IEC 61000-4-30

Edition 3.0 2015-02
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

BASIC EMC PUBLICATION

Electromagnetic compatibility (EMC) –
Part 4-30: Testing and measurement techniques – Power quality measurement methods

IEC 61400-4-30:2015-02 RLV(en)

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
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 corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue
The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub
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 It also gives information on projects, replaced and withdrawn publications.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 also once a month by email.

Electropedia - www.electropedia.org
The world's leading online dictionary of electronic and electrical terms containing more than 30 000 terms and definitions in English and French, with equivalent terms in 15 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary
More than 60 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

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: csc@iec.ch.

IEC 61000-4-30

Edition 3.0 2015-02
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

BASIC EMC PUBLICATION

Electromagnetic compatibility (EMC) –
Part 4-30: Testing and measurement techniques – Power quality measurement methods

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.100.99

ISBN 978-2-8322-2324-6

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

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 4-30: Testing and measurement techniques – Power quality measurement methods

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.

This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

International Standard IEC 61000-4-30 has been prepared by subcommittee 77A: EMC – Low-frequency phenomena, of IEC technical committee 77: Electromagnetic compatibility.

This standard forms part 4-30 of IEC 61000. It has the status of a basic EMC publication in accordance with IEC Guide 107.

This third edition cancels and replaces the second edition published in 2008. This edition constitutes a technical revision.

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

a) the measurement method for current, previously informative, is now normative with some changes;
b) the measurement method for RVC (rapid voltage change) has been added;
c) the measurement method for conducted emissions in the 2 kHz to 150 kHz range has been added in informative Annex C;
d) underdeviation and overdeviation parameters are moved to informative Annex D;
e) Class A and Class S measurement methods are defined and clarified, while Class B is moved to informative Annex E and considered for future removal;
f) measurement methods continue in this standard, but responsibility for influence quantities, performance, and test procedures are transferred to IEC 62586-2.

The text of this standard is based on the following documents:

FDIS	Report on voting
77A/873/FDIS	77A/878/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 61000 series, published under the general title *Electromagnetic compatibility (EMC)*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

The contents of the corrigendum of December 2016 have been included in this copy.

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.

INTRODUCTION

IEC 61000 is published in separate parts according to the following structure:

Part 1: General

General considerations (introduction, fundamental principles)

Definitions, terminology

Part 2: Environment

Description of the environment

Classification of the environment

Compatibility levels

Part 3: Limits

Emission limits

Immunity limits (in so far as they do not fall under the responsibility of the product committees)

Part 4: Testing and measurement techniques

Measurement techniques

Testing techniques

Part 5: Installation and mitigation guidelines

Installation guidelines

Mitigation methods and devices

Part 6: Generic standards

Part 9: Miscellaneous

Each part is further subdivided into several parts, published either as International Standards or as Technical Specifications or Technical Reports, some of which have already been published as sections. Others will be published with the part number followed by a dash and completed by a second number identifying the subdivision (example: 61000-6-1).

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 4-30: Testing and measurement techniques – Power quality measurement methods

1 Scope

This part of IEC 61000-4 defines the methods for measurement and interpretation of results for power quality parameters in ~~50/60 Hz~~ a.c. power supply systems with a declared fundamental frequency of 50 Hz or 60 Hz.

Measurement methods are described for each relevant parameter in terms that give reliable and repeatable results, regardless of the method's implementation. This standard addresses measurement methods for in-situ measurements.

Measurement of parameters covered by this standard is limited to ~~voltage~~ conducted phenomena ~~that can be conducted~~ in power systems. The power quality parameters considered in this standard are power frequency, magnitude of the supply voltage, flicker, supply voltage dips and swells, voltage interruptions, transient voltages, supply voltage unbalance, voltage harmonics and interharmonics, mains signalling on the supply voltage, rapid voltage changes, and current measurements. Emissions in the 2 kHz to 150 kHz range are considered in Annex C (informative), and over- and underdeviations are considered in Annex D (informative). Depending on the purpose of the measurement, all or a subset of the phenomena on this list may be measured.

NOTE 1 ~~Information about current parameters may be found in A.3 and A.5.~~ Test methods for verifying compliance with this standard can be found in IEC 62586-2.

~~This standard gives measurement methods and appropriate performance requirements, but does not set thresholds.~~

NOTE 2 The effects of transducers inserted between the power system and the instrument are acknowledged but not addressed in detail in this standard. ~~Precautions on installing monitors on live circuits are addressed.~~ Guidance about effects of transducers ~~may~~ can be found in ~~IEC 61557-12~~ IEC TR 61869-103.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

~~IEC 60050-161, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*~~

IEC 60050 (all parts), *International Electrotechnical Vocabulary (IEV)* (available at www.electropedia.org)

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

IEC 61000-2-4, *Electromagnetic compatibility (EMC) – Part 2-4: Environment – Compatibility levels in industrial plants for low-frequency conducted disturbances*

IEC 61000-3-8, *Electromagnetic compatibility (EMC) – Part 3: Limits – Section 8: Signalling on low-voltage electrical installations – Emission levels, frequency bands and electromagnetic disturbance levels*

~~IEC 61000-4-4:2004, *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*~~

IEC 61000-4-7:2002, *Electromagnetic compatibility (EMC) – Part 4-7: Testing and measurement techniques – General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto*
IEC 61000-4-7:2002/AMD1:2008

IEC 61000-4-15:2010, *Electromagnetic compatibility (EMC) – Part 4-15: Testing and measurement techniques – Flickermeter – Functional and design specifications*

IEC 61180 (all parts), *High-voltage test techniques for low voltage equipment*

IEC 62586-1, *Power quality measurement in power supply systems – Part 1: Power quality instruments (PQI)*

IEC 62586-2, *Power quality measurement in power supply systems – Part 2: Functional tests and uncertainty requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-161, as well as the following apply.

3.1
channel
individual measurement path through an instrument

Note 1 to entry: "Channel" and "phase" are not the same. A voltage channel is by definition the difference in potential between 2 conductors. Phase refers to a single conductor. On polyphase systems, a channel may be between 2 phases, or between a phase and neutral, or between a phase and earth, or between neutral and earth.

~~**3.2**~~
~~**Coordinated Universal Time**~~
~~**UTC**~~
~~time scale which forms the basis of a coordinated radio dissemination of standard frequencies and time signals. It corresponds exactly in rate with international atomic time, but differs from it by an integral number of seconds.~~

~~NOTE 1 Coordinated universal time is established by the International Bureau of Weights and Measures (BIPM) and the International Earth Rotation Service (IERS).~~

~~NOTE 2 The UTC scale is adjusted by the insertion or deletion of seconds, so called positive or negative leap seconds, to ensure approximate agreement with UT1.~~

~~[IEV 713-05-20]~~

3.2
declared input voltage
U_{din}
value obtained from the declared supply voltage by a transducer ratio

3.3
declared supply voltage
U_c
normally the nominal voltage U_n of the system

Note 1 to entry: If, by agreement between the supplier and the customer, a voltage different from the nominal voltage is applied to the terminals, then this voltage is the declared supply voltage U_c.

3.4
dip threshold
voltage magnitude specified for the purpose of detecting the start and the end of a voltage dip

3.5
flagged data
~~data that has been marked to indicate that its measurement or its aggregation may have been affected by interruptions, dips, or swells~~
for any measurement time interval in which interruptions, dips or swells occur, the marked measurement results of all other parameters made during this time interval

Note 1 to entry: ~~Flagging enables other methods that may prevent a single event from being counted as several different types of events. Flagging is supplemental information about a measurement or aggregation. Flagged data is not removed from the data set. In some applications, flagged data may be excluded from further analysis but in other applications, the fact that data was flagged may be unimportant. The user, application, regulation, or other standards determine the use of flagged data.~~ For some applications, this 'marked' or 'flagged' data may be excluded from further analysis, for example. See 4.7 for further explanation.

3.6
flicker
impression of unsteadiness of visual sensation induced by a light stimulus whose luminance or spectral distribution fluctuates with time

[SOURCE: IEC 60050-161:1990, 161-08-13]

3.6.1
P_{st}
short-term flicker evaluation based on an observation period of 10 min

[SOURCE: IEC 61000-4-15]

3.6.2
P_{lt}
long-term flicker evaluation

[SOURCE: IEC 61000-4-15]

3.7
fundamental component
component whose frequency is the fundamental frequency

~~[IEV 101-14-49, modified]~~

3.8
fundamental frequency
frequency in the spectrum obtained from a Fourier transform of a time function, to which all the frequencies of the spectrum are referred

~~[IEV 101-14-50, modified]~~

Note 1 to entry: In case of any remaining risk of ambiguity, the fundamental frequency may be derived from the number of poles and speed of rotation of the synchronous generator(s) feeding the system.

3.9
harmonic component
any of the components having a harmonic frequency

Note 1 to entry: Its value is normally expressed as an r.m.s. value. For brevity, such component may be referred to simply as a harmonic.

[SOURCE:IEC 61000-2-2:2002, 3.2.4~~, modified~~]

3.10
harmonic frequency
frequency which is an integer multiple of the fundamental frequency

Note 1 to entry: The ratio of the harmonic frequency to the fundamental frequency is the harmonic order (recommended notation: ~~*h*~~ n) (IEC 61000-2-2:2002, 3.2.3)

3.11
hysteresis
difference in magnitude between the start and end thresholds

Note 1 to entry: This definition of hysteresis is relevant to ~~Power Quality (~~PQ~~)~~ measurement parameters and is different from the IEC 60050 definition which is relevant to iron core saturation.

Note 2 to entry: The purpose of hysteresis in the context of PQ measurements is to avoid counting multiple events when the magnitude of the parameter oscillates about the threshold level.

3.12
influence quantity
~~any quantity which may affect the working performance of a measuring equipment~~
quantity which is not the subject of the measurement and whose change affects the relationship between the indication and the result of the measurement

[SOURCE: IEC 60050-311:2001, 311-06-01~~, modified~~]

~~NOTE This quantity is generally external to the measurement equipment.~~

3.13
interharmonic component
spectral component~~ having an interharmonic~~ with a frequency between two consecutive harmonic frequencies

~~[IEC 61000-2-2:2002, 3.2.6]~~

Note 1 to entry: The definition is derived from IEC 61000-4-7.

Note 2 to entry: Its value is normally expressed as an r.m.s. value. For brevity, such a component may be referred to simply as an interharmonic.

3.14
interharmonic frequency
any frequency which is not an integer multiple of the fundamental frequency

Note 1 to entry: By extension from the harmonic order, the interharmonic order is the ratio of an interharmonic frequency to the fundamental frequency. This ratio is not an integer (recommended notation m).

Note 2 to entry: In the case where $m < 1$ the term subharmonic frequency may be used.

[SOURCE: IEC 61000-2-2:2002, 3.2.5]

3.15
interruption
reduction of the voltage at a point in the electrical system below the interruption threshold

3.16
interruption threshold
voltage magnitude specified for the purpose of detecting the start and the end of a voltage interruption

3.17
measurement uncertainty
parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand

[SOURCE: IEC 60050-311:2001, 311-01-02]

3.18
nominal voltage
U_n
voltage by which a system is designated or identified

3.19
overdeviation
~~absolute value of the~~ difference between the measured value and the nominal value of a parameter, only when the measured value of the parameter is greater than the nominal value

3.20
power quality
characteristics of the electricity at a given point on an electrical system, evaluated against a set of reference technical parameters

Note 1 to entry: These parameters might, in some cases, relate to the compatibility between electricity supplied on a network and the loads connected to that network.

~~**3.22**~~
~~**Real-Time Clock**~~
~~**RTC**~~
~~local timekeeping device used for implementing certain methods in this standard.~~

~~NOTE The relationship between the real-time clock and UTC is defined in 4.6.~~

3.21
root-mean-square value
r.m.s. ~~value~~
square root of the arithmetic mean of the squares of the instantaneous values of a quantity taken over a specified time interval and a specified bandwidth

[SOURCE: IEC 60050-103:2009, 103-02-03 ~~101-14-16, modified~~]

3.22
r.m.s. voltage refreshed each half-cycle
$U_{\text{rms(½)}}$
value of the r.m.s. voltage measured over 1 cycle, commencing at a fundamental zero crossing, and refreshed each half-cycle

Note 1 to entry: This technique is independent for each channel and will produce r.m.s. values at successive times on different channels for polyphase systems.

Note 2 to entry: This value is used only for voltage dip, voltage swell, interruption, and RVC detection and evaluation, in Class A.

Note 3 to entry: This r.m.s. voltage value may be a phase-to-phase value or a phase-to-neutral value.

3.23
r.m.s. current refreshed each half-cycle
$I_{rms(½)}$
value of the r.m.s. current measured over 1 cycle, commencing at a fundamental zero crossing on an associated voltage channel, and refreshed each half-cycle

Note 1 to entry: For guidance, the associated voltage channel might be the corresponding phase-to-neutral channel on single-phase or star networks. If there is no corresponding voltage channel, for example on delta network currents, or earth current or neutral current measurements, then the reference channel (see 5.1.3) used for frequency measurements might be used.

3.24
r.m.s. voltage refreshed each cycle
$U_{rms(1)}$
value of the r.m.s. voltage measured over 1 cycle and refreshed each cycle

Note 1 to entry: In contrast to $U_{rms(½)}$, this technique does not define when a cycle commences.

Note 2 to entry: This value is used only in Class S, and is used for voltage dip, voltage swell, and interruption detection and evaluation.

Note 3 to entry: This r.m.s. voltage value can be a phase-to-phase value or a phase-to-neutral value.

3.25
range of influence quantities
range of values of a single influence quantity

3.26
rapid voltage change
RVC
a quick transition in r.m.s. voltage occurring between two steady-state conditions, and during which the r.m.s. voltage does not exceed the dip/swell thresholds

Note 1 to entry: This note applies to the French language only.

3.27
reference channel
one of the voltage measurement channels designated as the reference channel for polyphase measurements

Note 1 to entry: In the case of a single-phase measurement, the voltage measuring channel is also the reference channel.

3.28
residual voltage
U_{res}
minimum value of $U_{rms(½)}$ ~~or $U_{rms(1)}$~~ recorded during a voltage dip or interruption

Note 1 to entry: The residual voltage is expressed as a value in volts, or as a percentage or per unit value of ~~U_{din}. $U_{rms(1/2)}$ is used for Class A~~ the declared input voltage. ~~Either $U_{rms(1/2)}$ or $U_{rms(1)}$ may be used for Class S. See 5.4.1.~~

3.29
sliding reference voltage
U_{sr}
voltage magnitude averaged over ~~a specified time interval~~ one minute, representing the voltage preceding a ~~voltage-change type of event (e.g. voltage dips and swells, rapid voltage changes)~~ voltage dip or swell

Note 1 to entry: It is precisely defined in 5.4.4.

Note 2 to entry: The sliding reference voltage may be used to determine the voltage change during a dip or a swell, typically for medium-voltage or high-voltage systems.

3.30
swell threshold
voltage magnitude specified for the purpose of detecting the start and the end of a swell

3.31
time aggregation
combination of several sequential values of a given parameter (each determined over identical time intervals) to provide a value for a longer time interval

Note 1 to entry: Aggregation in this document always refers to time aggregation.

3.32
underdeviation
absolute value of the difference between the measured value and the nominal value of a parameter, only when the value of the parameter is lower than the nominal value

3.33
UTC
coordinated universal time
time scale which forms the basis of a coordinated radio dissemination of standard frequencies and time signals which corresponds exactly in rate with international atomic time, but differs from it by an integral number of seconds

Note 1 to entry: Coordinated universal time is established by the International Bureau of Weights and Measures (BIPM) and the International Earth Rotation Service (IERS).

Note 2 to entry: The UTC scale is adjusted by the insertion or deletion of seconds, so called positive or negative leap seconds, to ensure approximate agreement with UT1.

Note 3 to entry: This note applies to the French language only.

[SOURCE: Recommendation ITU-R RF.686.3]

3.34
voltage dip
temporary reduction of the voltage magnitude at a point in the electrical system below a threshold

Note 1 to entry: Interruptions are a special case of a voltage dip. Post-processing may be used to distinguish between voltage dips and interruptions.

Note 2 to entry: A voltage dip is also referred to as sag. The two terms are considered interchangeable; however, this standard will only use the term voltage dip.

3.35
voltage swell
temporary increase of the voltage magnitude at a point in the electrical system above a threshold

3.36
voltage unbalance
condition in a polyphase system in which the r.m.s. values of the line voltages (fundamental component), and/or the phase angles between consecutive line voltages, are not all equal

Note 1 to entry: The degree of the inequality is usually expressed as the ratios of the negative- and zero-sequence components to the positive-sequence component.

Note 2 to entry: In this standard, voltage unbalance is considered in relation to 3-phase systems.

[SOURCE: IEC 60050-161:2002, 161-08-09, modified – notes to entry have been added]

4 General

4.1 Classes of measurement ~~methods~~

For each parameter measured, ~~three~~ two classes (A and S ~~and B~~) are defined in this standard. For each class, measurement methods and appropriate performance requirements are included.

– **Class A**

This class is used where precise measurements are necessary, for example, for contractual applications that may require resolving disputes, verifying compliance with standards, etc. Any measurements of a parameter carried out with two different instruments complying with the requirements of Class A, when measuring the same signals, will produce matching results within the specified uncertainty for that parameter.

NOTE 1 Class A measurements produce matching results only if the user-selected parameters (thresholds, hysteresis, etc.) match.

– **Class S**

This class is used for statistical applications such as surveys or power quality assessment, possibly with a limited subset of parameters. Although it uses equivalent intervals of measurement as Class A, the Class S processing requirements are much lower. Some surveys may assess power quality parameters of several measurement sites on a network; other surveys assess power quality parameters at a single site over a period of time, or at locations within a building or even within a single large piece of equipment.

– **Class B**

~~This class is defined in order to avoid making many existing instruments designs obsolete.~~

~~NOTE Class B methods are not recommended for new designs. Readers are advised that Class B may be removed in a future Edition of this standard.~~

For Class B information, see Annex E (informative) of this standard. Class B methods shall not be employed for new instruments. Class B is moved to Annex E on the basis that all new instrument designs will comply with either Class A or Class S. Class B may be relevant for legacy instruments that are still in use. Class B may be removed in the next edition of this standard.

NOTE 2 Class B measurement methods will provide useful but not necessarily comparable information. Class B was introduced in IEC 61000-4-30:2003 (edition 1) specifically to avoid making older instrument designs obsolete. IEC 61000-4-30:2008 (edition 2) warned that Class B may be removed in a future edition of this standard. IEC 61000-4-30:– (this edition 3) warns again that Class B may be removed in a future edition, and moves Class B to Informative Annex E.

NOTE 3 In this standard, "A" stands for "Advanced", and "S" stands for "Surveys". ~~("B" or "Basic" methods are not recommended for new designs, because Class B may be removed in a future Edition of this standard.)~~

~~For each class, the range of influencing factors that shall be complied with is specified in Clause 6.~~ Users shall select the class that they require, based on their application(s). For troubleshooting applications, depending on the type of problem either Class A or Class S methods may be selected by the user.

~~NOTE 1~~ The instrument manufacturer should declare influence quantities which are not expressly given and which may degrade performance of the instrument. ~~Guidance can be found, for example, in IEC 61557-12.~~

~~NOTE 2~~ An instrument may measure some or all of the parameters identified in this standard, and preferably uses the same class for all parameters. For guidance, see IEC 62586-1 and IEC 62586-2.

~~NOTE 3~~ The instrument manufacturer ~~should~~ shall declare which parameters are measured, which class is used for each parameter, the range of U_{din} for which each class is fulfilled, and all the necessary requirements and accessories (synchronization, probes, calibration period, temperature ranges, etc.) to meet each class.

4.2 Organization of the measurements

The electrical quantity to be measured may be either directly accessible, as is generally the case in low-voltage systems, or accessible via measurement transducers.

The whole measurement chain is shown in Figure 1.

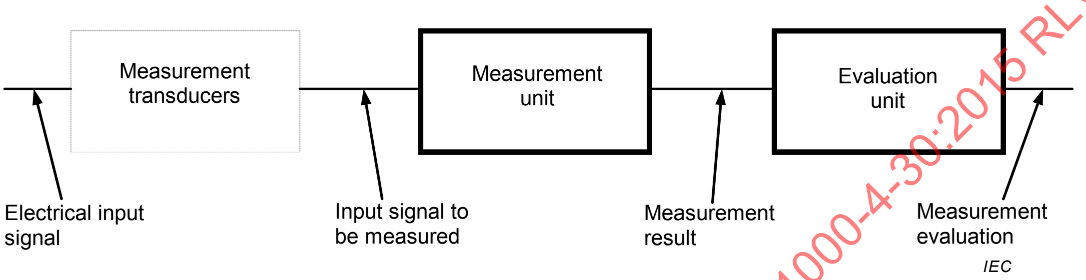


Figure 1 – Measurement chain

An "instrument" may include the whole measurement chain (see Figure 1). In this standard, the normative part does not consider ~~the~~ any possible measurement transducers external to the instrument and their associated uncertainty, but Clause ~~A.3~~ A.2 gives guidance.

4.3 Electrical values to be measured

Measurements can be performed on single-phase or polyphase supply systems. Depending on the context, it may be necessary to measure voltages between phase conductors and neutral (line-to-neutral) or between phase conductors (line-to-line) or between phase conductors or neutral and earth (phase-to-earth, neutral-to-earth). It is not the purpose of this standard to impose the choice of the electrical values to be measured. Moreover, except for the measurement of voltage unbalance, which is intrinsically polyphase, the measurement methods specified in this document are such that independent results can be produced on each measurement channel.

NOTE Phase-to-phase instantaneous values can be measured directly, or can be derived from instantaneous phase-to-neutral measured values or from phase-to-earth measured values.

Current measurements ~~can~~ may be performed on each conductor of supply systems, including the neutral conductor and the protective earth conductor (see 5.13).

~~NOTE It is often useful to measure current simultaneously with voltage and to associate the current measurements in one conductor with voltage measurements between that conductor and a reference conductor, such as an earth conductor or a neutral conductor.~~

4.4 Measurement aggregation over time intervals

~~The following measurement aggregations apply:~~

– **Class A**

The basic measurement time interval for parameter magnitudes (supply voltage, harmonics, interharmonics and unbalance) shall be a 10-cycle time interval for a 50 Hz power system or a 12-cycle time interval for a 60 Hz power system.

The 10/12-cycle measurement shall be re-synchronized at every ~~RTC~~ UTC (coordinated universal time) 10-min tick. See Figure 2.

NOTE 1 The uncertainty of this measurement is included in the uncertainty measurement protocol of each parameter.

The 10/12-cycle values are then aggregated over 3 additional intervals:

- 150/180-cycle interval (150 cycles for 50 Hz nominal or 180 cycles for 60 Hz nominal),
- 10-min interval,
- 2-hour interval for P_{lt} flicker.

NOTE 2 In some applications, other time intervals (e.g. 1 min) may be useful. These other time intervals, if used, should be implemented with an aggregation method that is analogous to a method defined in this standard (e.g. a 1 min time interval, if used, should be implemented using a method that is analogous to the 10 minute aggregation method). A 2-hour aggregation interval is optional for all parameters, with the exception of flicker measurements which require a 2-hour aggregation interval for P_{lt}. This 2-hour aggregation interval may possibly be useful in some applications, and may possibly be necessary for measuring compliance with some national or international standards.

NOTE 3 Clauses B.1 and B.2 discuss some applications of these aggregation time intervals.

– **Class S**

Same time intervals as Class A. The 10/12-cycle measurement shall be re-synchronized as described in Figure 3 and Figure 4.

– **Class B**

The manufacturer shall specify the number and duration of aggregation time intervals.

4.5 Measurement aggregation algorithm

4.5.1 Requirements

Aggregations shall be performed using the square root of the arithmetic mean of the squared input values.

NOTE For flicker measurements, a different aggregation algorithm is used (see IEC 61000 4-15).

4.5.2 150/180-cycle aggregation

– **Class A**

The data for the 150/180-cycle time interval shall be aggregated without gap from fifteen 10/12-cycle time intervals.

The 150/180-cycle time interval is resynchronized upon the UTC 10-min tick as shown in Figure 2.

When a 10-min tick occurs, a new 150/180-cycle time interval begins, and the pending 150/180-cycle time interval also continues until it is completed. This may create an overlap between these two 150/180-cycle intervals (overlap 2 in Figure 2).

– **Class S**

The data for the 150/180-cycle time interval shall be aggregated from 10/12-cycle time intervals. Resynchronization with the UTC 10-min tick is permitted but not required mandatory. (See Figure 3)

Gaps are permitted but not required mandatory for harmonics, interharmonics, mains signalling voltage and unbalance. A minimum of three 10/12-cycle values shall be used each 150/180-cycle time interval, i.e. at least one 10/12-cycle value shall be used each 50/60 cycles (see Figure 4). For all other parameters, the data for the 150/180-cycle time interval shall be aggregated without gap from fifteen 10/12-cycle time intervals.

