If multiple normal mode UPS, for each applicable input dependency characteristic – stored energy mode	% %	[THD declared in 5.3.2 a)] [THD declared in 5.3.2 a)]
5.3.2 a) [6.4.2.10.5] [Annex H]	Dynamic output performance following a step load application	Dynamic output performance class 1, 2 or 3	[Dynamic output performance class declared in 5.3.2 a)]
5.3.2 k), [6.4.2.9.1]	Overload capacity – normal mode	% / s	
	– stored energy mode	% / s	
	– bypass mode	(See Bypass section in this Table D.1)	
	RMS output voltage tolerance band affected?	Yes/no	
	If yes, new tolerance band	+ %, – %	
5.3.2 m), [6.4.2.9.2]	Fault clearing capacity (max. protective device) – normal mode	A trip curve dynamic output performance class 1, 2, 3, or clearing time (ms)	[C IEC 60898-1] [Class 3]

Subclause description [test item]	Declared characteristic	Units/Value	Manufacturer's declared value [default value]
	– stored energy mode	A trip curve dynamic output performance class 1, 2, 3 or clearing time (ms)	[C IEC 60898-1] [Class 3]
5.3.2 n)	Load power factor at rated load		[rated output active power/ rated output apparent power]
5.3.2 o)	Permissible displacement power factor tolerance band of the load (cos Φ)	% Lead to % Lag	
5.3.2 p) [6.4.2.4]	Voltage unbalance resulting from 100 % load unbalance ratio (polyphase UPS only)	%	
5.3.2 q) [6.4.1.9] [Annex J]	UPS efficiency in normal mode If multiple normal mode UPS, for each applicable input dependency characteristic – $Eff_{100\ \%}$	%	
	– $Eff_{75\ \%}$	%	
	– $Eff_{50\ \%}$	%	
	– $Eff_{25\ \%}$	%	
[Annex I]	– Eff_{W}	%	
5.3.2 r), [6.4.1.10] [Annex J]	No load losses If multiple normal mode UPS, for each applicable input dependency characteristic	W	
5.3.2 s), [6.4.2.10.6]	Parallel redundant UPS failure – High impedance failure	Dynamic output performance class 1, 2 or 3	[dynamic output performance class declared in 5.3.2 a)]
	– Low impedance failure	Dynamic output performance class 1, 2 or 3	[Class 3]
5.3.2 t), [6.4.2.6]	Rated output active power and rated output apparent power for a system consisting of two UPS operating in parallel (if applicable)	W VA	
Bypass (as applicable)			
5.5.1, Clause C.3 [6.2.2.3 g)]	Maintenance bypass switch	Internal or External	
Clause C.2, [6.2.2.3 f)], [6.2.2.9]	Automatic bypass switch	Static or electro-mechanical	

Subclause description [test item]	Declared characteristic	Units/Value	Manufacturer's declared value [default value]
5.3.4.4: 1st character [6.4.2.10.4]	Bypass switch transfer time	≤ 0,1 ms ≤ 1,0 ms ≤ 10 ms > 10 ms	
5.2.2 a)	Number of phases		
5.2.2 b)	Neutral requirements		
5.2.2 c)	Rated current	A	
5.3.2 k) [6.4.2.9.1]	Overload capacity: % of rated current and time duration	% s	
5.2.3 b)	Bypass protective device rating	A Trip curve	[C IEC 60898-1]
5.2.2 j)	Earth leakage current	mA	[< 3,5 mA]
5.2.2 d)	Power factor		
5.2.2 i)	Minimum short-circuit power (S_{sc}) capacity required from the AC input power	VA	
5.2.2 k)	AC power distribution system compatibility	TN; TT; IT	
5.2.2 l)	Rated voltage Voltage tolerance band	V + %, – %	[± 10 %]
5.2.2 m)	Rated frequency Frequency tolerance band	Hz + %, – %	[± 2 %]
Clause B.1	Bypass isolation transformer	(details)	
5.2.2 e)	Inrush current (if transformer or inductor is supplied)	% s	
5.4.2 Energy storage device – Battery			
5.4.2.2 a)	Service life	years	
5.4.2.2 b)	Quantity of blocks or cells and of paralleled strings if more than one string		
5.4.2.2 c)	Nominal string voltage	V DC	
5.4.2.2 d)	Battery technology	Vented or valve-regulated lead-acid, NiCd, NiMH, Li-Ion, etc.	
5.4.2.2 e)	Nominal capacity of total battery and reference discharge rate (Cx rate)	Ah Cx	Ah [C10]
5.4.2.2 f) [6.4.3.1]	Stored energy time (back-up time at reference test load)	hh:mm	
5.4.2.2 g) [6.4.3.2]	Restored energy time (recharge time to 90 % capacity)	hh:mm	
5.4.2.2 h)	Ambient temperature at which battery performance is rated	°C	
5.4.2.2 i)	Earth condition of DC port (remote battery only)	(+), (–) or centre or Not earthed	
5.4.2.2 i)	Isolation of DC port from input and/or output (remote battery only)	- Referenced to input or output, or - Isolated from input and output	

Subclause description [test item]	Declared characteristic	Units/Value	Manufacturer's declared value [default value]
5.4.2.2 j)	battery ripple current during normal mode operation (if exceeding 5 % of total battery Ah capacity)	% of the numerical Ah capacity [C10 discharge rate]	
5.4.2.2 k) to r)	Additional characteristics provided by the battery supplier for a remote battery		
5.4.2.3	Additional or unusual conditions		
5.6 Communication circuits			
5.6	Signal, control and communication ports available		

NOTE For information, the manufacturer can complement Table D.1 with safety, electromagnetic compatibility and environmental characteristics of IEC 62040-1, IEC 62040-2 and IEC 62040-4.