– **Class B**

The manufacturer shall specify the method of aggregation.

4.5.3 10-min aggregation

– **Class A**

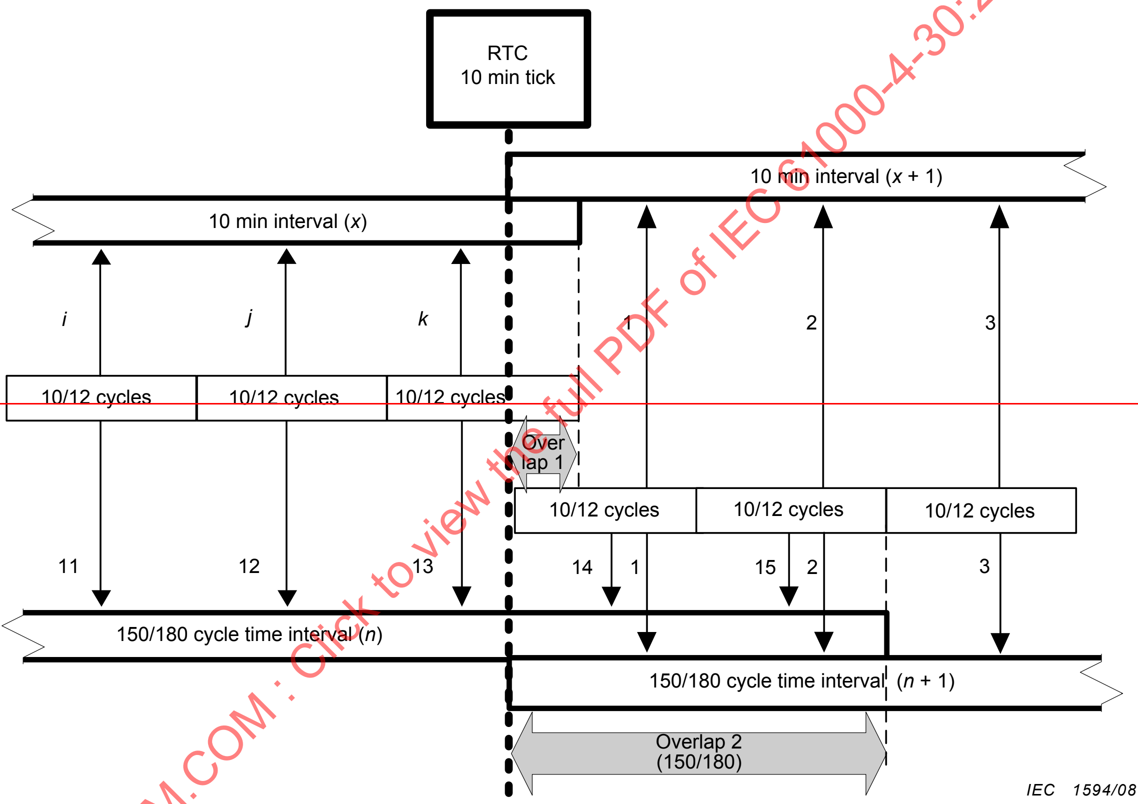
The 10 min aggregated value shall be tagged with the ~~absolute~~ UTC time (for example, 01H10.00,000)~~. The time tag is the time~~ at the conclusion of the 10-min aggregation interval, rounded to the nearest second.

NOTE In some circumstances, it can be useful to use local time, which can differ from UTC by a fixed offset, or an offset that can vary based on time of year. This type of time stamp often includes both a time and a date. This type of time stamp can be referred to as “absolute time”.

The data for the 10-min time interval shall be aggregated ~~without gaps~~ from 10/12-cycle time intervals.

Each 10-min interval shall begin on a ~~RTC~~ UTC 10-min tick. The 10-min tick is also used to re-synchronize the 10/12-cycle intervals and the 150/180-cycle intervals. See Figure 2.

The final 10/12-cycle interval(s) in a 10-min aggregation period will typically overlap in time with the ~~RTC~~ UTC 10 min clock tick. Any overlapping 10/12-cycle interval (overlap 1 in Figure 2) is included in the aggregation of the previous 10-min interval.



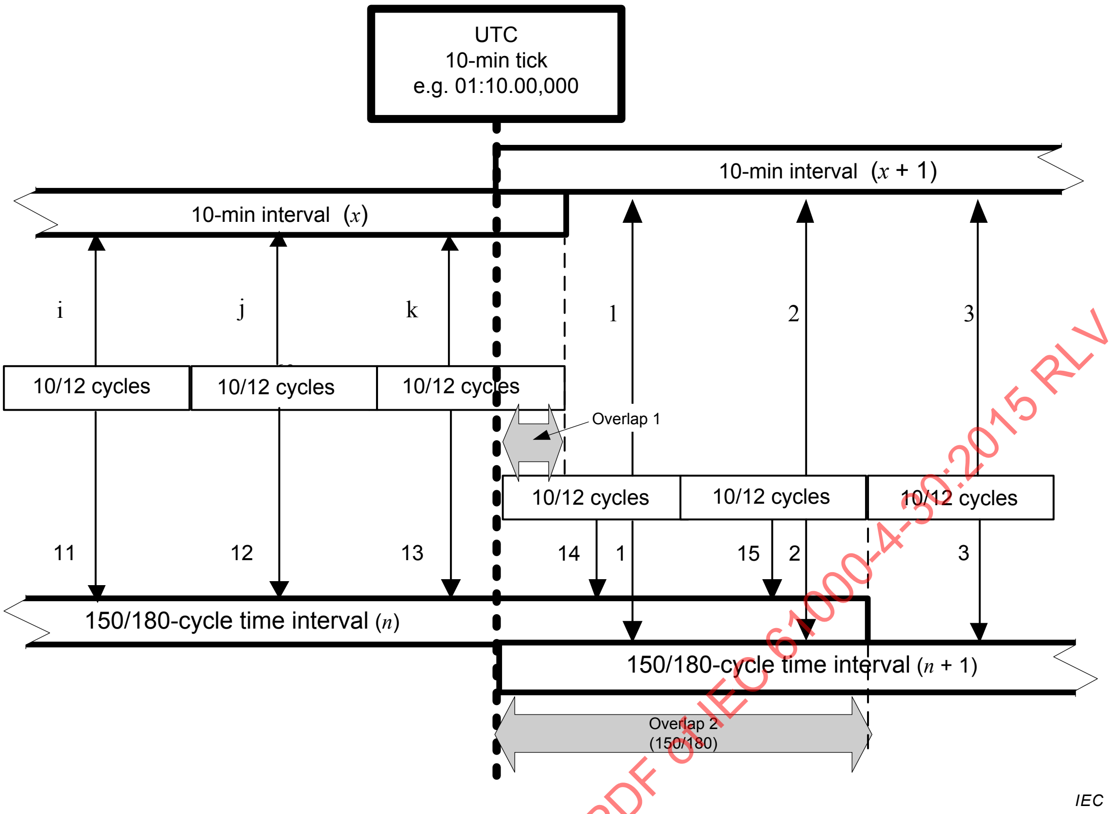


Figure 2 – Synchronization of aggregation intervals for Class A

– **Class S**

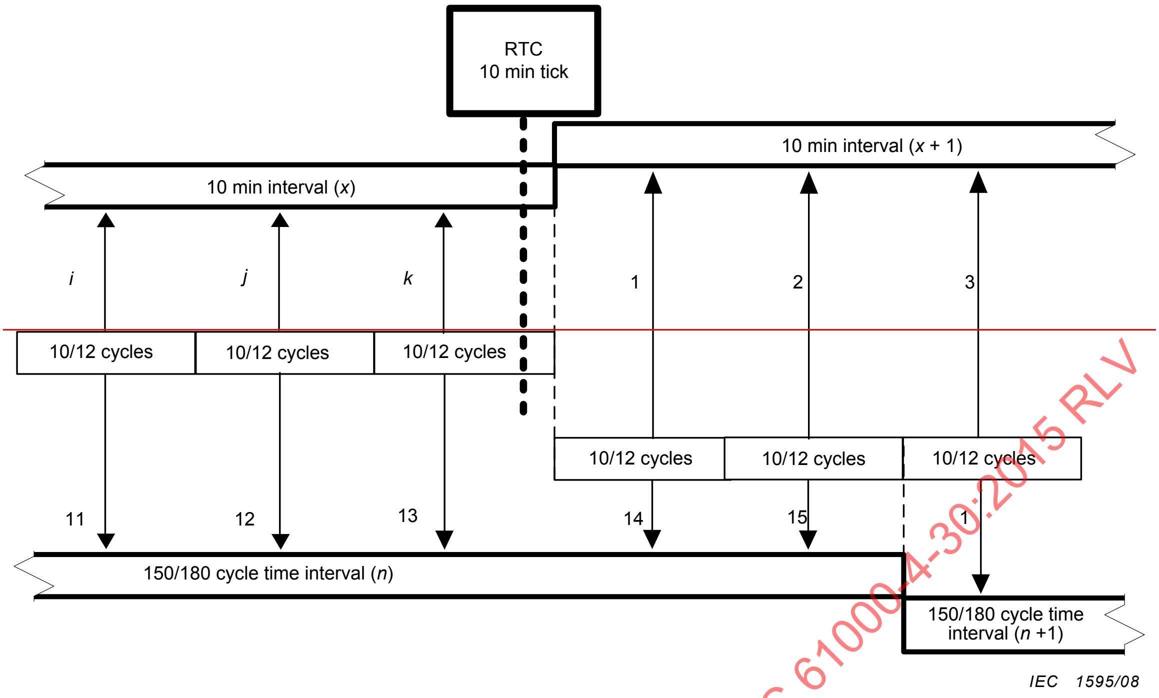
The 10-min aggregation method used for Class S shall be either the Class A method, or the following simplified method:

~~A new 10-min time interval shall commence after a 10-min tick occurs, at the beginning of the next 10/12 cycle time interval.~~

The data for the 10-min time interval shall be aggregated from 10/12-cycle time intervals. There is no resynchronization on the UTC 10-min tick. The 10-min intervals are free running.

The 10-min aggregated value shall be tagged with ~~the absolute time. The time tag is~~ the time at the conclusion of the 10-min aggregation interval (e.g. 01h10.00,040).

There will be no overlap, as illustrated in Figure 3 and Figure 4.



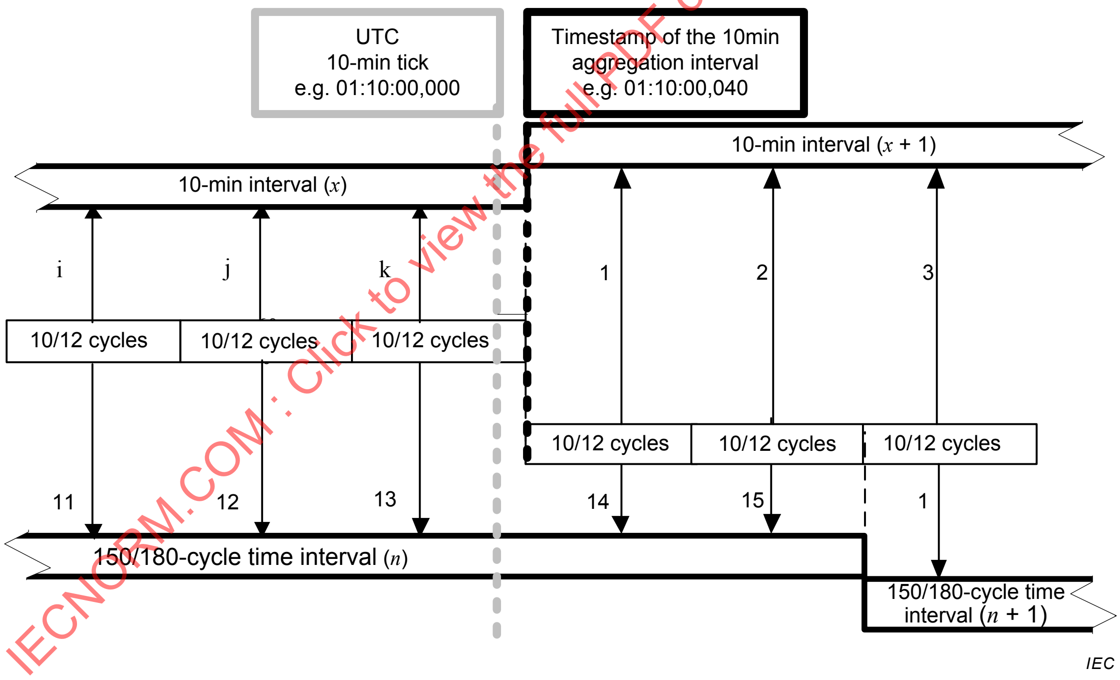
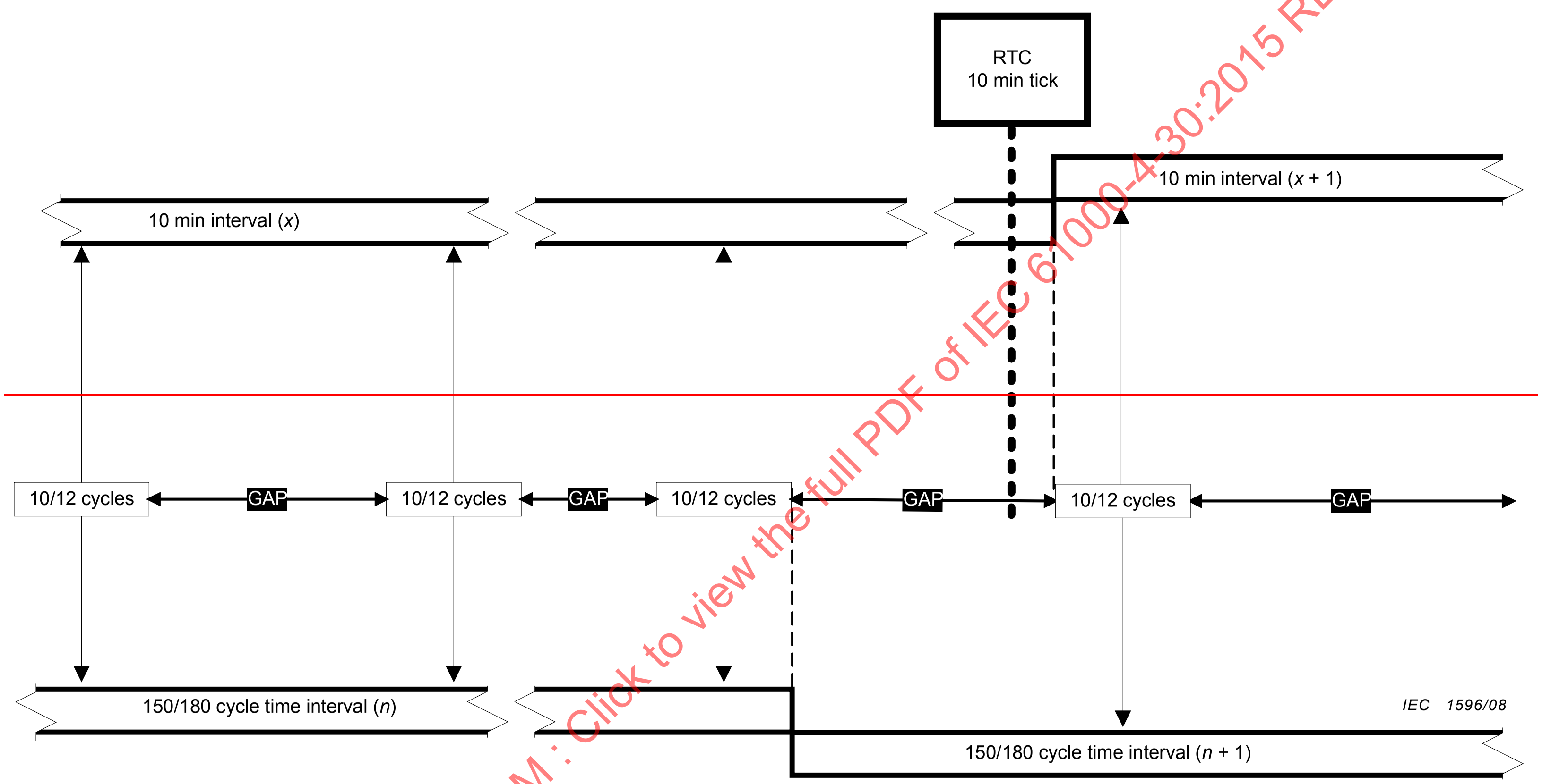


Figure 3 – Synchronization of aggregation intervals for Class S: parameters for which gaps are not permitted



~~NOTE The mains frequency may be either higher or lower than expected. In the example shown in Figure 3, the frequency is lower than expected, so the 150/180 cycle interval continues beyond the 10 min tick. In the example shown in Figure 4, the frequency is higher than expected and/or there are gaps, so the 150/180 cycle interval concludes before the 10 min tick.~~

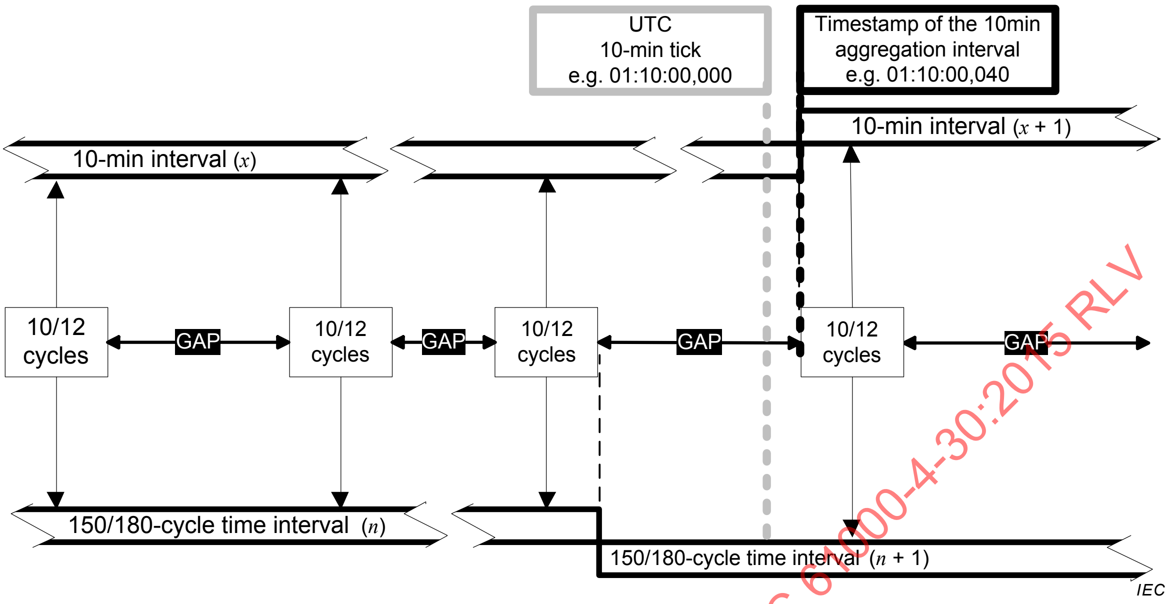


Figure 4 – Synchronization of aggregation intervals for Class S: parameters for which gaps are permitted (see 4.5.2)

– ~~Class B~~

~~The manufacturer shall specify the method of aggregation.~~

4.5.4 2-hour aggregation

– **Class A**

The data for the 2-hour interval shall be aggregated from twelve 10-min intervals. The 2-hour interval shall be gapless and not overlapping. ~~2 h intervals commence at even-numbered 2 h RTC intervals.~~

– **Class S**

Same as Class A.

– ~~Class B~~

~~The manufacturer shall specify the method of aggregation.~~

4.6 ~~Real time clock (RTC)~~ Time-clock uncertainty

~~RTC~~ Time-clock uncertainty is defined relative to coordinated universal time (UTC), which is continuously incrementing and available world-wide.

NOTE 1 The time clock may move forward or backward under certain circumstances, such as daylight savings time, external synchronization updates, etc. When the clock moves forward in time, there may be gaps in the data. When the clock moves backwards in time, data may overlap in time.

– **Class A**

The ~~RTC~~ time-clock uncertainty shall not exceed ±20 ms for 50 Hz or ±16,7 ms for 60 Hz, regardless of the total time interval.

NOTE 2 This performance can be achieved, for example, through a synchronization procedure applied periodically during a measurement campaign, through a GPS receiver, or through reception of transmitted radio timing signals or by using network timing signals.

When synchronization by an external signal becomes unavailable, the ~~RTC~~ time tagging tolerance shall be better than ±1 s per 24-h period; however, this exception does not eliminate the requirement for compliance with the first part of this paragraph.

NOTE 3 This performance is necessary to ensure that two instruments using Class A methods produce the same 10-min ~~and 2 h~~ aggregation results when connected to the same signal. ~~This performance is also necessary when it is required to use simultaneously more than one instrument using Class A methods, possibly placed at different locations.~~

– **Class S**

The ~~RTC~~ time-clock uncertainty shall not exceed ±5 s per 24-h period.

~~– **Class B**~~

~~The manufacturer shall specify the RTC uncertainty and the method to determine aggregation intervals, if any.~~

4.7 Flagging concept

During a dip, swell, or interruption, the measurement algorithm for other parameters (for example, frequency measurement) might produce an unreliable value. The flagging concept avoids counting a single event more than once in different parameters (for example, counting a single dip as both a dip and a frequency variation), and indicates that an aggregated value might be unreliable.

Flagging is only triggered by dips, swells, and interruptions. The detection of dips and swells is dependent on the threshold selected by the user, and this selection will influence which data are "flagged".

The flagging concept is applicable for Class A and Class S during measurement of power frequency, voltage magnitude, flicker, supply voltage unbalance, voltage harmonics, voltage interharmonics, mains signalling and measurement of underdeviation and overdeviation parameters.

If during a given time interval any value is flagged, the aggregated value which includes that value shall also be flagged. The flagged value shall be stored and also included in the aggregation process. For example, if during a given time interval any value is flagged, then the aggregated value that includes this value shall also be flagged and stored.

~~NOTE The flag may be made available with the data. The user, application, regulation, or other standards determine the use of flagged data. The fact that data have been flagged is an alert that there are possible problems in the data.~~

NOTE 1 Information about other types of flagging, or data marking, can be found in IEC 62586-1.

NOTE 2 The user can decide how to evaluate flagged data.

5 Power quality parameters

5.1 Power frequency

5.1.1 Measurement method

– **Class A**

The frequency reading shall be obtained every 10 s. As power frequency may not be exactly 50 Hz or 60 Hz within the 10-s time clock interval, the number of cycles may not be an integer number. The fundamental frequency output is the ratio of the number of integral cycles counted during the 10-s time clock interval, divided by the cumulative duration of the integer cycles.

When a zero crossing method is used for frequency calculation, then, before the assessment, harmonics and interharmonics shall be attenuated to minimize the effects of multiple zero crossings.

The measurement time intervals shall be non-overlapping. Individual cycles that overlap the 10-s time clock are discarded. Each 10-s interval shall begin on an absolute 10-s time clock, with uncertainty as defined in 4.6.

Other techniques that provide equivalent results, such as convolution, are acceptable.

NOTE For some applications, the use of time intervals shorter than 10 s may possibly be useful, such as 10/12 cycles (wind turbines), 1 s (national standards), etc.

– **Class S**

Same as Class A.

– **Class B**

The manufacturer shall specify the process used for frequency measurement.

5.1.2 Measurement uncertainty and measuring range

– **Class A**

Under the conditions described in Clause 6.1, the measurement uncertainty shall not exceed ±10 mHz over the measuring ranges 42,5 Hz to 57,5 Hz / 51 Hz to 69 Hz.

– **Class S**

Under the conditions described in Clause 6.1, the measurement uncertainty shall not exceed ±50 mHz over the measuring ranges 42,5 Hz to 57,5 Hz / 51 Hz to 69 Hz.

– **Class B**

The manufacturer shall specify the uncertainty over the measuring ranges 42,5 Hz ~ 57,5 Hz / 51 Hz ~ 69 Hz.

5.1.3 Measurement evaluation

– **Class A**

The frequency measurement shall be made on the reference channel.

NOTE The manufacturer should shall specify the behaviour of frequency measurement whenever the reference channel loses voltage.

– **Class S**

Same as Class A.

– **Class B**

The manufacturer shall indicate the process used for frequency measurement.

5.1.4 Aggregation

Aggregation is not required mandatory.

5.2 Magnitude of the supply voltage

5.2.1 Measurement method

– **Class A**

The measurement shall be the r.m.s. value of the voltage magnitude over a 10-cycle time interval for a 50 Hz power system or a 12-cycle time interval for a 60 Hz power system. Every 10/12-cycle interval shall be contiguous, and not overlapping with adjacent 10/12-cycle intervals except as shown in overlap 1 in Figure 2.

NOTE 1 This specific measurement method is used for quasi-stationary signals and is not used for the detection and measurement of disturbances: dips, swells, voltage interruptions and transients.

NOTE 2 The r.m.s. value includes, by definition, harmonics, interharmonics, mains signalling, etc.

– **Class S**

Same as Class A.

~~– Class B~~

~~The measurement shall be the r.m.s. value of the voltage over a period specified by the manufacturer.~~

5.2.2 Measurement uncertainty and measuring range

– **Class A**

Under the conditions described in Clause 6~~.1~~, the measurement uncertainty shall not exceed ±0,1 % of U_{din}, over the range of 10 % to 150 % of U_{din}.

– **Class S**

Under the conditions described in Clause 6~~.1~~, the measurement uncertainty shall not exceed ±0,5 % of U_{din}, over the range of 20 % to 120 % of U_{din}.

~~– Class B~~

~~Under the conditions described in 6.1, the measurement uncertainty shall be specified by the manufacturer, in such a way as not to exceed ±1 % of U_{din}, over a range specified by the manufacturer.~~

5.2.3 Measurement evaluation

No requirements.

5.2.4 Aggregation

Aggregation shall be performed according to 4.4 and 4.5.

5.3 Flicker

5.3.1 Measurement method

– **Class A**

IEC 61000-4-15 Class F3 applies as the minimum requirement. Class F3 should not be used for new designs. Class F1 is recommended, and may be required in the next edition of this standard.

– **Class S**

IEC 61000-4-15 Class F3 applies as the minimum requirement.

~~– Class B~~

~~Not applicable.~~

~~NOTE In IEC 61000-4-15, measurements are defined only at 120 V / 60 Hz and 230 V / 50 Hz. At present, an extension of the flicker definition to other voltages is being considered.~~

5.3.2 Measurement uncertainty and measuring range

– **Class A**

See IEC 61000-4-15. Under the conditions described in Clause 6~~.1~~, the measurement uncertainty required by 61000-4-15 shall be met over the measuring range of 0,2 P_{st} to10 P_{st}.

– **Class S**

See IEC 61000-4-15. Under the conditions described in Clause 6~~.1~~, twice the permitted measurement uncertainty required by 61000-4-15 shall be met over the measuring range of 0,4 P_{st} to 4 P_{st}.

~~– Class B~~

~~Not applicable.~~

5.3.3 Measurement evaluation

– **Class A**

IEC 61000-4-15 applies.

The 10-min time interval for P_{st} shall commence on a ~~RTC~~ UTC 10-min tick, and shall be tagged with the ~~absolute~~ time at the conclusion of the interval (see 4.5.3).

Voltage dips, swells, and interruptions shall cause P_{st} and P_{lt} output values (see IEC 61000-4-15) to be flagged.

– **Class S**

Same as Class A.

~~– **Class B**~~

~~Not applicable.~~

5.3.4 Aggregation

– **Class A**

Aggregation shall be performed according to IEC 61000-4-15. ~~For P_{lt}, aggregation shall be performed according to IEC 61000-4-15 over 2 h periods, as per 4.5.4 of this standard.~~

– **Class S**

Same as Class A.

~~– **Class B**~~

~~Not applicable.~~

5.4 Supply voltage dips and swells

5.4.1 Measurement method

– **Class A**

The basic measurement U_{rms} of a voltage dip and swell shall be the $U_{rms(½)}$ on each measurement channel (see 3.22).

The cycle duration for $U_{rms(½)}$ depends on the frequency. The frequency might be determined by the last non-flagged power frequency measurement (see 4.7 and 5.1), or by any other method that yields the uncertainty requirements of Clause 6~~.2~~.

NOTE 1 The $U_{rms(½)}$ value includes, by definition, harmonics, interharmonics, mains signalling voltage, etc.

NOTE 2 It is important to avoid loss of data when dips and swells occur in a rapid sequence (for example, three events in one second, with up to one minute between sequences, could possibly occur when a recloser operates into a sustained fault). If, during a rapid burst, the dip/swell event characteristics cannot be recorded, then a count of events could possibly be useful.

– **Class S**

The basic measurement U_{rms} of a voltage dip and swell shall be either the $U_{rms(½)}$ on each measurement channel (see Clause 3.22), or the $U_{rms(1)}$ on each measurement channel (see Clause 3.23). The manufacturer shall specify which measurement is used.

NOTE 3 The $U_{rms(1)}$ value includes, by definition, harmonics, interharmonics, mains signalling voltage, etc.

~~– **Class B**~~

~~The manufacturer shall specify the method used for U_{rms}.~~

5.4.2 Detection and evaluation of a voltage dip

5.4.2.1 Voltage dip detection

The dip threshold is a percentage of either U_{din} or the sliding voltage reference U_{sr} (see 5.4.4). The user shall declare the reference voltage in use.

NOTE The sliding voltage reference U_{sr} is generally not used in LV systems. See IEC TR 61000-2-8 for further information and advice.

- On single-phase systems a voltage dip begins when the U_{rms} voltage falls below the dip threshold, and ends when the U_{rms} voltage is equal to or above the dip threshold plus the hysteresis voltage.
- On polyphase systems a dip begins when the U_{rms} voltage of one or more channels is below the dip threshold and ends when the U_{rms} voltage on all measured channels is equal to or above the dip threshold plus the hysteresis voltage.

The dip threshold and the hysteresis voltage are both set by the user according to the application.

5.4.2.2 Voltage dip evaluation

A voltage dip is characterized by a pair of data, either residual voltage (U_{res}) or depth, and duration:

- the residual voltage of a voltage dip is the lowest U_{rms} value measured on any channel during the dip;
- the depth is the difference between the reference voltage (either U_{din} or U_{sr}) and the residual voltage. It is generally expressed in percentage of the reference voltage.

NOTE 1 During the dip it may be useful to also record the lowest $U_{rms(½)}$ on each channel, in addition to the residual voltage of the dip. The duration spent below the dip threshold on each channel may also be useful.

NOTE 2 If voltage waveforms are recorded before, during, and after a dip, useful information about phase angle changes may be available in the recorded data.

The start time of a dip shall be time stamped with the time of the end of the U_{rms} of the channel that initiated the event and the end time of the dip shall be time stamped with the time of the end of the U_{rms} that ended the event, as defined by the threshold plus the hysteresis.

The duration of a voltage dip is the time difference between the start time and the end time of the voltage dip.

NOTE 3 For polyphase measurements, the dip duration ~~may~~ can start on one channel and terminate on a different channel.

NOTE 4 Voltage dip envelopes are not necessarily rectangular. As a consequence, for a given voltage dip, the measured duration is dependent on the selected dip threshold value. The shape of the envelope ~~may~~ can be assessed using several dip thresholds set within the range of voltage dip and voltage interruption thresholds.

NOTE 5 Typically, the hysteresis is equal to 2 % of U_{din}.

NOTE 6 Dip thresholds are typically in the range 85 % to 90 % of the fixed voltage reference for troubleshooting or statistical applications.

NOTE 7 Residual voltage is often useful to end-users, and ~~may~~ can be preferred because it is referenced to zero volts. In contrast, depth is often useful to electric suppliers, especially on HV systems or in cases when a sliding reference voltage is used.

NOTE 8 Phase shift ~~may~~ can occur during voltage dips. See ~~A.7.5.~~ A.5.5.

NOTE 9 When a threshold is crossed, a time stamp ~~may~~ can be recorded.

5.4.3 Detection and evaluation of a voltage swell

5.4.3.1 Voltage swell detection

The swell threshold is a percentage of either U_{din} or the sliding reference voltage U_{sr} (see 5.4.4). The user shall declare the reference voltage in use.

NOTE Sliding reference voltage U_{sr} is generally not used in LV systems. See IEC TR 61000-2-8 for further information and advice.

– On single-phase systems a swell begins when the U_{rms} voltage rises above the swell threshold, and ends when the U_{rms} voltage is equal to or below the swell threshold minus the hysteresis voltage.

– On polyphase systems a swell begins when the U_{rms} voltage of one or more channels is above the swell threshold and ends when the U_{rms} voltage on all measured channels is equal to or below the swell threshold minus the hysteresis voltage.

The swell threshold and the hysteresis voltage are both set by the user according to the application.

5.4.3.2 Voltage swell evaluation

A voltage swell is characterized by a pair of data: maximum swell voltage magnitude and duration:

– the maximum swell magnitude voltage is the largest U_{rms} value measured on any channel during the swell;

– the start time of a swell shall be time stamped with the time of the end of the U_{rms} of the channel that initiated the event and the end time of the swell shall be the time stamped with the time of the end of the U_{rms} that ended the event, as defined by the threshold minus the hysteresis;

– the duration of a voltage swell is the time difference between the beginning and the end of the swell.

NOTE 1 For polyphase measurements, the swell duration measurement ~~may~~ can start on one channel and terminate on a different channel.

NOTE 2 Voltage swell envelope may possibly not be rectangular. As a consequence, for a given swell, the measured duration is dependent on the swell threshold value.

NOTE 3 Typically, the hysteresis is equal to 2 % of U_{din}.

NOTE 4 Typically, the swell threshold is ~~equal to or~~ greater than 110 % of U_{din}.

NOTE 5 Phase shift ~~may~~ can also occur during voltage swells.

NOTE 6 When a threshold is crossed, a time stamp ~~may~~ can be recorded.

5.4.4 Calculation of a sliding reference voltage

The sliding reference voltage implementation is optional, not ~~required~~ mandatory. If a sliding reference is chosen for voltage dip or swell detection, this shall be calculated using a first-order filter with a 1-min time constant. This filter is given by

$$U_{sr(n)} = 0{,}9967 \times U_{sr(n-1)} + 0{,}0033 \times U_{(10/12)rms}$$

where

$U_{sr(n)}$ is the present value of the sliding reference voltage;

$U_{sr(n-1)}$ is the previous value of the sliding reference voltage; and

$U_{(10/12)rms}$ is the most recent 10/12-cycle r.m.s. value.

When the measurement is started, the initial value of the sliding reference voltage is set to the declared input voltage. The sliding reference voltage is updated every 10/12 cycles. If a 10/12-cycle value is flagged, the sliding reference voltage is not updated and the previous value is used.

5.4.5 Measurement uncertainty and measuring range

5.4.5.1 Residual voltage and swell voltage magnitude measurement uncertainty

- **Class A**

  The measurement uncertainty shall not exceed ±0,2 % of U_{din}.

- **Class S**

  The measurement uncertainty shall not exceed ±1,0 % of U_{din}.

- ~~**Class B**~~

  ~~The manufacturer shall specify the uncertainty which shall not exceed ±2,0 % of U_{din}.~~

5.4.5.2 Duration measurement uncertainty

- **Class A**

  The uncertainty of a dip or swell duration is equal to the dip or swell commencement uncertainty (half a cycle) plus the dip or swell conclusion uncertainty (half a cycle).

- **Class S**

  If $U_{rms(½)}$ is used, then the uncertainty of a dip or swell duration is equal to the dip or swell commencement uncertainty (half a cycle) plus the dip or swell conclusion uncertainty (half a cycle). If $U_{rms(1)}$ is used, then the uncertainty of a dip or swell duration is equal to the dip or swell commencement uncertainty (one cycle) plus the dip or swell conclusion uncertainty (one cycle).

- ~~**Class B**~~

  ~~The manufacturer shall specify the duration measurement uncertainty.~~

5.4.5.3 Aggregation

Aggregation is not applicable for triggered events.

5.5 Voltage interruptions

5.5.1 Measurement method

The basic measurement of the voltage shall be as defined in 5.4.1 for each class.

5.5.2 Evaluation of a voltage interruption

The voltage interruption threshold is a percentage of U_{din}.

On single-phase systems, a voltage interruption begins when the U_{rms} voltage falls below the voltage interruption threshold and ends when the U_{rms} value is equal to, or greater than, the voltage interruption threshold plus the hysteresis.

On polyphase systems, a voltage interruption begins when the U_{rms} voltages of all channels fall below the voltage interruption threshold, and ends when the U_{rms} voltage on any one channel is equal to, or greater than, the voltage interruption threshold plus the hysteresis.

The voltage interruption threshold and the hysteresis voltage are both set by the user according to the application. The voltage interruption threshold shall not be set below the uncertainty of the residual voltage measurement plus the value of the hysteresis. Typically, the hysteresis is equal to 2 % of U_{din}.

The start time of a voltage interruption shall be time stamped with the time of the end of the U_{rms} of the channel that initiated the event and the end time of the voltage interruption shall be the time stamped with the time of the end of the U_{rms} that ended the event, as defined by the threshold plus the hysteresis.

The duration of a voltage interruption is the time difference between the beginning and the end of the voltage interruption.

NOTE 1 The voltage interruption threshold can, for example, be set to 5 % or to 10 % of U_{din}.

NOTE 2 IEC 60050-161:1990, 161-08-20, considers an interruption to have occurred when the voltage magnitude is less than 1 % of the nominal voltage. However, it is difficult to correctly measure voltages below 1 % of the nominal voltage. Therefore,~~ this standard recommends that~~ the user~~ set~~ could consider setting an appropriate voltage interruption threshold.

NOTE 3 The interruption of one or more phases on a polyphase system can be seen as an interruption of the supply to single-phase customers connected to that system, even though this would not be classified as an interruption in a polyphase measurement.

5.5.3 Measurement uncertainty and measuring range

For duration measurement uncertainty, see 5.4.5.2.

5.5.4 Aggregation

Aggregation is not applicable for triggered events.

5.6 Transient voltages

Clause~~ A.4~~ A.3 provides some informative information on the significant parameters necessary to characterize transient voltages~~ and currents~~. Measurement of transient voltages can be useful but is not mandatory.

5.7 Supply voltage unbalance

5.7.1 Measurement method

Unbalance measurements apply only to 3-phase systems.

– **Class A**

The supply voltage unbalance is evaluated using the method of symmetrical components. In addition to the positive sequence component U_1, under unbalanced conditions there also exists at least one of the following components: negative sequence component U_2 and/or zero sequence component U_0.

The fundamental component of the voltage input signal is measured over a 10-cycle time interval for 50 Hz power systems or a 12-cycle time interval for 60 Hz power systems.

NOTE 1 The effect of harmonics is minimized by the use of a filter or by using a DFT (Discrete Fourier Transform) algorithm.

NOTE 2 Algorithms that use only the r.m.s. values to calculate unbalance fail to take into account the contributions of angular displacement to unbalance, and cause unpredictable results when harmonic voltages are present. The negative sequence unbalance and zero sequence unbalance provide more precise and more directly useful values.

The negative sequence unbalance ratio u_2 expressed as a percentage is evaluated by:

$$u_2 = \frac{U_2}{U_1} \times 100\% = \frac{\text{negative sequence}}{\text{positive sequence}} \times 100\% \qquad (1)$$

~~For 3-phase systems considering only phase-to-phase voltages, and only fundamental voltages, this can be written (with $U_{ij\ fund}$ = phase i to phase j fundamental voltage)~~

~~$$u_2 = \sqrt{\frac{1-\sqrt{3-6\beta}}{1+\sqrt{3-6\beta}}} \times 100 \text{ with } \beta = \frac{U_{12\text{ fund}}^4 + U_{23\text{ fund}}^4 + U_{31\text{ fund}}^4}{\left(U_{12\text{ fund}}^2 + U_{23\text{ fund}}^2 + U_{31\text{ fund}}^2\right)^2} \qquad (2)$$~~

The zero-sequence unbalance ratio u_0 expressed as a percentage is evaluated by

$$u_0 = \frac{U_0}{U_1} \times 100\% = \frac{\text{zero sequence}}{\text{positive sequence}} \times 100\% \qquad (2)$$

NOTE 3 The zero sequence unbalance by definition is zero when phase-to-phase voltages are measured. However, the phase-to-neutral or phase-to-earth voltages ~~may~~ can still contain the zero sequence component in that case.

NOTE 4 Any other methods that can be shown to be mathematically equivalent to Equation (1) and Equation (2) are acceptable.

– **Class S**

~~The negative sequence ratio is evaluated in the same way as for Class A.~~ The manufacturer shall specify the algorithms and methods used to calculate the negative sequence ratio u_2.The evaluation of the zero-sequence unbalance ratio u_0 is optional, not mandatory.

~~– **Class B**~~

~~The manufacturer shall specify the algorithms and methods used to calculate unbalance.~~

5.7.2 Measurement uncertainty and measuring range

– **Class A**

~~When a 3-phase a.c. voltage that fulfils the requirements of "testing state 1" conditions (see Table 2), except for negative- and zero-sequence unbalance in the measuring range 1 % to 5 % of U_1, is applied at the input, then the instrument shall present an uncertainty less than ±0,15 % for both u_2 and u_0.~~
The uncertainty shall be less than ±0,15 % for both u_2 and u_0. For example, an instrument presented with a 1,0 % negative sequence shall provide a reading x such that 0,85 % ≤ x ≤ 1,15 % (see Figure 5).

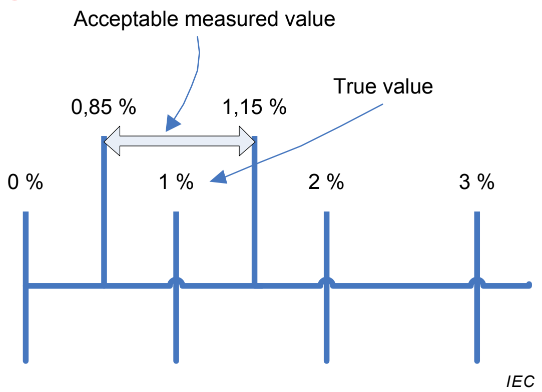


Figure 5 – Example of supply voltage unbalance uncertainty

– **Class S**

Same as class A~~, except for the uncertainty, which is less than ±0,3% for u_2 (and for u_0 if it is evaluated)~~.

~~– **Class B**~~

~~Same as class A, except for the uncertainty, which is less than ±0,3% for any unbalance parameter that is evaluated.~~

5.7.3 Measurement evaluation

No requirements.

NOTE The uncertainty of measurement transformers, if present, may have a large impact on the calculation of unbalance.

5.7.4 Aggregation

Aggregation shall be performed according to 4.4 and 4.5.

5.8 Voltage harmonics

5.8.1 Measurement method

– **Class A**

The basic measurement of voltage harmonics, for Class A, is defined in IEC 61000-4-7 Class I. IEC 61000-4-7 shall be used to determine a 10/12-cycle gapless harmonic subgroup measurement, denoted $U_{\text{sg,h}}$ in IEC 61000-4-7.

NOTE 1 Other methods, including analogue and frequency domain methods, ~~may~~ can be preferred in special cases (see, for example, IEC 61000-3-8).

~~NOTE 2 Current harmonic measurements are considered in Clause A.6.~~

Measurements shall be made at least up to the 50^{th} order.

If the total harmonic distortion is calculated, then it shall be calculated as the subgroup total harmonic distortion ($THDS_{\text{Y}}$), defined in IEC 61000-4-7.

NOTE 2 This measurement method generates a large amount of data, which, depending on the application, may need to be stored, transmitted, analysed, and/or archived. Depending on the application, the amount of data may be reduced. To reduce the amount of data, consider applying statistical methods at the measuring location, or storing only extreme and average values, or storing detailed data only when trigger thresholds are exceeded, or other methods.

NOTE 3 IEC 61000-4-7 refers to replacing the symbol 'Y' by the symbol 'I' for currents, and by the symbol 'U' for voltages. $THDS_{\text{U}}$ may be the preferred terminology for voltage THD. However, when searching the 61000-4-7 document for information about these parameters, search for the symbol 'Y'.

– **Class S**

The basic measurement of voltage harmonics, for Class S, is defined in IEC 61000-4-7 Class II. Gaps are permitted (see 4.5). The manufacturer shall select either a 10/12-cycle harmonic group designated $U_{\text{g,h}}$ in IEC 61000-4-7, or a 10/12-cycle subgroup measurement designated $U_{\text{sg,h}}$ in IEC 61000-4-7. The manufacturer shall specify which has been selected.

Measurements shall be made at least up to the 40^{th} order.

NOTE 4 The EN 50160 assessment requires the 40^{th} order.

If the total harmonic distortion is calculated, then it shall be calculated either as the total harmonic distortion (THD_{Y}) if ~~$U_{g,h}$~~ $Y_{\text{g,h}}$ is selected, or as the subgroup total harmonic distortion ($THDS_{\text{Y}}$) if ~~$U_{\text{sg,h}}$~~ $Y_{\text{sg,h}}$ is selected, both defined in IEC 61000-4-7.

NOTE 5 IEC 61000-4-7 refers to replacing the symbol 'Y' by the symbol 'I' for currents, by the symbol 'U' for voltages, so $U_{\text{g,h}}$ or $U_{\text{sg,h}}$ may be the preferred terminology. However, when searching the 61000-4-7 document for information about these parameters, search for the symbol 'Y'.

~~– **Class B**~~

~~The manufacturer shall specify the measurement method.~~

5.8.2 Measurement uncertainty and measuring range

– **Class A**

The maximum uncertainty shall be the levels specified in IEC 61000-4-7 Class I.

The measuring range shall be 10 % to 200 % of Class 3 ~~compatibility level~~ electromagnetic environment in IEC 61000-2-4.

– **Class S**

The maximum uncertainty shall be twice the levels specified in IEC 61000-4-7 Class II. The anti-aliasing low-pass filter specified in IEC 61000-4-7~~, 5.3~~ shall be optional. The ±0,03 % maximum permissible error for time between leading edges requirement as specified in IEC 61000-4-7~~, 4.4.1~~ shall be optional, but the maximum uncertainty requirement shall still be met over the range of influence quantities specified in Clause 6 of this standard.

The measuring range shall be 10 % to 100 % of Class 3 ~~compatibility level~~ electromagnetic environment in IEC 61000-2-4.

~~– **Class B**~~

~~The manufacturer shall specify measurement uncertainty and measuring range.~~

5.8.3 Measurement evaluation

No requirements.

5.8.4 Aggregation

Aggregation shall be performed according to 4.4 and 4.5.

NOTE To minimize storage requirements, after aggregation has been completed it may be practical to discard the source data (such as 10/12-cycle or 150/180-cycle data) if it is no longer required.

5.9 Voltage interharmonics

5.9.1 Measurement method

– **Class A**

The basic measurement of voltage interharmonics, for the purpose of this standard, is defined in IEC 61000-4-7 Class I. IEC 61000-4-7 shall be used to determine a 10/12-cycle gapless centred interharmonic subgroup measurement, denoted ~~$U_{isg,h}$~~ $Y_{isg,h}$ in IEC 61000-4-7.

~~NOTE Current interharmonic measurements are considered in Clause A.6.~~

Measurements shall be made at least up to the 50th order.

NOTE 1 This measurement method generates a large amount of data, which, depending on the application, may need to be stored, transmitted, analysed, and/or archived. Depending on the application, the amount of data may be reduced. To reduce the amount of data, consider applying statistical methods at the measuring location, or storing only extreme and average values, or storing detailed data only when trigger thresholds are exceeded, or other methods.

NOTE 2 IEC 61000-4-7 refers to replacing the symbol 'Y' by the symbol 'I' for currents, by the symbol 'U' for voltages, so $U_{ig,h}$ or $U_{isg,h}$ may be the preferred terminology. However, when searching the 61000-4-7 document for information about these parameters, search for the symbol 'Y'.

– **Class S**

The manufacturer shall specify the measurement method.

~~– **Class B**~~

~~The manufacturer shall specify the measurement method.~~

5.9.2 Measurement uncertainty and measuring range

– **Class A**

The maximum uncertainty shall be the levels specified in IEC 61000-4-7 Class I.

The measuring range shall be 10 % to 200 % of Class 3 ~~compatibility level~~ electromagnetic environment in IEC 61000-2-4.

– **Class S**

The manufacturer shall specify the measurement uncertainty ~~and measuring range~~.

The measuring range shall be 10 % to 100 % of Class 3 electromagnetic environment in IEC 61000-2-4.

~~– **Class B**~~

~~The manufacturer shall specify measurement uncertainty and measuring range.~~

5.9.3 ~~Measurement~~ Evaluation

No requirements.

5.9.4 Aggregation

Aggregation shall be performed according to Clause 4.4 and Clause 4.5.

NOTE To minimize storage requirements, after aggregation has been completed it may be practical to discard the source data (such as 10/12-cycle or 150/180-cycle data) if it is no longer required.

5.10 Mains signalling voltage on the supply voltage

5.10.1 General

Mains signalling voltage, called “ripple control signal” in certain applications, is a burst of signals, often applied at a non-harmonic frequency, that remotely control industrial equipment, revenue meters, and other devices.

5.10.2 Measurement method

– **Class A**

The method described here shall be used for mains signalling frequencies below 3 kHz. For mains signalling frequencies above 3 kHz, see IEC 61000-3-8.

This method measures the level of the signal voltage for a user-specified carrier frequency.

NOTE The purpose of this method is to measure the maximum level of the signal voltage, and not to diagnose mains signalling difficulties.

Mains signalling voltage measurement shall be based on:

– either the corresponding 10/12-cycle r.m.s. value interharmonic bin; or

– the root of the sum of the squares of the 4 nearest 10/12-cycle r.m.s. value interharmonic bins (for example, a 316,67 Hz ripple control signal in a 50 Hz power system shall be approximated by a root of the sum of the squares of 310 Hz, 315 Hz, 320 Hz and 325 Hz bins, available from the DFT performed on a 10/12-cycle time interval).

The first method is preferred if the user-specified frequency is in the centre of a DFT bin. The second method is preferred if the frequency is not in the centre of a bin.

The user shall select a detection threshold above 0,3 % U_{din} as well as the length of the recording period up to 120 s. The beginning of a signalling emission shall be detected when the measured value of the concerned interharmonic exceeds the detection threshold. The measured values are recorded during a period of time specified by the user, in order to give the maximum level of the signal voltage.

– **Class S**

The manufacturer shall specify the measurement technique.

~~– **Class B**~~

~~The manufacturer shall specify the measurement technique.~~

5.10.3 Measurement uncertainty and measuring range

– **Class A**

The measurement range shall be at least 0 % to 15 % of U_{din}.

For mains signalling voltage between 3 % and 15 % of U_{din}, the uncertainty shall not exceed ±5 % of the measured value. For mains signalling voltage between 1 % and 3 % of U_{din}, the uncertainty shall not exceed ±0,15 % of U_{din}. For mains signalling voltage less than 1 % of U_{din}, no uncertainty requirement is given.

– **Class S**

The manufacturer shall specify the uncertainty and the measuring range.

~~– **Class B**~~

~~The manufacturer shall specify the uncertainty and the measuring range.~~

~~5.10.3 Measurement evaluation~~

~~No requirements.~~

5.10.4 Aggregation

Aggregation is not ~~required~~ mandatory.

5.11 Rapid voltage change~~s~~ (RVC)

~~NOTE Clause A.5 provides some information on the significant parameters necessary to characterize a rapid voltage change. Further information regarding loads in low voltage networks can be found in IEC 61000-3-3 and IEC 61000-3-11. This further information is not necessarily applicable to the networks themselves.~~

5.11.1 General

An RVC event is defined in 3.26 and is generally an abrupt transition between two r.m.s. voltages. By definition, the two r.m.s. voltages must be "steady state", a condition that is defined in the method below.

Dips and swells often begin or end with abrupt transitions between two r.m.s. voltages. However, by definition these are not RVC events because they exceed the dip or swell thresholds. Further guidance is found in the method below.

5.11.2 RVC event detection

– **Class A**

An r.m.s. voltage is in a steady-state condition if all the immediately preceding 100/120 $U_{rms(1/2)}$ values remain within an RVC threshold from the arithmetic mean of those 100/120 $U_{rms(1/2)}$ values. ("100/120" means 100 values for 50 Hz nominal, or 120 values for 60 Hz nominal.)

The RVC threshold is set by the user according to the application, as a percentage of U_{din}.

NOTE 1 Thresholds in the range of 1 % to 6 % might be considered. In IEC TR 61000-3-7, for example, RVC thresholds of 2,5 % to 6 % of U_{din} for medium voltage are considered. In IEC 61000-3-3, RVC thresholds of 3,3 % to 6 % for low voltage are considered. In both standards, the thresholds are linked to the number of RVC events per hour or per day. In IEC 61000-4-15, a threshold of 0,2 % is considered for a similar, but not identical, parameter.

The RVC hysteresis is set by the user according to the application, and shall be less than the RVC threshold.

NOTE 2 Hysteresis in the range of 50 % of the RVC threshold might be considered.

To initiate the RVC detection method:

- An initial set of 100/120 $U_{rms(1/2)}$ values is recorded.

- The arithmetic mean of those values is calculated, then the RVC detection method below is applied.

To detect an RVC event (see Figures 6 and 7):

- A 'voltage-is-steady-state' logic signal shall be created for each voltage channel. This logic signal is true when the voltage on that channel is in steady state, and false otherwise. This logic signal is determined from the $U_{rms(1/2)}$ values of each voltage channel, as follows. It is updated for each new $U_{rms(1/2)}$ value.
- Every time a new $U_{rms(1/2)}$ value is available, the arithmetic mean of the previous 100/120 $U_{rms(1/2)}$ values, including the new value, is calculated.
- If every one of the previous 100/120 $U_{rms(1/2)}$ values, including the new value, is within the RVC threshold (including the hysteresis, if applied) of the arithmetic mean, then the 'voltage-is-steady-state' logic signal for that channel is set to true; otherwise, it is set to false.
- On a polyphase system, the combined 'voltage-is-steady-state' logic signal is the logical-AND of the 'voltage-is-steady-state' logic signal of each voltage channel.
- An RVC event begins when the 'voltage-is-steady-state' logic signal changes from true to false.
- When an RVC event begins, the RVC hysteresis is applied to the RVC threshold, and changes to the voltage-is-steady-state logic signal are disabled for 100/120 half cycles.
- An RVC event ends when the 'voltage-is-steady-state' logic signal changes from false to true. When an RVC event ends, the RVC hysteresis is removed from the RVC threshold. The time stamp of the end of the RVC event is 100/120 half cycles prior to the logic signal changing from false to true.

If a voltage dip or voltage swell is detected during an RVC event, including the disabled 100/120 half cycles, then the RVC event is discarded because the event is not an RVC event. It is a voltage dip or voltage swell.

– **Class S**

The method for Class S is the same as the method for Class A, but in Class S the use of either $U_{rms(1/2)}$ or $U_{rms(1)}$ shall be selected according to 5.4.1. If $U_{rms(1)}$ is selected for Class S RVC, then "100/120", which refers to half-cycles, shall be replaced throughout the method with "50/60", which refers to the equivalent number of full cycles.

5.11.3 RVC event evaluation

An RVC event is characterized by four parameters: start time, duration, ΔU_{max} and ΔU_{ss}.

– **Class A**

- The start time of an RVC event shall be time stamped with the time that the 'voltage-is-steady-state' logic signal became false and initiated the RVC event.
- The RVC event duration is 100/120 half cycles shorter than the length of time during which the 'voltage-is-steady-state' logic signal is false.
- The RVC event ΔU_{max} is the maximum absolute difference between any of the $U_{rms(1/2)}$ values during the RVC event and the final arithmetic mean 100/120 $U_{rms(1/2)}$ value just prior to the RVC event. For polyphase systems, the ΔU_{max} is the largest ΔU_{max} on any channel.
- The RVC event ΔU_{ss} is the absolute difference between the final arithmetic mean 100/120 $U_{rms(1/2)}$ value just prior to the RVC event and the first arithmetic mean 100/120 $U_{rms(1/2)}$ value after the RVC event. For polyphase systems, the ΔU_{ss} is the largest ΔU_{ss} on any channel.

NOTE 1 It can be useful to count the number of RVC events in a certain period. The period can be an hour based on a fixed interval, or an hour based on a sliding interval comprising the most recent 60 minutes sliding once per minute on the minute. The period can also be a "day" and based on calendar time or based on a sliding interval comprising the most recent 24 hours, sliding once per hour on the hour.

NOTE 2 Other characteristics to evaluate an RVC event are under consideration. For example, the ΔU_{max} could be evaluated based on 10/12 cycle aggregated values.

NOTE 3 In some cases, this RVC measurement method may not fully characterize intricate variations between two steady states. Recording the sequence of U_{rms} values on each channel may be useful for deeper analysis.

– **Class S**

The RVC event evaluation for Class S is the same as the method for Class A, but in Class S the use of either $U_{rms(1/2)}$ or $U_{rms(1)}$ shall be selected according to 5.4.1 . If $U_{rms(1)}$ is selected for Class S RVC, then 100/120 half cycles shall be replaced throughout the event evaluation with 50/60 full cycles.

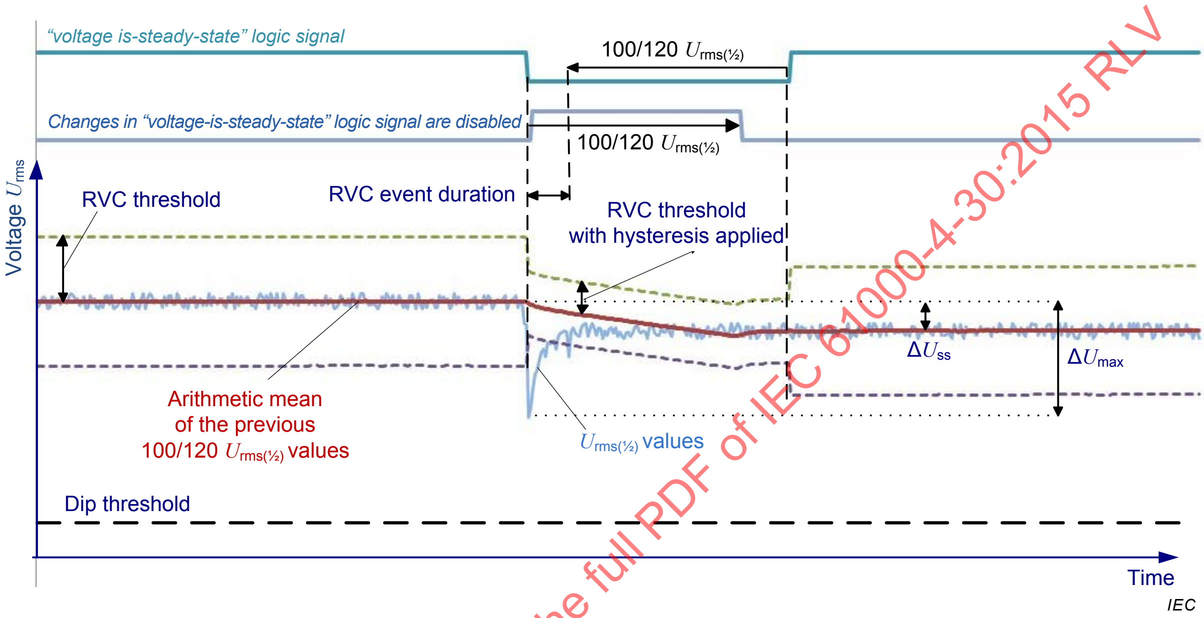


Figure 6 – RVC event: example of a change in r.m.s voltage that results in an RVC event

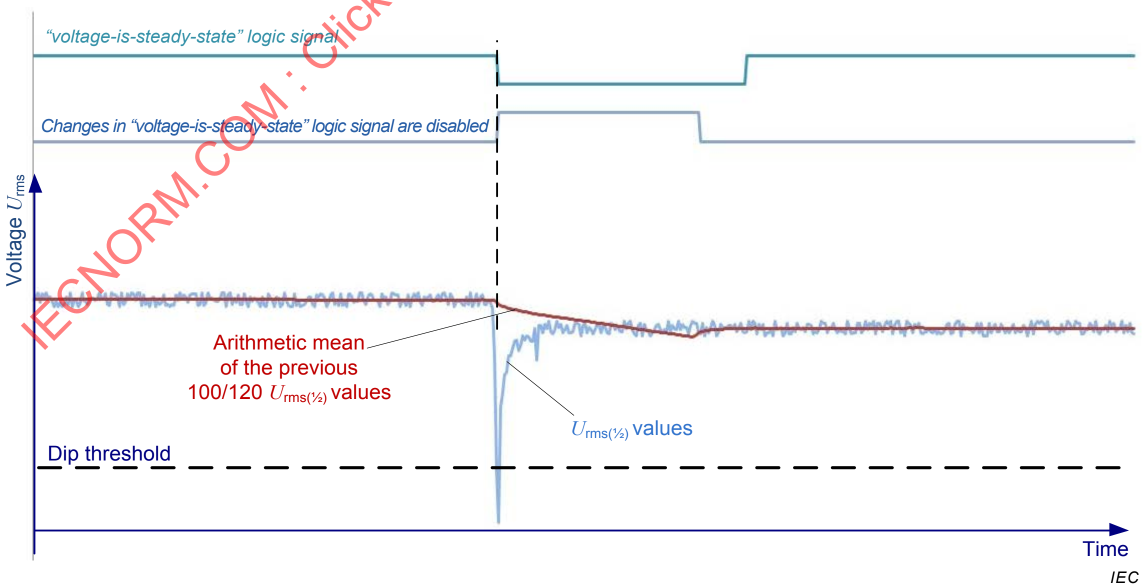


Figure 7 – Not an RVC event: example of a change in r.m.s voltage that does not result in an RVC event because the dip threshold is exceeded

5.11.4 Measurement uncertainty

The uncertainty of an RVC event characterization is determined by the uncertainty of U_{rms} measurements as described in 5.4.5.1, and on the correct implementation of the method in 5.11.1 and 5.11.2.

5.12 Measurement of underdeviation and overdeviation parameters

5.12.1 Measurement method

– **Class A**

The 10/12-cycle r.m.s. value $U_{rms-200ms}$ shall be used to assess the underdeviation and overdeviation parameters in per cent of U_{din}. The underdeviation $U_{rms-under}$ and overdeviation $U_{rms-over}$ parameters are determined by equations (4A), (4B), (5A), (5B), (6), and (7).

Underdeviation assessment:

the following rule (4) applies for the calculation of $U_{rms-under,i}$:

If $U_{rms-200ms,i} > U_{din}$ then $U_{rms-under,i} = U_{din}$ (4A)

If $U_{rms-200ms,i} \le U_{din}$ then $U_{rms-under,i} = U_{rms-200ms,i}$ (4B)

Overdeviation assessment:

the following rule (5) applies for the calculation of $U_{rms-over,i}$:

If $U_{rms-200ms,i} < U_{din}$ then $U_{rms-over,i} = U_{din}$ (5A)

If $U_{rms-200ms,i} \ge U_{din}$ then $U_{rms-over,i} = U_{rms-200ms,i}$ (5B)

NOTE On single-phase systems, there is a single underdeviation assessment and overdeviation assessment value for each interval. On 3-phase 3-wire systems, there are 3 values for each interval. Either 6 values or 3 values may be measured on 4-wire systems.

– **Class S**

Not required.

– **Class B**

Not required.

5.12.2 Measurement uncertainty and measuring range

The underlying 10/12-cycles r.m.s. values shall be consistent with the requirements of 5.2.2.

5.12.3 Aggregation

– **Class A**

Underdeviation assessment:

$$U_{under} = \frac{U_{din} - \sqrt{\dfrac{\sum_{i=1}^{n} U^2_{rms-under,i}}{n}}}{U_{din}} \quad [\%] \qquad (6)$$

where

n = number of 10/12-cycle r.m.s. values for under- or overdeviation during the aggregation interval

and $U_{rms-under,i}$ is the i[th] 10/12-cycle r.m.s. value.

Overdeviation assessment:

$$U_{over} = \frac{\sqrt{\frac{\sum_{i=1}^{n} U^2_{rms-over,i}}{n}} - U_{din}}{U_{din}} \quad [\%] \qquad (7)$$

where

$U_{rms-over,i}$ is the i[th] 10/12-cycle r.m.s. value.

NOTE Both underdeviation and overdeviation parameter equations (4) and (5) give positive values.

Aggregation shall be performed according to 4.4 and 4.5.

– **Class S**

Not required.

– **Class B**

Not required.

5.12 Underdeviation and overdeviation

See Annex D (informative).

5.13 Current

5.13.1 General

In a power quality context, current measurements are useful as a supplement to voltage measurements, especially when trying to determine the causes of events such as voltage magnitude change, dip, interruption, or unbalance.

The current waveform can further help associate the recorded event with a particular device and an action, such as a motor being started, a transformer being energized or a capacitor being switched.

Linked with voltage harmonics and interharmonics, the current harmonics and interharmonics can be useful to characterize the load connected to the network.

This standard does not define any trigger or threshold methods for current. If current changes, but the change is not sufficient to trigger one of the voltage threshold methods, then that change in current is not a power quality event.

NOTE Current transients are not considered in this standard. Some useful comments are provided in Annex A.

5.13.2 Magnitude of current

5.13.2.1 Measurement

The manufacturer shall specify a full-scale r.m.s. current, taking into account a minimum ratio between peak instantaneous value and r.m.s. value of 3,0.

NOTE This ratio is sometimes called “crest factor”.

– **Class A**

The basic measurement shall be the r.m.s. value of the current magnitude over a 10-cycle time interval for a 50 Hz power system or a 12-cycle time interval for a 60 Hz power system. The boundaries of any current measurement interval shall be determined by, and identical to, the boundaries of the interval for the corresponding voltage channel.

– **Class S**

The manufacturer shall specify the r.m.s. measurement method and time interval used.

NOTE More detailed requirements for Class S are under consideration.

5.13.2.2 Measurement uncertainty

– **Class A**

The measurement uncertainty shall not exceed ±1 % of reading in the range of 10 % to 100 % of the specified full-scale r.m.s. current.

NOTE This uncertainty requirement does not take into account uncertainties introduced by current sensors. Guidance on sensors can be found in in IEC 61557-12:2007, Annex C or Annex D.

– **Class S**

The measurement uncertainty shall not exceed ±2 % of reading in the range of 10 % to 100 % of the specified full-scale r.m.s. current.

5.13.2.3 Measurement evaluation

NOTE For single-phase systems, there is a single r.m.s. current value. For 3-phase 3-wire systems, there are typically three r.m.s. current values; for 3-phase 4-wire systems, there are typically four current values. The earth current may be measured as well, either by measuring current in an earth conductor or by determining residual current.

– **Class A**

Aggregation intervals as described in 4.4 and 4.5 shall be used.

For each current channel, the current aggregation intervals shall be determined by, and identical to, the aggregation intervals of the corresponding voltage channel.

– **Class S**

The manufacturer or the user shall specify the measurement intervals.

5.13.3 Current recording

– **Class A**

If current measurement methods are implemented, then whenever a voltage channel is recorded, the corresponding current channel shall also be recorded with timing determined by, and identical to, the corresponding voltage channel (for example, if $U_{\text{rms(1/2)}}$ is recorded, $I_{\text{rms(1/2)}}$ shall also be recorded, with all timing aspects of the current measurement determined by the timing of the corresponding voltage channel).

– **Class S**

The manufacturer or the user shall specify when the current will be recorded.

5.13.4 Harmonic currents

– **Class A**

The basic measurement method and accuracy of current harmonics, for the purpose of this standard, are defined in IEC 61000-4-7. Use that standard to determine a 10/12-cycle gapless harmonic sub-group measurement, denoted $Y_{\text{sg,h}}$

NOTE 1 IEC 61000-4-7 refers to replacing the symbol 'Y' by the symbol I for currents, by the symbol 'U' for voltages, so $I_{\text{sg,h}}$ may be the preferred terminology. However, when searching the 61000-4-7 document for information about these parameters, search for the symbol 'Y'. Aggregation intervals as described in 4.4 and 4.5 are used.

A 10/12-cycle current harmonic measurement is marked "flagged" if either a voltage dip or voltage swell (see 5.4) or a voltage interruption (see 5.5) occurs during this time interval.

NOTE 2 This measurement method generates a large amount of data, which, depending on the application, may need to be stored, transmitted, analysed, and/or archived. Depending on the application, the amount of data may be reduced. To reduce the amount of data, consider applying statistical methods at the measuring location, or storing only extreme and average values, or storing detailed data only when trigger thresholds are exceeded, or other methods.

– **Class S**

The manufacturer shall specify measurement and aggregation methods.

5.13.5 Interharmonic currents

– **Class A**

The basic measurement method and accuracy of current interharmonics, for the purpose of this standard, are defined in 61000-4-7. Use that standard to determine a 10/12-cycle gapless centred interharmonic sub-group measurements, denoted $Y_{isg,n}$.

Aggregation intervals as described in 4.4 and 4.5 shall be used.

A 10/12-cycle interharmonic current measurement is marked "flagged" if either a voltage dip or a voltage swell (see 5.4), or a voltage interruption (see 5.5) occurs during this time interval.

NOTE 1 This measurement method generates a large amount of data, which, depending on the application, may need to be stored, transmitted, analysed, and/or archived. Depending on the application, the amount of data may be reduced. To reduce the amount of data, consider applying statistical methods at the measuring location, or storing only extreme and average values, or storing detailed data only when trigger thresholds are exceeded, or other methods.

NOTE 2 IEC 61000-4-7 refers to replacing the symbol 'Y' by the symbol I for currents, by the symbol 'U' for voltages, so $I_{sg,h}$ may be the preferred terminology. However, when searching the 61000-4-7 document for information about these parameters, search for the symbol 'Y'.

– **Class S**

The manufacturer shall specify measurement and aggregation methods.

5.13.6 Current unbalance

– **Class A**

The basic measurement method for current unbalance shall be identical to the measurement method for supply voltage unbalance in 5.7.

Aggregation intervals as described in 4.4 and 4.5 shall be used. A 10/12-cycle current unbalance measurement is marked "flagged" if either a voltage dip or a voltage swell (see 5.4), or a voltage interruption (see 5.5) occurs during this time interval.

– **Class S**

The manufacturer shall specify measurement and aggregation methods.

6 ~~Range of influence quantities and steady-state verification~~ Performance verification

~~6.1 Range of influence quantities~~

~~The measurement of a specific characteristic can be adversely affected by the application of a disturbing influence (influence quantity) on the electrical input signal. For example, the measurement of supply voltage unbalance might be adversely affected if the voltage waveform is at the same time subject to a harmonic disturbance.~~

~~The result of a parameter measurement shall be within the specified measurement uncertainty given in Clause 5 when all other parameters are within their influence quantity range, given in the Table 1.~~

Table 1 – Influence quantity range

Section and parameter	Class	Influence quantity range
5.1 Frequency	A	42,5 Hz ~ 57,5 Hz, 51 Hz ~ 69 Hz
	S	42,5 Hz ~ 57,5 Hz, 51 Hz ~ 69 Hz
	B	42,5 Hz ~ 57,5 Hz, 51 Hz ~ 69 Hz
5.2 Magnitude of the supply	A	10 % ~ 200 % U_{din}
	S	10 % ~ 150 % U_{din}
	B	10 % ~ 150 % U_{din}
5.3 Flicker	A	0 ~ 20 P_{st}
	S	0 ~ 10 P_{st}
	B	N/A
5.4 Dips and swells	A	N/A
	S	N/A
	B	N/A
5.5 Interruptions	A	N/A
	S	N/A
	B	N/A
5.7 Unbalance	A	0 % ~ 5 % u_2, 0 % ~ 5 % u_0
	S	0 % ~ 5 % u_2
	B	SBM
5.8 Voltage harmonics	A	200 % of class 3 of IEC 61000-2-4
	S	200 % of class 3 of IEC 61000-2-4
	B	200 % of class 3 of IEC 61000-2-4
5.9 Voltage Interharmonics	A	200 % of class 3 of IEC 61000-2-4
	S	200 % of class 3 of IEC 61000-2-4
	B	200 % of class 3 of IEC 61000-2-4
5.10 Mains signalling voltage	A	0 % ~ 15 % U_{din}
	S	0 % ~ 15 % U_{din}
	B	0 % ~ 15 % U_{din}
5.12 Under/overdeviation	A	N/A
	S	N/A
	B	N/A
Transient voltages IEC 61180	A	6 kV peak
	S	N/R
	B	N/R
Fast transients IEC 61000-4-4	A	4 kV peak
	S	N/R
	B	N/R
SBM = Specified by manufacturer N/R = no requirement N/A = not applicable		
NOTE For safety requirements, EMC requirements or climatic requirements, see product standards, for instance IEC 61557-12.		

The instrument shall tolerate signals in the influence quantity range without shifting the measurement of other parameters out of their uncertainty requirement, and without instrument damage. The instrument may indicate overrange for signals greater than the measuring range, up to the influence quantity range (not including transients and fast transients).

For transient voltages and fast transients, there shall be no effect on any measurement after the transient. The transients are applied to the measuring terminals, not to the instrument power terminals.

6.2 Steady-state performance verification

The tests below confirm that steady-state signals are measured within their specified uncertainties, with influence quantities applied.

These tests are necessary but not sufficient to verify that an implementation meets the requirements of this standard. To fully verify that the measuring methods of Clause 5 have been implemented correctly, additional tests and/or validation may be necessary.

NOTE 1 See Annex C for guidance.

– **Class A**

To confirm that the steady-state performance of an instrument is correct, the tests below are applied.

NOTE 2 These tests are required as type tests, not as routine tests.

The uncertainty of an instrument shall be tested for each measured quantity as follows (see Table 2):

– select a measured quantity (for example, r.m.s. voltage magnitude);

– holding all other quantities in testing state 1, verify the uncertainty of the measured quantity to be tested at 5 approximately equally spaced points throughout the measurement range including the upper and lower limit (for example, 10 % of U_{din}, 45 % of U_{din}, 80 % of U_{din}, 115 % of U_{din}, 150 % of U_{din} for class A);

– holding all other quantities in testing state 2, repeat the test;

– holding all other quantities in testing state 3, repeat the test.

Other testing states may be used in addition to the testing states specified in Table 2. In this case, the values chosen for each influence quantity shall be within the range of variations for that influence quantity.

NOTE 3 In interpreting this subclause, it is intended that 15 series of testing states will be selected for each measured parameter. For parameters that have multiple sub-parameters (for example, voltage harmonics have fifty individual harmonics), select one representative sub-parameter.

NOTE 4 Some influence quantities should not influence the value of the measured parameter (for example, harmonics should not influence the value of unbalance). Other influence quantities should influence the value of the measured parameter (for example, harmonics should influence the value of r.m.s.). The uncertainty requirements should be met in both cases.

Table 2 – Uncertainty steady-state verification for class A and class S

Influence quantities	Testing state 1	Testing state 2	Testing state 3
Frequency	f_{nom} ± 0,5 Hz	f_{nom} – 1 Hz ± 0,5 Hz	f_{nom} + 1 Hz ± 0,5 Hz
Voltage magnitude	U_{din} ± 1 %	Determined by flicker, unbalance, harmonics, interharmonics (below)	Determined by flicker, unbalance, harmonics, interharmonics (below)
Flicker	P_{st} < 0,1	P_{st} = 1 ± 0,1 – rectangular modulation at 39 changes per minute	P_{st} = 4 ± 0,1 – rectangular modulation at 110 changes per minute
Unbalance	100% ±0,5 % of U_{din} on all channels. All phase angles 120° (equivalent to u_0 = 0 %, u_2 = 0 %)	73 % ±0,5 % of U_{din} Channel 1 80 % ±0,5 % of U_{din} Channel 2 87 % ±0,5 % of U_{din} Channel 3 all phase angles 120° (equivalent to u_0 = 5,05 %, u_2 = 5,05 %)	152 % ±0,5 % of U_{din} Channel 1 140 % ±0,5 % of U_{din} Channel 2 128 % ±0,5 % of U_{din} Channel 3 all phase angles 120° (equivalent to u_0 = 4,95 %, u_2 = 4,95 %)
Harmonics	0 % to 3 % of U_{din}	10 % ± 3 % of U_{din} 3rd at 0° 5 % ± 3 % of U_{din} 5th at 0° 5 % ± 3 % of U_{din} 29th at 0°	10 % ± 3 % of U_{din} 7th at 180° 5 % ± 3 % of U_{din} 13th at 0° 5 % ± 3 % of U_{din} 25th at 0°
Interharmonics	0 % to 0,5 % of U_{din}	1 % ± 0,5 % of U_{din} at 7,5 f_{nom}	1 % ± 0,5 % of U_{din} at 3,5 f_{nom}

When verifying magnitude of supply voltage performance, replace U_{din} in Table 2 with the magnitude of supply voltage value that has been selected for the test.

– **Class S**

Same as class A.

– **Class B**

No steady-state uncertainty testing requirements are specified.

Performance verification for Class A and Class S measurement methods may be found in IEC 62586-2, which includes influence quantities and performance verification tests.

Table 1 provides an informative summary of the requirements for Class A and Class S. In case of any conflict between Table 1 and the normative clauses of this document, the normative clauses prevail.

Note that compliance with the requirements in Table 1 is not sufficient for certification to this standard. The measurement and aggregation methods in this standard shall also be met.

Table 1 – Summary of requirements (see subclauses for actual requirements)

Subclause and parameter	Class	Measurement method	Uncertainty	Measuring range[a]	Influence quantity range[b]	Aggregation method
5.1 Frequency	A	See 5.1.1	±10 mHz	42,5 Hz to 57,5 Hz, 51 Hz to 69 Hz	IEC 62586-2	N/R
	S	See 5.1.1	±50 mHz	42,5 Hz to 57,5 Hz, 51 Hz to 69 Hz	IEC 62586-2	N/R
5.2 Magnitude of the supply	A	See 5.2.1	±0,1 % U_{din}	10 %to150 % U_{din}	IEC 62586-2	See 4.4 and 4.5
	S	See 5.2.1	±0,5 % of U_{din}	20 %to120 % U_{din}	IEC 62586-2	See 4.4 and 4.5
5.3 Flicker	A	IEC61000-4-15	IEC 61000-4-15	0,2 P_{st} to 10,0 P_{st}	IEC 62586-2	IEC 61000-4-15
	S	IEC61000-4-15	See 5.3.2	0,4 P_{st} to 4,0 P_{st}	IEC 62586-2	IEC 61000-4-15
5.4 Dips and swells	A	$U_{rms(1/2)}$	Amplitude ±0,2 % U_{din} Duration ± 1 cycle	N/A	N/A	N/R
	S	See 5.4.1	Amplitude ±1 % of U_{din} Duration ± 1 cycle or ± 2 cycles	N/A	N/A	N/R
5.5 Interruptions	A	$U_{rms(1/2)}$	Duration ± 1 cycle	N/A	N/A	N/R
	S	see 5.5.1	Duration ± 1 cycle or ± 2 cycles	N/A	N/A	N/R
5.7 Unbalance	A	Symmetrical components: U_2 and U_0	±0,15 %	0,5 % to 5 % u_2 0,5 % to 5 % u_0	IEC 62586-2	See 4.4 and 4.5
	S	Symmetrical components: U_2, and optionally U_0	±0,3 %	1 % to 5 % u_2 1 %to 5 % u_0 if implemented	IEC 62586-2	See 4.4 and 4.5
5.8 Voltage harmonics	A	See 5.8.1	IEC61000-4-7 Class I	10 % to 200 % of Class 3 of IEC 61000-2-4	IEC 62586-2	See 4.4 and 4.5
	S	See 5.8.1	200 % of IEC 61000-4-7 Class II	10 % to 100 % of Class 3 of IEC 61000-2-4	IEC 62586-2	See 4.4 and 4.5
5.9 Voltage inter-harmonics	A	See 5.9.1	IEC61000-4-7 Class I	10 % to 200 % of Class 3 of IEC 61000-2-4	IEC 62586-2	See 4.4 and 4.5
	S	SBM	SBM	SBM	IEC 62586-2	See 4.4 and 4.5
5.10 Mains signalling voltage	A	See 5.10.2	See 5.10.3	0 % to 15 % U_{din}	IEC 62586-2	N/R
	S	SBM	SBM	SBM	IEC 62586-2	N/R
5.11 Rapid voltage change	A	See 5.11.2	See 5.11.3	See 5.11.3	N/A	N/R
	S	See 5.11.2	See 5.11.3	See 5.11.3	N/A	N/R

Subclause and parameter	Class	Measurement method	Uncertainty	Measuring range[a]	Influence quantity range[b]	Aggregation method
5.13 Current	A	See 5.13.2. Crest factor of 3 is required	±1 %	10 % FS to 150 % FS	N/A	N/R
	S	N/R	N/R	N/R	N/A	N/R
Annex C 2 kHz to 150 kHz	A	See Annex C	±1 V	±50 V pk	N/A	See Annex C
	S	N/R	N/R	N/R	N/A	N/R
Transient voltages IEC 61180	A	N/R	N/R	N/R	6 kV pk [c]	N/A
	S	N/R	N/R	N/R	N/R	N/A
Fast transients IEC61000-4-4	A	N/R	N/R	N/R	4 kV pk [c]	N/A
	S	N/R	N/R	N/R	N/R	N/A

SBM = Specified by manufacturer

N/R = no requirement

N/A = not applicable

[a] The instrument shall meet the uncertainty requirements for signals within the measuring range.

[b] The instrument shall tolerate signals in the influence quantity range without shifting the measurement of other parameters out of their uncertainty requirement, and without instrument damage. The instrument may indicate overrange for signals greater than the measuring range, up to the influence quantity range (not including transients and fast transients).

[c] For transient voltages and fast transients, there shall be no effect on any measurement after the transient. The transients are applied to the measuring terminals, not to the instrument power terminals.

Annex A
(informative)

Power quality measurements – Issues and guidelines

A.1 General

Annex A is provided as an informative complement to the normative part of this standard.

Clauses A.2 and A.3 address general concerns and procedures for implementation of power quality measurements regardless of the purpose of the measurements:

– Clause A.2 – Installation precautions

– Clause A.3 – Transducers

Clauses A.4 and A.5 are pre-normative measurement methods:

– Clause A.4 – Transient voltages and currents

– A.5 – Rapid voltage changes

– A.6 – Current

– Clause A.5 – Voltage dip characteristics

A.2 Installation precautions

A.2.1 Installation General

During installation of power quality (PQ) measurement instruments, the safety of the installer and others, the integrity of the system being monitored and the integrity of the instrument itself shall have to be ensured.

While many installations are temporary in nature and consequently may not utilize the same practices as for permanent installations, local codes shall should never be compromised. Local codes, regulations and safety practices will cover most of the items below and will always take precedence over the precautions listed here. All local and national safety requirements shall be followed (for example, personal protective equipment requirements).

A.2.2 Test leads

A.2.2.1 Test lead connections General

For safety, IEC 61010, which gives the safety requirements for electrical equipment for measurement, control and laboratory use, applies.

Test lead connections made in load centre panel boards or junction boxes will be attached in a manner that does not violate the listed use of the devices to which they are attached. This generally includes returning doors, cover plates and access panels to their in-use position (i.e., closed, mounted with a full set of screws, etc.). If panels remain open during monitoring, adequate means will be provided to limit access to the area and inform others about the monitoring set-up and the responsible on-site contact.

It is for most cases recommended that the PQ measurement instrument be attached to a point in the system specifically designed for measurements or metering.

Test leads will be routed away from exposed conductors, sharp objects, low- and high-frequency electromagnetic fields, and other adverse environments. If possible, they will be strapped or tied to a solid object to prevent inadvertent disconnection.

A.2.2.2 Voltage test leads

Leads that are fused at the probe end, i.e. the end connected to the system being monitored, increase the safety of the connection. The instrument manufacturer ~~shall~~ has to specify the fuse size; this will be low enough to protect the test lead against overload conditions. Furthermore, the interrupting capacity of the fuse will be consistent with the available power-frequency fault current at the point of connection.

Voltage sense leads ~~shall~~ should not be casually twisted around existing wires or inserted in circuit- breaker connectors that are designed to receive a single conductor. Instead, a properly rated and installed mechanical connection should be used. Where clips are used for temporary installations, they ~~shall~~ should comply with IEC 61010. It is essential to ensure both that the clip is rated for the maximum voltage that may be present and that it is installed in a mechanically secure manner. During installation, the installer will consider what will happen if the clip is inadvertently dislodged, for example, by an abrupt tug on the cable.

Some test leads have insulated plugs capable of being stacked one on top of the other. Caution should be exercised so that when stacking, only intentional connections are made rather than creating an inadvertent short circuit. Always double-check the leads to ensure that short circuits have not been introduced. Also, connect the sense leads to the monitored circuit only after the leads have been connected to the PQ instrument and checked for correctness.

A.2.2.3 Current test leads

Care should be taken that the secondaries of current transformers, if used, do not become open circuit, i.e. there ~~shall~~ should be no fuse in the secondaries of such circuits, and the connection to the burden ~~shall~~ should be mechanically secure.

Clamp-on current transducers and associated leads, used for temporary installations, ~~shall~~ should be designed according to IEC 61010-2-032.

A.2.3 Guarding of live parts

Often panel covers are removed for installation, or during the monitoring period. If so, all live parts will be adequately protected and the area will be kept inaccessible. If screw terminals are used in the measurement instrument, appropriate covers will be used to insulate the terminations. All attachments to terminations will be made in accordance with the specifications and intent of the terminations. For example, multiple wires ~~shall~~ should not be connected to a screw terminal designed for a single wire.

A.2.4 Monitor placement

The PQ measurement instrument needs to be placed securely to minimize the risk of the instrument moving or loosening connections. If a paper printer is used for reporting disturbances, adequate precautions should be taken to ensure that accumulating paper does not present a hazard. Measurement instruments will not be left where excessive heat, moisture or dust may damage the instrument, or jeopardize the data collection process.

The measurement instrument will be placed so that it does not pose a hazard to those working in the area. A protective enclosure or barrier can sometimes be used to alleviate this concern. If possible, the measurement instrument will not be placed in a location where it will be exposed to many people, for example, in a heavily travelled hallway.

Also, the location should not pose an undue hazard to the person installing the PQ measurement instrument. There are many locations that are too cramped, or in other ways physically constrained, to allow suitable connection of instrument leads. In these situations, an alternative location will be selected.

A number of external environmental factors can affect the performance of a PQ measurement instrument. These environmental factors include temperature, humidity, low- and high-frequency electromagnetic fields, static discharge, mechanical shock and vibration.

A.2.5 Earthing

All instruments are capable of developing internal faults. The instruments' power supply will be properly connected to a protective earth if declared necessary by the manufacturer. Many safety regulations also require an earth connection associated with the voltage test leads. Instruments with two or more earth connections (for example, one earth connection for the power supply, and another for the test leads) can create ground loops if the earth connections are made to different physical points outside the instrument. The risk from ground loops on the measurements and on the system being measured will need to be carefully considered.

There is also a need to consider the potential hazard to personnel and the instrument due to high potentials between different points in the grounding system. The use of isolating transformers for the power supply of the instrument is in most cases useful.

In all cases, safety considerations will take the highest priority.

A.2.6 Interference

If the PQ measurement instrument is connected to a mobile phone or other radio transmitter, one should take care that the transmitter antenna is sufficiently far away from devices that could be sensitive to interference. Such sensitive devices can include protection devices, medical monitors, scientific instruments, etc.

A.3 Transducers

A.3.1 General

Power quality measurement instruments, especially those in portable packages, are generally provided with inputs designed for low-voltage applications. Some permanently installed PQ measurement instruments are mounted at a distance from the point of the circuit where the parameters are to be measured. In both cases, a suitable transducer might be needed, to step down the voltage, to isolate the input circuits from the system voltage, or to transmit the signals over some distance. To accomplish any of these functions, a transducer may be used, provided that its characteristics are suitable for the parameter of interest.

In low voltage systems, PQ measurement instruments are generally connected directly to the voltage point of interest, but transducers are often used for current measurements.

In medium and high voltage systems, transducers are used for both voltage and current PQ measurements.

There are two important concerns when using transducers:

– signal levels: signals levels should use the full scale of the instrument without distorting or clipping the desired signal;
– frequency and phase response: these characteristics are particularly important for transient and harmonic measurements.

In order to avoid incorrect measurements the full-scale rating, linearity, frequency and phase response, and burden characteristics of the transducer should be carefully considered.

NOTE Current transducers designed for protection purposes may be less accurate than metering transducers.

A.3.2 Signal levels

A.3.2.1 Voltage transducers

The most common voltage transducer is the voltage transformer. Two types of voltage transformers can be considered: those used by protective relay circuits, and those used by metering circuits. The first type is sized so as to provide a correct response even in the case of overvoltages due to an unbalanced short circuit. The second, in contrast, is designed to protect meters from network overvoltages. In the latter category, in case of saturation, distortion of the delivered signal will occur.

Where monitoring is attached to a voltage transformer which is also used for other functions (for example, metering), one ~~shall~~ should be careful that the additional burden does not affect the calibration or uncertainty of such other functions.

One should be careful when making connections to the secondary circuit of a transformer used for a protective relay. Connection errors might cause the relay to inadvertently trip.

NOTE For further details of the uncertainty of voltage transformers, see IEC 60044-2.

A.3.2.2 Current transducers

Guidance about effects of current transducers may be found in IEC 61869.

In the operation on the power system network, the value of the current can range from 0 to the short-circuit level of the network being monitored. The short-circuit current value can be well above the nominal current level. A value of 20 times nominal is not unusual.

The most common type of current transducer is the current transformer.

Some current transformers are equipped with two or more cores and/or two secondary windings: one for large current flows (20 times to 30 times the nominal current), typically for protection relays, and a second for nominal current flows. The correct secondary should be selected for the intended measurement. With direct connections, it is possible to damage the measuring instrument during faults if the wrong secondary has been selected; this damage can inadvertently provide an open circuit on the transformer secondary. Open circuits on the secondary winding of current transformers can give rise to dangerously high (and destructive) voltages.

~~Other considerations may affect the uncertainty of clamp-on current transducers, such as the centring and angle of the conductor as it passes through the window of the transducer.~~

Where practical the user should take measures to ensure that the conductor is centralised through the window of the current transducer and that the conductor is orthogonal to the window. The proximity of adjacent conductors should also be considered and the distance maximized if possible.

NOTE For further details of the uncertainty of current transformers, see ~~IEC 60044-1~~ IEC 61869-1 and IEC 61869-2.

Measurements of transients can be performed with shunts or current transformers designed for high-frequency response.

Coaxial shunts are routinely used in laboratory environments but have the disadvantage of requiring insertion into the current-carrying conductors, and the fact that the output signal of the shunt is not isolated from the power circuit. On the other hand, they are not susceptible to the saturation and residual magnetization that can affect measurements made with current transformers.

Current transformers operating with a suitable resistive burden deliver a voltage signal proportional to the primary current. In general, the primary consists of one or a few turns of the primary circuit fed through an opening in the core. The major advantage of these current transducers is to provide isolation from the power circuits, and a wide range of ampere-to-volt ratios. Another advantage is that some (but not all) current transformers do not require the disconnection of the power conductor from its load during installation.

Other types of current transducers are sometimes used, including optical polarization detectors and Hall-effect transducers.

A.3.3 Frequency response of transducers

A.3.3.1 Frequency and phase response of voltage transducers

In general, transformer-type electromagnetic voltage transducers have frequency and transient responses suitable up to typically 1 kHz; but the frequency range may sometimes be limited to well below 1 kHz, and sometimes may extend to a few kHz.

Simple capacitor dividers can have frequency and phase responses that are suitable up to hundreds of kHz or even higher; however, in many applications a resonant circuit is intentionally added, making the frequency response of the capacitive divider unsuitable for measurements at any frequency other than the fundamental.

Resistive voltage dividers may have frequency and phase response suitable up to hundreds of kHz. However, they may introduce other problems, for example, the capacitive load of the measurement instrument can influence the frequency and phase response of the resistive voltage dividers.

A.3.3.2 Frequency and phase response of current transducers

As current transformers are wound electromagnetic devices, the frequency response varies according to the uncertainty class, type (manufacturer), turns ratio, core material and cross-section, and the secondary circuit load.

Usually, the cut-off frequency of a current transducer ranges from 1 kHz to a few kHz, and the phase response degrades as the cut-off frequency is approached.

~~NOTE~~ New concepts of current transducers with higher cut-off frequency and better linearity are being developed (optical and Hall-effect transducers). Insulation coordination, noise issues, full-scale capability, and safety conditions should be carefully considered.

A.3.4 Transducers for measuring transients

There are two important concerns that ~~shall~~ should be addressed when selecting transducers for a.c. mains transients. First, signal levels should use the full scale of the instrument without distorting or clipping the desired signal. Second, the frequency response (both amplitude and phase) of the transducer should be adequate for the expected signal.

a) Voltage transducers (VTs)

   1) VTs should be sized to prevent measured disturbances from inducing saturation. For low-frequency transients, this requires that the knee point of the transducer saturation curve be at least 200 % of the nominal system voltage.

   2) The frequency response of a standard metering class VT depends on its type and the burden applied. With a high impedance burden, the response is usually adequate to at least 2 kHz, but it can be less.

3) Capacitively coupled voltage transformers generally do not provide accurate representation of any higher frequency components.

4) High-frequency transient measurements require a capacitor divider or pure resistive divider. Special purpose capacitor dividers can be obtained for measurements requiring accurate characterization of transients up to at least 1 MHz.

b) Current transducers (CTs)

1) Selecting the proper transducer for currents is more difficult. The current in a distribution feeder changes more often and with greater magnitude than the voltage.

2) Standard metering-class CTs are generally adequate for frequencies up to 2 kHz (phase error can start to become significant before this limit). For higher frequencies, window type CTs with a high turns ratio (doughnut, split core, bar type, and clamp-on) should be used.

3) Additional desirable attributes for CTs are: a large turns ratio, for example, 2 000:5; less than 5 turns in the primary; small remnant flux, for example, 10 % of core saturation; large core area; minimal secondary winding resistance and leakage impedance. When using a CT to measure transients there are 2 key parameters that need to be considered, current-time product ($I \cdot t$ max) and rise time/droop. Typical values of the rise time (10 % to 90 %) are in the range of 2 ns to 200 ns. Typical droop values range from 0,1 %/µs to 0,5 %/ms.

~~NOTE~~ In HV systems high-frequency and transient voltage measurements may sometimes be performed using capacitive taps often available on CTs and transformer bushings.

A.4 Transient voltages and currents

A.4.1 General

Clause A.4 is primarily focused on transients occurring in LV systems and does not cover transients from GIS[1] installations or HV systems.

Transients can occur on all a.c. power systems. Traditionally, they have been characterized as "transient voltages"; however, in many cases, the transient current may be more important. The detection, classification, and characterization of transient voltages are challenging subjects.

A.4.2 Terms and definitions

A.4.2.1
transient, adjective and noun
pertaining to or designating a phenomenon or a quantity which varies between two consecutive steady states during a time interval short when compared with the time-scale of interest

[SOURCE: IEC 60050-161:1990, 161-02-01]

A.4.2.2
surge
transient voltage wave propagating along a line or a circuit and characterized by a rapid increase followed by a slower decrease of the voltage

[SOURCE: IEC 60050-161:1990, 161-08-11]

A.4.3 Frequency and amplitude characteristics of a.c. mains transients

Transients in a.c. power circuits occur over a wide range of waveforms, amplitudes, and duration. It is difficult to describe these by a simple set of parameters, but obtaining their

1 Gas-insulated switchgear.

signatures allows them to be classified into a few typical waveforms that are used for test purposes. Figure A.1 shows the frequency spectrum of several representative test waveforms in general use. This information is useful in developing algorithms that will be necessary for appropriate reduction of the analogue signals into the digital recordings and data processing of these events.

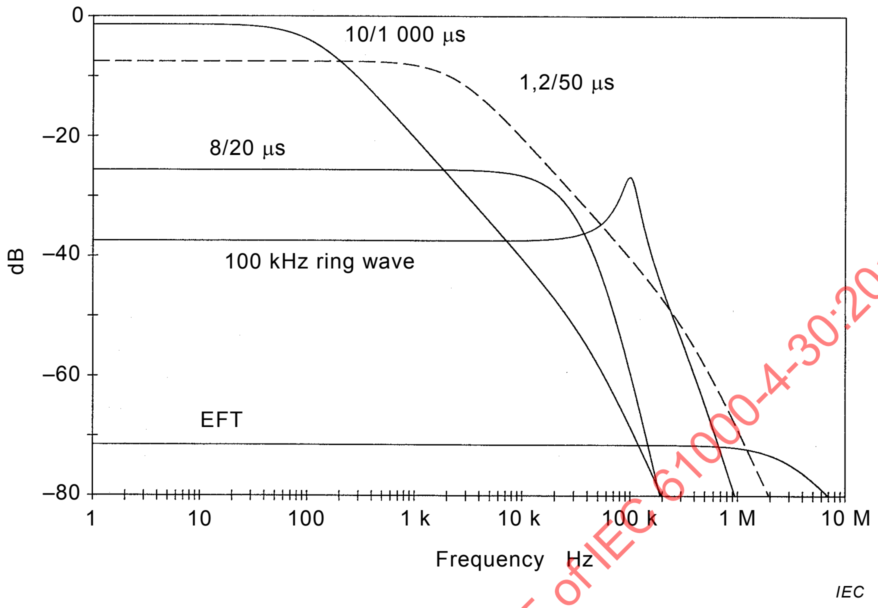


Figure A.1 – Frequency spectrum of typical representative transient test waveforms

For both voltage and current, the spectra of common test waveforms for a.c. mains transients contain frequencies that range up to approximately 10 MHz (lasting for 200 µs), with large amplitudes up to 1 MHz (lasting for 2 ms). For end-use a.c. mains connections, the amplitudes of common test waveforms range up to 6 kV, and up to 5 kA.

The sampling rate ~~shall~~ should therefore be at least twice the maximum frequency of the waveform; also, the corresponding anti-alias filter ~~shall~~ should have appropriate characteristics. See also ~~A.2.4~~ A.3.4 for further information related to transient measurement.

A.4.4 Transient voltage detection

The results of a transient measurement depend both on the actual nature of the transient, and on the parameters selected by the user and reported by the instrument. When insulation is the main concern, transient measurements are generally made from phase-to-earth. When instrument damage is the primary concern, transient measurements are generally made from phase-to-phase or from phase-to-neutral.

Some of the detection methods and examples of application include

– the comparative method: when a fixed, absolute threshold is exceeded, a transient is detected, for example, surge protective devices (SPDs) that are sensitive to the total voltage;

– the envelope method: similar to the comparative method, but with the fundamental removed prior to analysis, for example, in cases of capacitive coupled transients;

– the sliding-window method: the instantaneous values are compared to the corresponding values on the previous cycle, for example, low-frequency switching transients associated with capacitive banks used for power factor correction;

– the dv/dt method: when a fixed, absolute threshold of dv/dt is exceeded, for example, mistrigger of power electronics circuits or non-linear distribution on inductor winding;

- the r.m.s. value: using very rapid sampling, the r.m.s. value is computed for intervals much less than one fundamental period, and compared to a threshold, for example, when further computations are desirable such as energy deposition in an SPD or charge transfer;
- other methods such as frequency versus amplitude measurements (Discrete or Fast Fourier Transform, wavelet, etc.).

A.4.5 Transient voltage evaluation

Once the transient has been detected using the methods above, it can be classified. Some classification methods and parameters include

- the peak voltage and/or current. Note that the peak value is also influenced by the measurement interval;
- the overshoot voltage;
- the rate of rise (dv/dt or di/dt) of the leading edge;
- frequency parameters;
- the duration. This is a difficult parameter to define, due to damping, irregularity of wave-forms, etc.;
- the damping coefficient;
- the frequency of occurrence;
- the energy and power, available or conveyed;
- the continuous (every cycle, such as notches) or single-shot (unpredictable) transients.

All of these numerical parameters are helpful in developing a classification system to describe the transient environment in statistical terms.

On the other hand, especially when trouble-shooting, a signature can describe in one graphic representation several of these hard-to-quantify parameters.

A.4.6 Effect of surge protective devices on transient measurements

Surge protective devices (SPDs) are shunt-connected components that conduct when a threshold voltage is exceeded. They are commonly used to limit transient voltages. They may be found in plug-in mains filtering devices, and are often included as part of a sensitive electronic device, such as a personal computer.

Because all SPDs on a mains circuit are effectively connected in parallel, the one with the lowest limiting voltage will (within its performance capabilities) limit all transient voltages to its limiting voltage and divert the largest portion of the transient current impinging on the facility. Consequently, measuring transient voltages in many environments – offices, labs, factories, etc. – is of limited use: one is simply measuring the threshold voltage of one of the many SPDs that are present.

For this reason, the transient current is often a better measure of the severity of a.c. system transients than the transient voltage.

~~A.5 Rapid Voltage Changes (RVC)~~

~~A rapid voltage change is a quick transition in r.m.s. voltage between two steady-state conditions.~~

~~To measure rapid voltage changes, thresholds may be defined for each of the following: the minimum rate of change, the minimum duration of the steady-state conditions, the minimum difference in voltage between the two steady state conditions, the maximum voltage change~~

during the transition period (voltage change characteristic) and the steadiness of the steady-state conditions.

The voltage during a rapid voltage change shall not exceed the voltage dip and/or the voltage swell threshold, as it would otherwise be considered as a voltage dip or swell.

The characteristic parameter of the rapid voltage change is the difference between the steady-state value reached after the change and the initial steady-state value.

A.6 Current

A.6.1 General

In a power quality context, current measurements are useful as a supplement to voltage measurements, especially when trying to determine the causes of events such as voltage magnitude change, dip, interruption, or unbalance.

The current waveform can further help associate the recorded event with a particular device and an action, such as a motor being started, a transformer being energized or a capacitor being switched.

Linked with voltage harmonics and interharmonics, the current harmonics and interharmonics can be useful to characterize the load connected to the network.

Note that this annex does not consider the measurement transducers.

A.6.2 Term and definitions

$I_{\text{half cycle rms}}$
value of the r.m.s. current measured over each half-period

A.6.3 Magnitude of current

A.6.3.1 Measurement

The manufacturer or the user should specify a full-scale r.m.s. current, including a maximum crest-factor value.

NOTE Harmonics, interharmonics and ripple control signals are included in the evaluation.

– **Class A**

  The measurement should be the r.m.s. value (defined in) of the current magnitude over a 10-cycle time interval for a 50 Hz power system or 12-cycle time interval for a 60 Hz power system. Each 10/12-cycle interval should be contiguous and non-overlapping.

– **Class S**

  The manufacturer should specify the measurement time interval used.

– **Class B**

  Same as class S.

A.6.3.2 Measurement uncertainty

– **Class A**

  Over the specified influence quantity conditions described in 6.1, the measurement uncertainty ΔI should not exceed ±0,1 % of full scale.

– **Class S**

The manufacturer should specify the uncertainty Δ*I* over the specified influence quantity conditions described in 6.1. In all cases, the measurement uncertainty should not exceed ±1,0 % of full scale.

– **Class B**

The manufacturer should specify the uncertainty Δ*I* over the specified influence quantity conditions described in 6.1. In all cases, the measurement uncertainty should not exceed ±2,0 % of full scale.

A.6.3.3 Measurement evaluation

For single-phase systems, there is a single r.m.s. current value. For 3-phase 3-wire systems, there are typically 3 r.m.s. current values; for 3-phase 4-wire systems, there are typically 4 current values. It is optional to measure the current in the earth conductor as well.

– **Class A**

Aggregation intervals as described in 4.4 and 4.5 should be used, but additional aggregation techniques might be used for smoothing, for example with a digital filter as specified in IEC 61000-4-7.

If any of the 10/12-cycle r.m.s. values are greater than the full-scale current specified, the 10/12-cycle r.m.s. current value for that interval should be "flagged".

– **Class S**

The manufacturer and/or the user should specify the measurement intervals.

– **Class B**

Same as class S.

A.6.4 Inrush current

A.6.4.1 Measurement

– **Class A**

The inrush current begins when the $I_{half\ cycle\ rms}$ current rises above the inrush threshold, and ends when the $I_{half\ cycle\ rms}$ current is equal to or below the inrush threshold minus a user-selected hysteresis value.

The measurement should be the $I_{half\ cycle\ rms}$ values. Each half-cycle interval should be contiguous and non-overlapping.

NOTE 1 The inrush threshold is set by the user. Typically, the inrush threshold is greater than 120 % of the nominal current.

NOTE 2 For a full understanding of the inrush phenomena it is recommended that the user obtain a signature of all currents and voltages relating to the inrush current (see B.7.2).

– **Class S**

The measurement should be the r.m.s. value of the current over a short time interval specified by the manufacturer.

– **Class B**

Same as class S.

A.6.4.2 Measurement evaluation

– **Class A**

The inrush current can be further characterized by:

- the time duration between the beginning and the end of the inrush current;
- the maximum value of inrush current measured $I_{half\ cycle\ rms}$ value;
- the square root of the mean of the squared $I_{half\ cycle\ rms}$ values measured during the inrush duration.

– **Class S**

No requirement.

– **Class B**

Same as class S.

A.6.4.3 Measurement uncertainty

– **Class A**

Over the range of influence quantities described in 6.1. the measurement uncertainty should not exceed ±0,5 % of reading. The uncertainty of the duration measured is 1 half-cycle.

– **Class S**

The manufacturer should specify:

– the uncertainty over the specified influence quantities conditions described in 6.1,

– the range of current.

– **Class B**

Same as class S.

In all cases, the measurement uncertainty should not exceed ±5,0 % of reading.

A.6.5 Harmonic currents

– **Class A**

The basic measurement of current harmonics, for the purpose of this standard, is defined in IEC 61000-4-7. Use that standard to determine a 10/12-cycle gapless harmonic sub-group measurement, denoted $I_{sg,h}$.

Aggregation intervals as described in 4.4 and 4.5 should be used.

A 10/12-cycle current harmonic measurement is marked "flagged" if either a voltage dip or voltage swell (see 5.4) or a voltage interruption (see 5.5) occurs during this time interval.

– **Class S**

The manufacturer should specify measurement and aggregation methods.

– **Class B**

Same as class S.

A.6.6 Interharmonic currents

– **Class A**

The basic measurement of current interharmonics, for the purpose of this standard, is defined in 61000-4-7. Use that standard to determine a 10/12-cycle gapless centred interharmonic sub-group measurements, denoted $I_{isg,h}$.

Aggregation intervals as described in Clause 4.4 and Clause 4.5 should be used.

A 10/12-cycle interharmonic current measurement is marked "flagged" if either a voltage dip or a voltage swell (see Clause 5.4), or a voltage interruption (see Clause 5.5) occurs during this time interval.

– **Class S**

The manufacturer should specify measurement and aggregation methods.

– **For Class B**

Same as class S.

A.5 Voltage dip characteristics

A.5.1 General

Voltage dips are generally acknowledged to be a common power quality event.

The normative part of this standard characterizes voltage dips by two characteristics, depth (or residual voltage), and duration. It derives these characteristics from one-cycle r.m.s. values that are updated each half-cycle.

However, voltage dips are rarely rectangular, i.e. the U_{rms} value often varies during the dip, and limiting the characteristics to depth and duration can obscure useful information, for example, voltage dips due to motor-starting or due to transformer energizing during which there is a smooth transition between the dip and normal operation.

Ultimately, the greatest amount of information is available in waveforms recorded during the voltage dip. But characteristics are a useful way of reducing data, interpreting and categorizing events.

Multiple dips may occur, for example, during a failed attempt to auto-reclose and re-energize a faulty line section. Events that occur at approximately the same time may be counted as a single event.

Depending on the purpose of the measurement, other characteristics in addition to depth and duration should be considered.

A.5.2 Rapidly updated r.m.s values

During a voltage dip, it may be useful to calculate 1-cycle r.m.s values that are updated more frequently than every half-cycle (as specified in the normative part of standard). For example, it may be useful to update the 1-cycle r.m.s. value 128 times each cycle. This approach allows more precise identification of the beginning and end of the voltage dip, using simple thresholds. The drawbacks are increased data and processing and introducing a possibly misleading sliding filter.

R.m.s. voltage values correctly reflect the available power into a resistive load. However, electronic loads are not directly sensitive to r.m.s. voltage, instead, they are generally sensitive to voltage near the peak of the waveform, and are insensitive to other parts of the waveform. Algorithms other than r.m.s. may be useful to evaluate the effects of a voltage dip on electronic loads.

A.5.3 Phase angle/point-on-wave

For some applications, for example, electro-mechanical contactor drop-outs, the phase angle at which a voltage dip begins is an important characteristic, which is sometimes called point-on-wave.

This phase angle can be determined by capturing the pre-dip and during-dip waveforms, then examining them for the point at which the waveform deviates from the ideal by, for example, 10 %, then backing up along the waveform with a narrower threshold, for example, 5 %, to the beginning of the dip. This algorithm is highly sensitive for finding the exact beginning of a voltage dip, without triggering on minor non-dip variations.

A similar algorithm may be used to find the end of the dip. In addition to phase-angle information, this approach also permits the dip duration to be calculated precisely, with a resolution much finer than one cycle.

Also, advanced signal-processing techniques are capable of detecting the exact beginning of a voltage dip.

A.5.4 Voltage dip unbalance

Even very brief unbalance can damage 3-phase rectified loads, or cause over-current devices to trip. Three-phase dips are often unbalanced. With the rapidly updated r.m.s values described in A.5.2, it is often useful to calculate 3-phase unbalance during a dip. The unbalance often varies during a dip, so the unbalance might be presented in a graphic form, or the maximum unbalance during a dip might be presented.

It may be useful to analyse separately the zero sequence, negative sequence, and positive sequence of the fundamental frequency during an unbalanced dip. This approach yields information about how the dip propagates through the network and can be useful in understanding simultaneous dips and swells on different phases.

A.5.5 Phase shift during voltage dip

In some applications, for example, 3-phase rectifiers, the phase shift of the voltage dip can be important. Such a phase shift may be measured by, for example, a DFT applied to the cycle prior to the commencement of the dip, and another cycle after the commencement of the dip. If this approach is taken throughout the dip, a maximum phase shift during the dip may be calculated. The phase shift at the conclusion of the dip may also be useful. In some applications, for example, phase-locked-loop stability, it may be useful to calculate the maximum slew rate ($\mathrm{d}\Theta/\mathrm{d}t$) of the phase angle during the dip.

The calculation of phase shift during a voltage dip may be combined with voltage dip unbalance by calculating the magnitude and phase angle of zero-sequence, negative-sequence and positive-sequence components during an unbalanced dip.

A.5.6 Missing voltage

This characteristic of a voltage dip may be calculated by subtracting the dip waveform from an ideal waveform, with amplitude, phase, and frequency based on the pre-dip data. This characteristic can be useful for analysing the effect of the dip on voltage restoration devices, for example.

A.5.7 Distortion during voltage dip

The voltage during a dip is often distorted, and the distortion may be important for understanding the effect of the dip on electronic devices. Traditional methods such as THD may be considered for describing this distortion, but THD compares the distortion to the fundamental which, by definition, is rapidly varying during a dip. For this reason, it may be more useful to evaluate distortion during a dip simply as the r.m.s. value of the non-fundamental components.

The presence of even harmonics during or after the dip may point to transformer saturation.

A.5.8 Other characteristics and references

This list of voltage dip characteristics is not exhaustive. Other characteristics, not identified here, may be useful for analysing the effects of voltage dips on various types of loads, control devices, and correction devices. For further details and examples, the reader is encouraged to refer to the following publications: IEC TR 61000-2-8 and IEEE 1159.

Annex B
(informative)

Power quality measurement – Guidance for applications

B.1 Contractual applications of power quality measurements

B.1.1 General

Clause B.1 provides guidance on the measurement of power quality (PQ) for contractual purposes; it highlights factors that should be considered by the concerned parties.

NOTE The description of voltage quality parameters is discussed below.

It is recommended that B.1.2 should be consulted prior to entering into a PQ contract, whilst B.1.3 should be consulted prior to performing PQ measurements to test compliance with the contract terms.

B.1.2 General considerations

The terms specified in the contract will need to be both achievable by one party and acceptable to the other. The starting point for a PQ contract should be a PQ standard or specification. Consideration should be given to the planning and indicative values in the relevant IEC standards, for example, IEC 61000-2-2, IEC 61000-2-4, IEC 61000-2-12 and parts of IEC TR 61000-3-6 and IEC TR 61000-3-7, and IEC TR 61000-3-13.

In order to ensure that the results are representative of normal system operating conditions, the PQ measurement survey may discount but not discard data at times when the supply network is subject to severe disturbance resulting from

– exceptional weather conditions;
– third-party interference;
– acts by public authorities;
– industrial action;
– force majeure;
– power shortages resulting from external events.

The contract should specify whether flagged data, as described in the normative part (see 4.7) in this standard, should be excluded from the analysis when assessing the results for contract compliance. If flagged data are excluded, the measurement results will generally be mutually independent for each parameter, and each parameter may be more easily compared directly to a contractual value. If flagged data is included, the measurement results will generally be more directly related to the effects of power quality on sensitive loads, but will be far more difficult or even impossible to compare to any contractual values.

NOTE Flagged data indicate that a disturbance might have influenced the measurement and that consequently a single disturbance might have affected multiple parameters.

When PQ measurements are considered necessary to assess compliance of the supply against contract terms, it is the responsibility of the party that considers the measurements necessary to arrange for them to be performed, if permanent monitoring is not already available. However, this should not preclude the contract from detailing who should perform the measurements. There might be a need to consult third parties.

The contract should indicate how the financial cost of the measurements is to be borne by the concerned parties. This can be dependent upon the measurement results.

The terms of this contract should specify the duration of the contract, the measurement time interval, the PQ parameters to be measured and the electrical location of the measuring instrument(s). See B.1.3 for examples of measurement time interval and PQ parameters.

The choice of the connection mode of the measuring device (i.e. phase-to-neutral or phase-to-phase) should be coherent with the type of supply connection or should result from a common decision between the concerned parties. It should be explicitly mentioned in the contract.

The terms of the contract should specify the use of the measurement methods and the uncertainty described in the normative part of this standard.

The contract should specify the method for determining compensation, in the event of one party failing to honour the terms of the contract.

The contract may contain provisions for the resolution of disputes regarding interpretation of measurements.

The contract will need to address the subject of data access and confidentiality, for example, the party carrying out the PQ measurements might not be the same party that has to analyse the data and assess contract conformity.

B.1.3 Specific considerations

B.1.3.1 General

Power quality (PQ) is assessed by a comparison between the results of measured PQ parameters, and the limits (contractual values) given in a PQ contract. These limits are beyond the scope of this standard.

In a contract, description of each PQ parameter may include: contractual value(s), time interval to be considered, duration of the assessment time interval(s), and possibly special procedures regarding “flagged” measurements.

Many PQ parameters (voltage, harmonics, flicker) can show variations between weekday and weekends. For these, the assessment period should be for a week minimum (or an integer number of weeks).

B.1.3.2 Power frequency

Measurement interval: 1-week minimum assessment period.

Evaluation techniques: 10-s values are considered. The following techniques are suggested, but other evaluation techniques might be agreed between the parties:

– the number, or per cent, of values during the measurement interval that exceed high or low contractual values might be counted;
– the worst-case values might be compared to high and/or low contractual values (the measurement interval might be different for this possibility);
– one or more 95 % (or other percentage) probability weekly values, expressed in hertz, might be compared to high and/or low contractual values;
– the number of consecutive values that exceed high and/or low contractual values might be counted;

– the integration over the measurement interval, of values that deviate from nominal frequency might be compared to contractual values.

B.1.3.3 Magnitude of the supply voltage

Measurement interval: 1-week minimum assessment period.

Evaluation techniques: 10-min values should be considered. The following techniques are suggested, but other evaluation techniques might be agreed between the parties:

– the number, or per cent, of values during the measurement interval that exceed high or low contractual values might be counted;

– the worst-case values might be compared to high and/or low contractual values (the measurement interval might be different for this possibility);

– one or more 95 % (or other percentage) probability weekly values, expressed in volts, might be compared to high and/or low contractual values;

– the number of consecutive values that exceed high and/or low contractual values might be counted.

B.1.3.4 Flicker

Measurement interval: 1-week minimum assessment period.

Evaluation techniques: 10-min values (P_{st}) and/or 2-h values (P_{lt}) might be considered. The following techniques are suggested for both values, but other evaluation techniques might be agreed between the parties:

– the number, or per cent, of values during the measurement interval that exceed contractual values might be counted;

– 99 % (or other percentage) probability weekly values for P_{st}, or 95 % (or other percentage) probability weekly values for P_{lt}, might be compared to contractual values.

B.1.3.5 Voltage dips/swells

Measurement interval: 1-year minimum assessment period.

Evaluation techniques: the parties to the contract should agree on the declared input voltage U_{din}.

NOTE For LV customers, the declared voltage is usually equal to the nominal voltage of the supply system. For MV or HV customers, the declared voltage ~~may~~ can be different from the nominal voltage.

The parties to the contract should agree on

– the dip and swell detection thresholds;

– time aggregation techniques;

– location aggregation techniques if more than one location is measured;

– reporting techniques such as residual voltage/duration tables,

– any other evaluation techniques that might be relevant.

B.1.3.6 Voltage interruptions

Measurement interval: 1-year minimum assessment period.

Evaluation techniques: the parties might agree on a duration that defines the borderline between "short" and "long" voltage interruptions. The count of the voltage interruptions, and the total duration of the "long" voltage interruptions during the measurement interval, might be considered. Other evaluation techniques might be agreed between the parties.

Interruptions for which the customer is informed in advance (for example, minimum 24 h) could be counted separately from interruptions for which the customer is not informed in advance.

B.1.3.7 Supply voltage unbalance

Measurement interval: 1-week minimum assessment period.

Evaluation techniques: 10-min values and/or 2-h values might be considered. The following techniques are suggested for both values, but other evaluation techniques might be agreed between the parties:

– the number, or per cent, of values during the measurement interval that exceed contractual values might be counted;

– the worst-case values might be compared to contractual values (the measurement interval might be different for this possibility, for example one year);

– one or more 95 % (or other percentage) probability weekly values, expressed in per cent, might be compared to contractual values.

B.1.3.8 Harmonic voltages

Measurement interval: one-week minimum assessment period for 10-min values, and daily assessment of 150/180-cycle values for at least 1 week.

Evaluation techniques: 150/180-cycle time interval and/or 10-min values might be considered. Contractual values may be applied to individual harmonics, or range of harmonics, or other groupings, for example, even and odd harmonics, according to agreement between the parties to the contract. The following techniques are suggested for all values, but other evaluation techniques might be agreed between the parties:

– the number, or per cent, of values during the measurement interval that exceed contractual values might be counted;

– the worst-case values might be compared to contractual values (the measurement interval might be different for this possibility, for example one year);

– one or more 95 % (or other percentage) probability weekly values for 10-min values, and/or 95 % (or other percentage) probability daily values for 150/180-cycle time interval values, expressed in per cent, might be compared to contractual values.

B.1.3.9 Interharmonic voltages

Measurement interval: 1-week minimum assessment period for 10-min values, and daily assessment of 150/180-cycle values for at least 1 week.

Evaluation techniques: 150/180-cycle time interval and/or 10-min values might be considered. Contractual values may be applied to a range of interharmonics, or other groupings, according to agreement between the parties to the contract. The following techniques are suggested for all values, but other evaluation techniques might be agreed between the parties:

– the number, or per cent, of values during the measurement interval that exceed contractual values might be counted;

– the worst-case values might be compared to contractual values (the measurement interval might be different for this possibility, for example one year);

– one or more 95 % (or other percentage) probability weekly values for 10-min values, and/or 95 % (or other percentage) probability daily values for 150/180-cycle time interval values, expressed in per cent, might be compared to contractual values.

B.1.3.10 Mains signalling voltage on the supply voltage

Measurement interval: 1-~~week~~-day minimum assessment period.

Evaluation techniques: the following techniques are suggested for all values, but other evaluation techniques might be agreed between the parties:

– the number, or per cent, of values during the measurement interval that exceed contractual values might be counted;

– the worst-case values might be compared to contractual values (the measurement interval might be different for this possibility, for example one week).

B.2 Statistical survey applications

B.2.1 General

These provide guidance for designing and performing statistical power quality surveys (including permanent monitoring) in support of:

1) Consumer requirements, where the aim of such surveys is to provide the consumer with information on the power quality parameters seen by the consumer referenced against a set of recognized power quality indices. These indices may relate to recognized standards, or a pre-defined set of requirements specified for a particular installation or item of equipment (e.g. contracts or equipment specifications).
2) Network operator requirements for assessing existing levels of distortion/disturbance on the network (e.g. in the assessment required for the connection of new loads).

Historically, networks have been designed and operated differently in different countries and any attempt to normalize the outputs of different national power quality surveys will be extremely complex and open to misinterpretation.

Clause B.2 explains the aim of power quality statistics and gives some guidelines.

The first objective of these techniques is to compress a large number of measured values.

The second objective is to compute power quality indices for benchmarking, either on one specific point or for a whole network in order to

– verify the compliance with contractual agreement (see Clause B.1);
– monitor the performance evolution of a network during long periods;
– compare different networks during the same interval.

B.2.2 Considerations

A statistical analysis ~~shall~~ should be done with homogeneous values: same measurement time interval, same measurement data, same network, etc.

Statistics computation is based on a classification of the measured values.

For each parameter, the user defines a "normal range" of variation and may choose to include or not, flagged data (see 4.7), since this data by definition can be irrelevant.

The normal range of variation is then divided into several ~~classes~~ bins of equal width.

NOTE The number of bins depends on the measured parameter, on the accuracy, on the commitment. A minimum of 40 bins can be adequate for some applications; in other applications, 100 bins can be more useful.

The number of ~~classes~~ bins determines the confidence interval. ~~Classes~~ Bins remain constant over a measurement period – 1-day, 1-week, 1-year, etc. – and are ordered from the lowest to the greatest ~~class~~ bin value within the normal range of variation.

The number of measured values within each ~~class~~ bin is counted. These counts may be used to determine cumulative curves, which in turn may be used to determine percentiles.

The statistics formula with the confidence level, for example 95 %, should be used to determine the confidence interval. When the number of statistical values is small, one should be careful about the confidence interval.

B.2.3 Power quality indices

B.2.3.1 Characterizing a single point on the network

One single measurement point may be characterized by two kinds of power quality indices depending on the phenomena concerned:

– statistical indices like percentiles, maximum or mean values over a period of time (see IEC TR 61000-3-6 for harmonics or IEC TR 61000-3-7 for flicker~~, or IEC 61000-3-13 for unbalance~~);

– event counting and tabulating.

Examples of power quality indices are given for each parameter in B.1.3.

B.2.3.2 Characterizing an entire network

An entire network is a collection of single points classified by type of network or customers. Weighting rules might be defined in order to get global results. Weighting rules might apply both to statistical indices and events.

B.2.4 Monitoring objectives

Power quality monitoring is necessary to characterize electromagnetic phenomena at a particular location on an electric power circuit.

The objective may be as simple as verifying steady state voltage regulation at a service entrance, or may be as complex as analysing the harmonic current flows within a distribution network.

Generally speaking power quality monitoring is carried out for one of three reasons:

1) PQ evaluation: To evaluate the electrical environment at a particular location to refine modelling techniques or to develop a power quality baseline.
2) Planning the connection of new equipment: To predict future performance of equipment or power quality mitigating devices that are planned to be connected within an installation. In any event, the most important task in any monitoring project is to define clearly the objectives of monitoring
3) Troubleshooting: To diagnose incompatibilities, if any, between the electric power source and the existing equipment connected within an installation.

The procedure for defining monitoring objectives will depend upon the reason for carrying out the monitoring. From this will come the parameters to be measured, the duration of the monitoring and the thresholds against which the parameters will be evaluated.

B.2.5 Economic aspects of power quality surveys

There are several elements that impact on the cost and overall economics of a measurement campaign. These elements include:

- measurement equipment
- transducers

- installation, including connection access
- labour
- communications
- data management (database, etc.)
- data processing and analysis
- survey duration

Of these elements, the measurement equipment cost itself is rarely the most expensive item. In electric utility substation and feeder applications, the installation and labour costs usually dominate the measurement equipment costs by a significant margin. When the total life cycle of a long term measurement campaign is considered, the communication and data analysis costs begin to dominate. It is wise therefore to choose instrumentation that is easy to install, has many communication options, and provides the data in a form that simplifies the analysis task (e.g. the data is available in a standardized format).

An obvious multiplier of measurement campaign cost, is related to the duration of a survey. This is applicable to compliance measurement campaigns such as those associated with standards such as EN 50160. The guidance in this regard is to first, comply with national standards requirements for survey durations and then second, take into consideration the context of the measurement when the duration is not explicitly mandated in a national standard. The duration of the measurement campaign should be tailored to the situation such that the survey duration can be minimized whilst obtaining enough information to properly conduct the assessment. Factors that influence the selection of the duration of a measurement campaign include:

- customer type (e.g. residential, commercial, industrial)
- reason for monitoring (see above)
- variability of the load and time frame over which that variability is expected to be experienced

Prior to installing a permanent power quality monitoring system, a business case should often ~~has to~~ be developed. Typical business cases include both tangible and intangible benefits. Direct, tangible benefits include:

- identification by signature analysis of failing equipment before total failure (e.g. tap changers, capacitor banks and their switches, transformers)
- reduction of system restoration time (e.g. fault finding)
- contract compliance
- connection requirements for new equipment

Intangible benefits include:

- identifying problem feeders to help improve reliability indices
- customer feedback to improve customer relations

The economics of a power quality measurement campaign can be improved by augmenting the system with information gathered by other equipment not specifically designed for power quality measurement. Sharing resources in this manner allows the cost of measurement to be shared with the primary cost of the device: reclosers, capacitor switch controllers, etc.

B.3 Locations and types of surveys

B.3.1 Monitoring locations

The choice of locations to install power quality monitors will be dependent upon the objective of the survey. If the monitoring objective is to diagnose an equipment performance problem then the monitor should be placed as close to the load as possible. This applies to performance problems with both sensitive electronic loads such as computers and adjustable speed drives, and electrical distribution equipment such as circuit breakers and capacitors. After the voltage fluctuations are detected, the monitor may be moved upstream on the circuit to determine the source of the disturbance.

Monitoring location may also be determined by cost and convenience as long as it does not compromise the technical, regulatory, or legal objectives. For example, it is less costly to monitor at low voltage than high voltage. Measuring in a substation is generally less expensive than part way out on a feeder ~~or~~ on a pole.

For compliance monitoring related to service contracts, a monitoring location ~~shall~~ should be agreed to by all parties to the contract in advance. This is typically defined as the point of common coupling (PCC) between the customer and the system where the PCC is defined as: the point on a public power supply network, electrically nearest to a particular load, at which other loads are, or could be, connected.

B.3.2 Pre-monitoring site surveys

Prior to conducting a measurement campaign, it is recommended that information regarding the system environment be gathered to facilitate proper instrument placement, operation, and analysis. Elements that are common to all surveys include among others:

- electrical system data (single-line diagrams, transformer specifications, transformer connection, short-circuit levels, capacitor bank size and location, branch circuit data, load data, grounding, etc.),
- changes in installation topology over time (e.g. power factor capacitor status, loads, transformers in/out of service, etc.),
- known disturbing loads, rating and operating regime.

B.3.3 Customer side site survey

For surveys within a customer's installation, in addition to the information mentioned above, it is useful to gather information on any problems encountered, for example the nature and characteristics of sensitive equipment, the time stamp of any events that coincide with a reduction in performance. These events should be checked for coincidence with operations within the installation and on the network.

B.3.4 Network side survey

Surveys of the supply network itself require that network specific information be gathered including:

- network protection equipment and settings
  - if the settings are changed for any reason during the course of a survey, it can impact the statistics of voltage dips for example,
  - this permits evaluation of alternative protection scenarios based on survey results;
- existence and characteristics of ripple control (or other relevant telecontrol via power line carrier) that may impact measurements;
- load characteristics (e.g. industrial, commercial, residential or mixture);
- network operation protocol with regards to volt/var control – regulation.

B.4 Connections and quantities to measure

B.4.1 Equipment connection options

There are several decisions that need to be made related to connecting the measurement equipment. These decisions include:

- single-phase versus three-phase measurement,
- line-to-line versus line-to-neutral or line-to-ground connection,
- high side versus low side measurement near transformers.

These decisions will be heavily influenced by the reason for the survey. Sometimes connection requirements may be specified inherently by a particular standard against which the survey is being conducted. Whatever the case the connection should be made in a way that is consistent with the requirements or connection of the affected equipment – taking into account transformer connection issues.

A general observation can be made that when measuring steady state phenomena such as harmonics and flicker, single-phase measurements can often be made instead of three-phase measurements. This is possible because these phenomena are often reasonably balanced. This assumption should be checked by performing a temporary three-phase measurement. When voltage dips and swells are the primary reason for monitoring, it is necessary to monitor all phases powering the affected equipment.

When general surveys are being performed with a three-phase connection and/or there are several voltage transformations downstream from the monitored location, connecting the measurement equipment from line-to-neutral on grounded systems is recommended because the line-to-line values can often be derived either in the instrument or off-line.

Where this is not the case, the connection mode of the monitoring instrument should be chosen taking into account both the connection mode of the potentially affected equipment and the successive voltage transformations downstream.

B.4.2 Priorities: Quantities to measure

The quantities to measure will generally be defined by the monitoring objectives, relevant compliance standards, and other factors. For general surveys it will be necessary, in order to conserve memory space, to identify a priority order for the quantities to monitor. For example:

1) power parameters (V, I, P, Q, S, DPF, TPF, etc. – these are not generally considered to be power quality parameters)
2) voltage dips/swells
3) harmonic voltage
4) harmonic current
5) unbalance
6) transients (e.g. capacitor switching – low frequency)
7) flicker
8) interharmonic voltages and currents
9) mains signaling

NOTE DPF is the displacement power factor, or the cosine of the angle between the fundamental voltage and the fundamental current. TPF is the true power factor, or the ratio between ~~watts~~ active power and ~~volt-amperes~~ apparent power.

This ordering is an example; the actual prioritization depends on the overall goals and objectives of a particular measurement campaign.

Once the priority is established and an instrument chosen based on those priorities, it is recommended that as much information as the instrument can provide be utilized. It is generally easier to discard data after a survey rather than to derive it when a quantity is desired later that was not directly measured. Generally the only issues affecting this decision are instrument storage capabilities and communication time/cost impacts.

B.4.3 Current monitoring

In general, customers are responsible for the current that their equipment draws from or injects into the system and the supplier is responsible for the supply voltage. This fact can be used as the basis for deciding when to measure currents.

The measurement of current is important for the concept of emission assessment however the critical point is to accurately determine the phase angle; this becomes increasingly difficult when trying to measure harmonic currents. The measurement of the magnitudes of the harmonic currents is normally sufficient for compliance tests. In other types of tests, knowledge of the phase angles of the harmonic currents is important, for example in studies to determine whether the harmonic currents of a planned new installation, when superimposed on the already existing harmonic currents, are acceptable or not. Moreover, the information on phase angles between harmonic currents and harmonic voltages helps to find unknown sources of possibly distorting harmonic currents. The accurate measurement of phase angles needs appropriate instrumentation, including voltage and current sensors, and may become increasingly difficult with increasing order of the harmonics.

The measurement of current can be invaluable in determining the sources/cause of power quality events, since it can help to determine if the cause of the event is upstream or downstream of the measuring instrument. This is particularly true for voltage dips.

B.5 Selecting the monitoring thresholds and monitoring period

B.5.1 Monitoring thresholds

Monitoring thresholds may be determined by the power quality indices against which the results are to be compared, or may be determined by the load requirements. Once again, the reasons for performing the power quality survey shall should be consulted.

The difference between thresholds used for disturbance capture, versus thresholds used for event characterization, counting, and analysis, should be considered.

As a general recommendation, thresholds should be as tight as feasible (while avoiding continuous triggering). Wider thresholds can be effectively implemented subsequently on captured data, but data that was missed due to loose thresholds can never be recaptured.

Thresholds on sliding references should be used when measuring at an unregulated portion of the network. For example, monitors deployed on distribution feeders with load tap changers or capacitor bank based voltage regulation may be able to use fixed thresholds. Transmission systems or other portions of the network that are not directly regulated with regards to voltage should use the sliding reference method.

NOTE Thresholds are used for detecting events, e.g. dips, swells, RVC, etc. However, for statistical analysis of quasi-steady-state parameters such as harmonics, unbalance, and flicker, continuous recording without thresholds is needed.

B.5.2 Monitoring period

The monitoring period will be determined by the reasons for performing the power quality survey. For example, if the results are to be compared against power quality indices, there may be guidance in those indices regarding the monitoring period.

It is often useful to compare power quality measurements over time, for example comparing one year to the previous year. If this type of comparison is useful, the monitoring period may be permanent.

Some standards may specify minimum measurement periods. In any case, event measurements such as voltage dips and swells generally require longer measurement periods in order to capture enough events to provide meaningful statistics (months). Rarer events such as interruptions may require even longer periods; in contrast, for harmonics and other steady state measurements, meaningful information may be captured in relatively short periods of time (minimum of one week).

For compliance monitoring, the monitoring period should already be specified in the relevant standard. For practical reasons, one may need to interpret the standard – e.g. do you need to measure for one year for EN 50160 compliance? Does it need to be continuous?

B.6 Statistical analysis of the measured data

B.6.1 General

A suitable statistical analysis method ~~shall~~ should be chosen for the data. Different statistical methods may be selected, depending on the power quality parameter and measurement objectives, but the methods can be roughly divided into:

- methods that count the number of events that exceed some threshold, and
- methods that summarize large numbers of quasi-steady-state measurements into a single number, or a few numbers.

For the latter methods, various possible numbers may be chosen as the most useful summary value: maximum value, 99 % value, 95 % value, average value, minimum value, etc. In many references, the 95 % probability value has been found to be useful.

Data from multiple sites may be analysed statistically to assess network performance.

B.6.2 Indices

Prior to carrying out a measurement campaign it is necessary to understand the indices against which the results of the campaign will be compared. This information will help to determine the duration of the campaign, trigger thresholds and statistical analysis of the results. In the absence of a recognized standard it will be necessary to devise a specific set of indices for each measurement campaign.

There has been much work done by various professional bodies around the world on the subject of power quality indices. Some of the more well known of these are listed in the bibliography.

B.7 Trouble-shooting applications

B.7.1 General

Power-quality-related trouble-shooting is generally performed in response to operational incidents or problems. Consequently, it is often desirable to produce results as quickly as possible, rather than producing data of archival or contractual value. Nevertheless, this need for fast diagnosis should not lead to premature or unfounded conclusions.

Typically, raw unaggregated samples are most useful for trouble-shooting, as they permit any type of post-processing that may be desired, for example, signatures, wavelets, etc. However, to minimize the amount of data to be stored and reviewed, for trouble-shooting, it is useful for the instrument to record and present only data that were recorded just prior to, during, and after an event such as a voltage dip or transient.

B.7.2 Power quality signatures

Signatures are graphic presentations of power quality events, often accompanied by a short table of numeric characteristics.

The most common form is a time-domain plot of voltage and current. Other forms, such as histogram displays of harmonics, cumulative probability distributions, etc. may also be useful. Common time-scales for signatures range from 100 μs to 30 days. Usually an instrument determines the best time-scale for presenting a power quality event based on the event's characteristics and duration.

It is generally agreed that useful signatures show the signal before, during, and after the power quality event (pre-trigger system). Typically, one-fourth of the graph is allocated to the signal just prior to the event.

These power quality signatures are useful for trouble-shooting problems throughout electrical networks, including customers' installations. Typically, they are used to identify and locate the source of a power quality event and to select an appropriate solution.

An expert might use the signature of a voltage dip, for example, to determine that the cause is a large motor starting downstream from the monitoring location, and to select an appropriate solution. Although this example deals with voltage dips, widely available reference books set out the typical signatures for hundreds of different power quality events: switching of power factor correction capacitor, lightning strikes, utility and customer faults, loose wiring, arcing contacts, radio transmission interference, electronic loads that share circuits with motors, etc.

Although many experts can identify common power quality events from their voltage signatures alone, having current signatures as well greatly increases the range and precision of statements that can be made about a power quality event. Moreover, current signatures can assist in identifying the direction of the cause of a disturbance.

Annex C
(informative)

Guidance on instruments

C.1 General

This standard is a basic EMC publication. Detailed guidance on instrument performance, performance verification methods, additional influence quantities and other similar information should, in general, be found in a product standard.

However, such product standards are not yet available, and it is recognized that users of this standard wish to design, specify, test or select a power quality instrument using this basic standard. This annex provides some informative guidance.

After complete product standards become available, this annex may be removed in a future edition.

C.2 Summary of requirements

Table C.1 provides an informative summary of the requirements for classes A and S. In case of any conflict between Table C.1 and the normative clauses of this standard, the normative clauses prevail.

Table C.1 – Summary of requirements

Section and Parameter	Class	Measurement Method	Uncertainty	Measuring range(1)	Influence Quantity range(2)	Aggregation method
5.1 Frequency	A	See 5.1.1	±10 mHz	42,5 Hz ~ 57,5 Hz, 51 Hz ~ 69 Hz	42,5 Hz ~ 57,5 Hz, 51 Hz ~ 69 Hz	N/R
	S	See 5.1.1	±50 mHz	42,5 Hz ~ 57,5 Hz, 51 Hz ~ 69 Hz	42,5 Hz ~ 57,5 Hz, 51 Hz ~ 69 Hz	N/R
5.2 Magnitude of the Supply	A	See 5.2.1	±0,1 % U_{din}	10 % ~ 150 % U_{din}	10 % ~ 200% U_{din}	See 4.4 and 4.5
	S	See 5.2.1	±0,5 % of U_{din}	20 % ~ 120 % U_{din}	10 % ~ 150% U_{din}	See 4.4 and 4.5
5.3 Flicker	A	IEC 61000-4-15	IEC 61000-4-15	0,2 ~ 10,0 P_{st}	0 ~ 20 P_{st}	IEC 61000-4-15
	S	IEC 61000-4-15	See 5.3.2	0,4 ~ 4,0 P_{st}	0 ~ 10 P_{st}	IEC 61000-4-15
5.4 Dips and Swells	A	$U_{rms(1/2)}$	Amplitude ±0,2 % U_{din} Duration +/- 1 cycle	N/A	N/A	N/R
	S	See 5.4.1	Amplitude ±1 % of U_{din} Duration +/- 1 cycle or +/-2 cycles	N/A	N/A	N/R
5.5 Interruptions	A	$U_{rms(1/2)}$	Duration +/- 1 cycle	N/A	N/A	N/R
	S	see 5.5.1	Duration +/- 1 cycle or +/-2 cycles	N/A	N/A	N/R
5.7 Unbalance	A	Symmetrical components: U_2 and U_0	±0,15 %	0,5 % ~ 5 % u_2 0,5 % ~ 5 % u_0	0 % ~ 5 % u_2 0 % ~ 5 % u_0	See 4.4 and 4.5
	S	Symmetrical components: U_2, and optionally U_0	±0,3 %	1 % ~ 5 % u_2 1 % ~ 5 % u_0 if implemented	0 % ~ 5 % u_2 0 % ~ 5 % u_0 if implemented	See 4.4 and 4.5
5.8 Voltage Harmonics	A	See 5.8.1	IEC 61000-4-7 Class I	10 % ~ 200 % of Class 3 of IEC 61000-2-4	200 % of Class 3 of IEC 61000-2-4	See 4.4 and 4.5

	S	See 5.8.1	200 % of IEC 61000-4-7 Class II	10 % ~ 100 % of Class 3 of IEC 61000-2-4	200 % of Class 3 of IEC 61000-2-4	See 4.4 and 4.5
5.9 Voltage Inter-harmonics	A	See 5.9.1	IEC 61000-4-7 Class I	10 % ~ 200 % of Class 3 of IEC 61000-2-4	200 % of Class 3 of IEC 61000-2-4	See 4.4 and 4.5
	S	SBM	SBM	SBM	200 % of Class 3 of IEC 61000-2-4	See 4.4 and 4.5
5.10 Mains Signalling Voltage	A	See 5.10.1	See 5.10.2	0 % ~ 15% U_{din}	0 % ~ 15% U_{din}	N/R
	S	SBM	SBM	SBM	0 % ~ 15% U_{din}	N/R
5.12 Under/over deviation	A	See 5.12.1	See 5.12.2	See 5.12.2	N/A	See 4.4 and 4.5
	S	N/R	N/R	N/R	N/A	N/R
Transient Voltages IEC 61180	A	N/R	N/R	N/R	6 kV peak see (3) below	N/A
	S	N/R	N/R	N/R	N/R	N/A
Fast Transients IEC 61000-4-4	A	N/R	N/R	N/R	4 kV peak see (3) below	N/A
	S	N/R	N/R	N/R	N/R	N/A

SBM = Specified by Manufacturer, **N/R** = no requirement, **N/A** = not applicable

(1) The instrument shall meet the uncertainty requirements for signals within the measuring range.

(2) The instrument shall tolerate signals in the influence quantity range without shifting the measurement of other parameters out of their uncertainty requirement, and without instrument damage. The instrument may indicate overrange for signals greater than the measuring range, up to the influence quantity range (not including transients and fast transients).

(3) For transient voltages and fast transients, there shall be no effect on any measurement after the transient. The transients are applied to the measuring terminals, not to the instrument power terminals.

NOTE Class B methods are not included in the table above because they are not recommended for new designs. Readers are advised that Class B may be removed in a future Edition of this standard.

C.3 Guidance on testing

The power quality parameters in this standard may be grouped into two categories: non-triggered and triggered. Non-triggered parameters, for example, include magnitude of the supply, frequency, harmonics, flicker, unbalance and related parameters. Triggered parameters, for example, include dips, swells and interruptions.

The steady-state tests given in Clause 6 are sufficient to verify the uncertainty, performance and influence quantity response of non-triggered parameters. However, the steady-state tests given in Clause 6 do not completely verify that all parameters have been implemented correctly.

For both triggered and non-triggered parameters, implementation according to Clause 5 may be verified with non-steady-state waveforms.

For example, to verify that an instrument's voltage dip measurement method is implemented according to 5.4, one non-steady-state waveform might be used to verify that voltage dips are measured using true RMS; and a second non-steady-state waveform might be used to verify that the true RMS is calculated every cycle; and a third non-steady-state waveform might be used to verify that the true RMS is updated every half-cycle; and a fourth non-steady-state waveform might be used to verify the half-cycle is independently synchronized to each channel, and a fifth non-steady-state signal might be used to verify that the depth and duration on poly-phase dips are correctly reported.

The example given in the preceding paragraph is intended only as an illustration for guidance. Full verification of all parameters might require testing with hundreds of non-steady-state waveforms. (Alternatively, method implementation verification might, in some cases, be performed with a detailed firmware validation.)

~~This standard does not provide a complete list of tests for verifying that measurement methods have been implemented correctly. Such a list may, in the future, be found in product standards.~~

~~Also, for certain parameters in some classes, there are requirements that certain items be "specified by the manufacturer". During performance verification, compliance with this type of requirement should be verified by examining the published specifications of the instrument.~~

~~C.4 Guidance on reporting~~

~~Reporting that an instrument complies with class A, B, or S is not sufficient.~~

~~At a minimum, the following items should also be reported:~~

- ~~the acceptable range of U_{din} and its associated frequency;~~
- ~~any accessories or options that may be necessary for compliance;~~
- ~~a list of each of the parameters in this standard, with the verified class for each parameter.~~

Annex C
(informative)

Conducted emissions in the 2 kHz to 150 kHz range

C.1 General

The purpose of Annex C is to consider measurement methods that could provide an overview, in a power quality context, of conducted voltage emissions in the 2 kHz to 150 kHz range. These emissions are presumed to be quasi-steady-state levels, although they may have amplitude modulation. It is emphasized that the purpose of Annex C is to describe overview measurement methods, as opposed to precision measurement methods.

Background information on emissions and sensitivity in this frequency range can be found in IEC 61000-4-19:2014, Annex A.

The understanding of measurement methods in this frequency range is still evolving, so Annex C only provides general guidance.

For applications where highly detailed measurements are required, such as type tests for emissions measurements or compliance measurements, the measurement methods found in IEC 61000-4-7 and/or CISPR 16 should be considered.

NOTE 1 Useful information about measurement in the 2 kHz to 150 kHz range can be found in IEC 61000-4-7:2002, Annex B (2 kHz to 9 kHz), and in CISPR 16 (9 kHz to 150 kHz).

NOTE 2 Immunity test methods for 2 kHz to 150 kHz emissions can be found in IEC 61000-4-19.

NOTE 3 The measurement methods for 2 kHz to 9 kHz in IEC 61000-4-7 are informative, not normative. The measurement method for this frequency range in CISPR 16 focuses on emissions from equipment under test (EUT), and does not directly address power quality investigations and surveys. In CISPR 16, the in-situ measurements are considered in terms of an EUT.

NOTE 4 This frequency range is a relatively new consideration in a power quality context, so there may be differences between standards. For example, IEC 61000-4-7 considers phase-to-neutral voltages, while CISPR 16 considers phase-to-earth voltages. (Annex C does not select a physical connection method for measurement channels.) For example, the measurement methods of CISPR 16 may not accurately record the characteristics of some immunity test waveforms in IEC 61000-4-19, due to the rapid modulation of those test waveforms. These are examples; other differences between standards may be found.

NOTE 5 Information about emission magnitudes in the 2 kHz to 9 kHz band can be found in IEC 61000-2-4:2002, Clause C.3, where, for example, on systems with U_{din} = 230 V, "few troubles were reported on networks having" emissions in the range 0,46 V to 3,45 V. For the same 2 kHz to 9 kHz band, IEC 61000-2-2:2002, B.2.3, suggests a reference level for any 200 Hz bandwidth of 0,69 V.

Users of this standard should be aware that the contents of Annex C may become normative in a future edition.

Measurements in this frequency range may be strongly affected by transducers, if present. Guidance about effects of transducers may be found in IEC TR 61869-103.

C.2 Measurement method – 2 kHz to 9 kHz

The measurement method for 2 kHz to 9 kHz, including requirements for Class A and Class S, is under consideration. The measurement methods of IEC 61000-4-7:2002, Annex B (informative) could be considered.

C.3 Measurement method – 9 kHz to 150 kHz

The measurement method for 9 kHz to 150 kHz, including requirements for Class A and Class S, is under consideration.

One method under consideration is the method of CISPR 16-1-2. CISPR 16-1-2 emphasizes immunity and emission measurements for equipment under test (EUT), and may not be optimized for in-situ power quality measurements. For the purpose of in-situ power quality investigations and surveys, the measurement methods in CISPR 16 may be complex or expensive to implement, due to their gapless measurements and accuracy requirements. The measurement methods of CISPR 16 may provide a large amount of data in an in-situ power quality context. However, the amount of data for in-situ measurements specified by CISPR 16 may be required for coordination with levels defined by various IEC standards.

A second method under consideration is to extend the method of IEC 61000-4-7:2002, Annex B, from the present 9 kHz limit up to a 150 kHz limit.

A third method under consideration is the method described in the NOTE below. This method, although less complete and less accurate than CISPR 16-1-2, may possibly be more appropriate for in-situ power quality applications, and may be less expensive to implement, and may avoid providing an overwhelming amount of data. However, it may not provide sufficient data for coordination with levels defined by various IEC standards. Also, due to intervals between the measurements, it is not an appropriate method for measuring amplitude-modulated signals that vary with a period less than twice the interval between measurements. Also, if 2 kHz segment widths are selected for this measurement method, it may be difficult to differentiate phenomena within the same frequency segment.

Other methods may be considered during development of future editions of this standard.

NOTE The third measurement method under consideration for the frequency range 9 kHz to 150 kHz is the following:

The frequency range of 9 kHz to 150 kHz could be divided into equal-width segments. The segment width could be an integer multiple of 200 Hz, preferably either 200 Hz or 2 kHz. For the purposes of this measurement method, it is acceptable to process a frequency range beyond 9 kHz to 150 kHz, for example processing the range 8 kHz to 150 kHz if a 2 kHz segment width is selected.

The minimum, average, and maximum magnitude of the r.m.s. voltage in each frequency segment in the 9 kHz to 150 kHz range could be recorded during each 10/12-cycle interval. In addition, the single maximum value in any segment, on any channel, could be recorded.

The following example design demonstrates the intent of the measurement method, measurement range, and measurement uncertainty:

a) The 9 kHz to 150 kHz measurements could be made on each channel through cascaded high pass and low pass filters. The high pass filter could have 2 poles, with a 3 dB point at 1,5 kHz or higher. The low pass filter could have 4 poles, with the 3 dB point at 200 kHz. The measurement range after the filters could be at least ±50 V instantaneous, with a resolution of 12 bits or more.
b) 9 kHz to 150 kHz measurements could be taken at the output of the cascaded filters at equally spaced time intervals such that 32 approximately equally-spaced measurements are taken each 10/12-cycle interval. Cross-channel synchronization is not necessary. Each measurement could consist of 512 samples taken at a sampling rate of 1,024 MHz.
c) For 9 kHz to 150 kHz, the 512 samples could be processed with a Discrete Fourier Transform or equivalent, yielding 256 bins spaced at 2 kHz. The lowest 4 bins and the upper 181 bins could be discarded. The magnitudes of the remaining 71 bins contain the emissions from 8 kHz to 150 kHz. These emissions could be reported as an r.m.s. value.
d) For 9 kHz to 150 kHz, at each 10/12-cycle interval, 32 sets of these 71 bins are available. At each 10/12-cycle interval, the minimum, average, and maximum value of the 32 r.m.s. magnitudes of each of these 71 bins could be reported. In addition, at each 10/12-cycle interval, a single r.m.s. maximum value of all 71 bins across all channels could be reported.

C.4 Measurement range and measurement uncertainty

The measurement range and measurement uncertainty for Class A and Class S are under consideration.

A measurement range of at least 200 % of the largest applicable immunity level specified in IEC 61000-4-19:2014, Table 1, could be considered. A measurement uncertainty of at most 10 % of the smallest applicable immunity level specified in IEC 61000-4-19:2014, Table 1, could be considered.

For conducted emissions in the range 2 kHz to 9 kHz, additional information can be found in IEC 61000-4-7.

C.5 Aggregation

The time aggregation methods, including the requirements for Class A and Class S, are under consideration.

NOTE 1 Minimum, maximum, and average values could be considered during each aggregation interval. The average r.m.s. value could be used, for example, to determine typical emissions. The maximum r.m.s. value could be used, for example, to determine worst-case emissions. The difference between the minimum and maximum values could be used, for example, to detect the presence of amplitude modulation. The single maximum r.m.s. value could be used, for example, to set worst-case 95 % limits.

NOTE 2 Measurement methods may generate a large amount of data, which, depending on the application, may need to be stored, transmitted, analysed, and/or archived. Depending on the application, the amount of data may be reduced. To reduce the amount of data, consider applying statistical methods at the measuring location such as 95 % or 99 % levels, or storing only extreme and average values, or storing detailed data only when trigger thresholds are exceeded, or other methods.

NOTE 3 In general, measurements in the 2 kHz to 150 kHz range could be aggregated using the aggregation intervals of 4.5.

Annex D
(informative)

Underdeviation and overdeviation

D.1 General

Underdeviation and overdeviation parameters may be useful when it is important to avoid, for example, having sustained undervoltages being cancelled in data by sustained overvoltages.

D.2 Measurement method

– **Class A**

The $U_{\mathrm{rms(10/12)}}$ should be used to assess the underdeviation and overdeviation parameters in per cent of U_{din}. The underdeviation $U_{\mathrm{rms\text{-}under}}$ and overdeviation $U_{\mathrm{rms\text{-}over}}$ parameters are determined by Equations (D.1),(D.2), (D.3), (D.4) and (D.5) and (D.6):

Underdeviation assessment:

the following rule applies for the calculation of $U_{\mathrm{rms-under},i}$:

$$\text{if} \quad U_{\mathrm{rms(10/12)},i} > U_{\mathrm{din}} \quad \text{then} \quad U_{\mathrm{rms-under},i} = U_{\mathrm{din}} \tag{D.1}$$

$$\text{if} \quad U_{\mathrm{rms(10/12)},i} \leq U_{\mathrm{din}} \quad \text{then} \quad U_{\mathrm{rms-under},i} = U_{\mathrm{rms(10/12)},i} \tag{D.2}$$

Overdeviation assessment:

the following rule applies for the calculation of $U_{\mathrm{rms-over},i}$:

$$\text{if} \quad U_{\mathrm{rms(10/12)},i} < U_{\mathrm{din}} \quad \text{then} \quad U_{\mathrm{rms-over},i} = U_{\mathrm{din}} \tag{D.3}$$

$$\text{if} \quad U_{\mathrm{rms(10/12)},i} \geq U_{\mathrm{din}} \quad \text{then} \quad U_{\mathrm{rms-over},i} = U_{\mathrm{rms(10/12)},i} \tag{D.4}$$

NOTE On single-phase systems, there is a single underdeviation assessment and overdeviation assessment value for each interval. On 3-phase 3-wire systems, there are 3 values for each interval. Either 6 values or 3 values can be measured on 4-wire systems.

– **Class S**

No requirement.

D.3 Measurement uncertainty and measuring range

The underlying $U_{\mathrm{rms(10/12)}}$ values should be consistent with the requirements of 5.2.2.

D.4 Aggregation

– **Class A**

Underdeviation assessment:

$$U_{\text{under}} = \frac{U_{\text{din}} - \sqrt{\frac{\sum_{i=1}^{n} U_{\text{rms-under},i}^{2}}{n}}}{U_{\text{din}}} \quad [\%] \tag{D.5}$$

where n = the number of 10/12-cycle r.m.s. values for under- or overdeviation during the aggregation interval

and $U_{\text{rms-under},i}$ is the i^{th} 10/12-cycle r.m.s. value

Overdeviation assessment:

$$U_{\text{over}} = \frac{\sqrt{\frac{\sum_{i=1}^{n} U_{\text{rms-over},i}^{2}}{n}} - U_{\text{din}}}{U_{\text{din}}} \quad [\%] \tag{D.6}$$

where

$U_{\text{rms-over},i}$ is the i^{th} $U_{\text{rms(10/12)}}$ value

NOTE Both underdeviation and overdeviation parameter Equations (D.4) and (D.5) give positive values.

Aggregation should be performed according to 4.4 and 4.5.

– **Class S**

No requirement.

Annex E
(informative)

Class B Measurement Methods

E.1 Background for Class B

References to Class B in this edition of IEC 61000-4-30 exist only to support legacy instruments still in operation.

When IEC 61000-4-30 was first drafted in the final years of the 20th century, the goal was to provide measurement methods that would cause two compliant instruments, when connected to the same signals, to provide identical results.

It was realized at the time that such a standard could make existing, useful instruments obsolete, and this was not the result that was desired. So two classes were defined: Class A, which achieved the goal above, and Class B, which would avoid making existing instruments obsolete. (Class S, for Survey instruments that produce statistically useful but not necessarily identical results, was added later in IEC 61000-4-30:2008 (edition 2).)

Class B instruments existed in 2003 when this standard was first published. IEC 61000-4-30:2008 (edition 2) made it clear that Class B methods are not recommended for new designs. In the present edition, Class B has now been moved from the normative section of this standard to Annex E (informative).

Because Class B exists only to support legacy instruments still in operation but becoming obsolete, it is expected that Class B will be removed from the next edition of this standard.

E.2 Class B – Measurement aggregation over time intervals

The manufacturer should specify the number and duration of aggregation time intervals.

E.3 Class B – Measurement aggregation algorithm

The manufacturer should specify the method of aggregation.

E.4 Class B – Real time clock (RTC) uncertainty

E.4.1 General

The manufacturer should specify the RTC uncertainty and the method to determine aggregation intervals, if any.

E.4.2 Class B – Frequency – Measurement method

The manufacturer should specify the process used for frequency measurement.

E.4.3 Class B – Frequency – Measurement uncertainty

The manufacturer should specify the uncertainty over the measuring ranges 42,5 Hz to 57,5 Hz/51 Hz to 69 Hz.

E.4.4 Class B – Frequency – Measurement evaluation

The manufacturer should indicate the process used for frequency measurement evaluation.

E.4.5 Class B – Magnitude of the supply – Measurement method

The measurement should be the r.m.s. value of the voltage over a period specified by the manufacturer.

E.4.6 Class B – Magnitude of the supply – Measurement uncertainty and measuring range

The measurement uncertainty should be specified by the manufacturer, in such a way as not to exceed ±1 % of U_{din} , over a range specified by the manufacturer.

E.5 Class B – Flicker

E.5.1 General

Not applicable.

E.5.2 Class B – Supply voltage dips and swells – Measurement method

E.5.2.1 General

The manufacturer should specify the method used for U_{rms}.

E.5.2.2 Class B – Supply voltage dips and swells – Magnitude uncertainty

The manufacturer should specify the uncertainty which shall not exceed ±2,0 % of U_{din}.

E.5.2.3 Class B – Supply voltage dips and swells – Duration uncertainty

The manufacturer should specify the duration measurement uncertainty.

E.6 Class B – Voltage interruptions

E.6.1 General

All of 5.5 should apply.

E.6.2 Class B – Supply voltage unbalance – Measurement method

The manufacturer should specify the algorithms and methods used to calculate unbalance.

E.6.3 Class B – Supply voltage unbalance –Uncertainty

Should be the same as 5.7.2, Class A, except for the uncertainty which is less than 0,3 % for any unbalance parameter that is evaluated.

E.6.4 Class B – Voltage harmonics – Measurement method

The manufacturer should specify the measurement method.

E.6.5 Class B –Voltage harmonics – Measurement uncertainty and range

The manufacturer should specify the measurement uncertainty and measurement range.

E.6.6 Class B – Voltage interharmonics – Measurement method

The manufacturer should specify the measurement method.

E.6.7 Class B –Voltage interharmonics – Measurement uncertainty and range

The manufacturer should specify the measurement uncertainty and measurement range.

E.6.8 Class B – Mains signalling voltage – Measurement method

The manufacturer should specify the measurement method.

E.6.9 Class B –Mains signalling voltage – Measurement uncertainty and range

The manufacturer should specify the measurement uncertainty and measurement range.

E.6.10 Class B – Current – Measurement method

No requirement. If included, the manufacturer should specify the measurement method.

E.6.11 Class B – Current – Measurement uncertainty and range

No requirement. If included, the manufacturer should specify the measurement uncertainty and measurement range.

Bibliography

IEC 60044-1:1996, *Instrument transformers – Part 1: Current transformers*

IEC 60044-2:1997, *Instrument transformers – Part 2: Inductive voltage transformers*

~~IEC 60050-101, *International Electrotechnical Vocabulary (IEV) – Part 101: Mathematics*~~

IEC 60050-161, *International Electrotechnical Vocabulary (IEV) – Part 161: Electromagnetic compatibility*

IEC 60050-300, *International Electrotechnical Vocabulary (IEV) – Part 300: Electrical and electronic measurements and measuring instruments*

IEC 60050-311, *International Electrotechnical Vocabulary (IEV) – Part 311: General terms relating to measurements*

IEC 60050-312, *International Electrotechnical Vocabulary (IEV) – Part 312: General terms relating to electrical measurements*

IEC 60050-313, *International Electrotechnical Vocabulary (IEV) – Part 313: Types of electrical measuring instruments*

IEC 60050-314, *International Electrotechnical Vocabulary (IEV) – Part 314: Specific terms according to the type of instruments*

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

IEC TR 61000-2-8, *Electromagnetic compatibility (EMC) – Part 2-8: Environment – Voltage dips and short interruptions on public electric power supply systems with statistical measurement results*

IEC 61000-2-12, *Electromagnetic compatibility (EMC) – Part 2-12: Environment – Compatibility levels for low-frequency conducted disturbances and signalling in public medium-voltage power supply systems – Basic EMC publication*

~~IEC 61000-3-3:1994, *Electromagnetic compatibility (EMC) – Part 3-3: Limits – Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems, for equipment with rated current ≤ 16 A per phase and not subject to conditional connection*~~
~~Amendment 1 (2001) –~~
~~Amendment 2 (2005)~~

IEC TR 61000-3-6:~~2008~~ 1996, *Electromagnetic compatibility (EMC) - Part 3-6: Limits - Assessment of emission limits for distorting loads in MV and HV power systems – Basic EMC publication*

IEC TR 61000-3-7:~~2008~~ 1996, *Electromagnetic compatibility (EMC) - Part 3-7: Limits - Assessment of emission limits for fluctuating loads in MV and HV power systems – Basic EMC publication – Basic EMC publication*

~~IEC 61000-3-11:2000, *Electromagnetic compatibility (EMC) – Part 3: Limits – Section 11: Limitation of voltage changes, voltage fluctuations and flicker in public low-voltage supply systems - Equipment with rated current ≤ 75 A and subject to conditional connection* – Basic EMC publication~~

IEC TR 61000-3-13, *Electromagnetic compatibility (EMC) - Part 3-13: Limits - Assessment of emission limits for the connection of unbalanced installations to MV, HV and EHV power systems*

IEC 61000-4-19, *Electromagnetic compatibility (EMC) – Part 4-19: Testing and measurement techniques – tests for immunity to conducted, differential mode disturbances and signalling in the frequency range 2 kHz to 150 kHz at a.c. power ports*

IEC 61010 (all parts), *Safety requirements for electrical equipment for measurement, control and laboratory use*

IEC 61010-2-032, *Safety requirements for electrical equipment for measurement, control and laboratory use – Part 2-032: Particular requirements for hand-held ~~and hand-manipulated~~ current ~~sensors~~ clamps for electrical measurement and test*

~~IEC 61557-12, *Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. – Equipment for testing, measuring or monitoring of protective measures – Part 12: Performance measuring and monitoring devices (PMD)*~~

IEC 61869-1, *Instrument transformers – Part 1: General requirements*

IEC 61869-2, *Instrument transformers – Part 2: Additional requirements for current transformers*

CISPR 16-1-1, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus*

CISPR 16-1-2, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-2: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Conducted disturbances*

CISPR 16-2-1, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-1: Methods of measurement of disturbances and immunity – Conducted disturbance measurements*

EN 50160:2000, *Voltage characteristics of electricity supplied by public distribution systems*

IEEE 1159:1995, *IEEE Recommended Practice on Monitoring Electrical Power Quality*

Recommendation ITU-R TF.686-3, *Glossary and definitions of time and frequency terms*

____

IEC 61000-4-30

Edition 3.0 2015-02

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

BASIC EMC PUBLICATION

PUBLICATION FONDAMENTALE EN CEM

Electromagnetic compatibility (EMC) – Part 4-30: Testing and measurement techniques – Power quality measurement methods

Compatibilité électromagnétique (CEM) – Partie 4-30: Techniques d'essai et de mesure – Méthodes de mesure de la qualité de l'alimentation

IEC 61000-4-30:2015-02(en-fr)

CONTENTS

INTERNATIONAL ELECTROTECHNICAL COMMISSION

____

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 4-30: Testing and measurement techniques – Power quality measurement methods

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 61000-4-30 has been prepared by subcommittee 77A: EMC – Low-frequency phenomena, of IEC technical committee 77: Electromagnetic compatibility.

This standard forms part 4-30 of IEC 61000. It has the status of a basic EMC publication in accordance with IEC Guide 107.

This third edition cancels and replaces the second edition published in 2008. This edition constitutes a technical revision.

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

a) the measurement method for current, previously informative, is now normative with some changes;

b) the measurement method for RVC (rapid voltage change) has been added;

c) the measurement method for conducted emissions in the 2 kHz to 150 kHz range has been added in informative Annex C;

d) underdeviation and overdeviation parameters are moved to informative Annex D;

e) Class A and Class S measurement methods are defined and clarified, while Class B is moved to informative Annex E and considered for future removal;

f) measurement methods continue in this standard, but responsibility for influence quantities, performance, and test procedures are transferred to IEC 62586-2.

The text of this standard is based on the following documents:

FDIS	Report on voting
77A/873/FDIS	77A/878/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 61000 series, published under the general title *Electromagnetic compatibility (EMC)*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

The contents of the corrigendum of December 2016 have been included in this copy.

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.

INTRODUCTION

IEC 61000 is published in separate parts according to the following structure:

Part 1: General

General considerations (introduction, fundamental principles)

Definitions, terminology

Part 2: Environment

Description of the environment

Classification of the environment

Compatibility levels

Part 3: Limits

Emission limits

Immunity limits (in so far as they do not fall under the responsibility of the product committees)

Part 4: Testing and measurement techniques

Measurement techniques

Testing techniques

Part 5: Installation and mitigation guidelines

Installation guidelines

Mitigation methods and devices

Part 6: Generic standards

Part 9: Miscellaneous

Each part is further subdivided into several parts, published either as International Standards or as Technical Specifications or Technical Reports, some of which have already been published as sections. Others will be published with the part number followed by a dash and completed by a second number identifying the subdivision (example: 61000-6-1).

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 4-30: Testing and measurement techniques – Power quality measurement methods

1 Scope

This part of IEC 61000-4 defines the methods for measurement and interpretation of results for power quality parameters in a.c. power supply systems with a declared fundamental frequency of 50 Hz or 60 Hz.

Measurement methods are described for each relevant parameter in terms that give reliable and repeatable results, regardless of the method's implementation. This standard addresses measurement methods for in-situ measurements.

Measurement of parameters covered by this standard is limited to conducted phenomena in power systems. The power quality parameters considered in this standard are power frequency, magnitude of the supply voltage, flicker, supply voltage dips and swells, voltage interruptions, transient voltages, supply voltage unbalance, voltage harmonics and interharmonics, mains signalling on the supply voltage, rapid voltage changes, and current measurements. Emissions in the 2 kHz to 150 kHz range are considered in Annex C (informative), and over- and underdeviations are considered in Annex D (informative). Depending on the purpose of the measurement, all or a subset of the phenomena on this list may be measured.

NOTE 1 Test methods for verifying compliance with this standard can be found in IEC 62586-2.

NOTE 2 The effects of transducers inserted between the power system and the instrument are acknowledged but not addressed in detail in this standard. Guidance about effects of transducers can be found IEC TR 61869-103.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60050 (all parts), *International Electrotechnical Vocabulary (IEV)* (available at www.electropedia.org)

IEC 61000-2-4, *Electromagnetic compatibility (EMC) – Part 2-4: Environment – Compatibility levels in industrial plants for low-frequency conducted disturbances*

IEC 61000-3-8, *Electromagnetic compatibility (EMC) – Part 3: Limits – Section 8: Signalling on low-voltage electrical installations – Emission levels, frequency bands and electromagnetic disturbance levels*

IEC 61000-4-7:2002, *Electromagnetic compatibility (EMC) – Part 4-7: Testing and measurement techniques – General guide on harmonics and interharmonics measurements and instrumentation, for power supply systems and equipment connected thereto*
IEC 61000-4-7:2002/AMD1:2008

IEC 61000-4-15:2010, *Electromagnetic compatibility (EMC) – Part 4-15: Testing and measurement techniques – Flickermeter – Functional and design specifications*

IEC 61180 (all parts), *High-voltage test techniques for low voltage equipment*

IEC 62586-1, *Power quality measurement in power supply systems – Part 1: Power quality instruments (PQI)*

IEC 62586-2, *Power quality measurement in power supply systems – Part 2: Functional tests and uncertainty requirements*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-161, as well as the following apply.

3.1
channel
individual measurement path through an instrument

Note 1 to entry: "Channel" and "phase" are not the same. A voltage channel is by definition the difference in potential between 2 conductors. Phase refers to a single conductor. On polyphase systems, a channel may be between 2 phases, or between a phase and neutral, or between a phase and earth, or between neutral and earth.

3.2
declared input voltage
U_{din}
value obtained from the declared supply voltage by a transducer ratio

3.3
declared supply voltage
U_{c}
normally the nominal voltage U_{n} of the system.

Note 1 to entry: If by agreement between the supplier and the customer a voltage different from the nominal voltage is applied to the terminals, then this voltage is the declared supply voltage U_{c}.

3.4
dip threshold
voltage magnitude specified for the purpose of detecting the start and the end of a voltage dip

3.5
flagged data
for any measurement time interval in which interruptions, dips or swells occur, the marked measurement results of all other parameters made during this time interval

Note 1 to entry: For some applications, this 'marked' or 'flagged' data may be excluded from further analysis, for example. See 4.7 for further explanation.

3.6
flicker
impression of unsteadiness of visual sensation induced by a light stimulus whose luminance or spectral distribution fluctuates with time

[SOURCE: IEC 60050-161:1990, 161-08-13]

3.6.1
P_{st}
short-term flicker evaluation based on an observation period of 10 min

[SOURCE: IEC 61000-4-15]

3.6.2
P_{lt}
long-term flicker evaluation

[SOURCE: IEC 61000-4-15]

3.7
fundamental component
component whose frequency is the fundamental frequency

3.8
fundamental frequency
frequency in the spectrum obtained from a Fourier transform of a time function, to which all the frequencies of the spectrum are referred

Note 1 to entry: In case of any remaining risk of ambiguity, the fundamental frequency may be derived from the number of poles and speed of rotation of the synchronous generator(s) feeding the system.

3.9
harmonic component
any of the components having a harmonic frequency

Note 1 to entry: Its value is normally expressed as an r.m.s value. For brevity, such component may be referred to simply as a harmonic.

[SOURCE: IEC 61000-2-2:2002, 3.2.4,]

3.10
harmonic frequency
frequency which is an integer multiple of the fundamental frequency

Note 1 to entry: The ratio of the harmonic frequency to the fundamental frequency is the harmonic order (recommended notation: n) (IEC 61000-2-2:2002, 3.2.3).

3.11
hysteresis
difference in magnitude between the start and end thresholds

Note 1 to entry: This definition of hysteresis is relevant to PQ measurement parameters and is different from the IEC 60050 definition which is relevant to iron core saturation.

Note 2 to entry: The purpose of hysteresis in the context of PQ measurements is to avoid counting multiple events when the magnitude of the parameter oscillates about the threshold level.

3.12
influence quantity
quantity which is not the subject of the measurement and whose change affects the relationship between the indication and the result of the measurement

[SOURCE: IEC 60050-311:2001, 311-06-01]

3.13
interharmonic component
spectral component with a frequency between two consecutive harmonic frequencies

Note 1 to entry: The definition is derived from IEC 61000-4-7.

Note 2 to entry: Its value is normally expressed as an r.m.s value. For brevity, such a component may be referred to simply as an interharmonic.

3.14
interharmonic frequency
any frequency which is not an integer multiple of the fundamental frequency

Note 1 to entry: By extension from the harmonic order, the interharmonic order is the ratio of an interharmonic frequency to the fundamental frequency. This ratio is not an integer (recommended notation m).

Note 2 to entry: In the case where $m < 1$ the term subharmonic frequency may be used.

[SOURCE: IEC 61000-2-2:2002, 3.2.5]

3.15
interruption
reduction of the voltage at a point in the electrical system below the interruption threshold

3.16
interruption threshold
voltage magnitude specified for the purpose of detecting the start and the end of a voltage interruption

3.17
measurement uncertainty
parameter, associated with the result of a measurement, that characterizes the dispersion of the values that could reasonably be attributed to the measurand

[SOURCE: IEC 60050-311:2001, 311-01-02]

3.18
nominal voltage
U_{n}
voltage by which a system is designated or identified

3.19
overdeviation
difference between the measured value and the nominal value of a parameter, only when the measured value of the parameter is greater than the nominal value

3.20
power quality
characteristics of the electricity at a given point on an electrical system, evaluated against a set of reference technical parameters

Note 1 to entry: These parameters might, in some cases, relate to the compatibility between electricity supplied on a network and the loads connected to that network.

3.21
root-mean-square value
r.m.s. value
square root of the arithmetic mean of the squares of the instantaneous values of a quantity taken over a specified time interval and a specified bandwidth

[SOURCE: IEC 60050-103:2009, 103-02-03]

3.22
r.m.s. voltage refreshed each half-cycle
$U_{\mathrm{rms(½)}}$
value of the r.m.s. voltage measured over 1 cycle, commencing at a fundamental zero crossing, and refreshed each half-cycle

Note 1 to entry: This technique is independent for each channel and will produce r.m.s. values at successive times on different channels for polyphase systems.

Note 2 to entry: This value is used only for voltage dip, voltage swell, interruption, and RVC detection and evaluation, in Class A.

Note 3 to entry: This r.m.s. voltage value may be a phase-to-phase value or a phase-to-neutral value.

3.23
r.m.s. current refreshed each half-cycle
$I_{\mathrm{rms}(½)}$
value of the r.m.s. current measured over 1 cycle, commencing at a fundamental zero crossing on an associated voltage channel, and refreshed each half-cycle

Note 1 to entry: For guidance, the associated voltage channel might be the corresponding phase-to-neutral channel on single-phase or star networks. If there is no corresponding voltage channel, for example on delta network currents, or earth current or neutral current measurements, then the reference channel (see 5.1.3) used for frequency measurements might be used.

3.24
r.m.s. voltage refreshed each cycle
$U_{\mathrm{rms}(1)}$
value of the r.m.s. voltage measured over 1 cycle and refreshed each cycle

Note 1 to entry: In contrast to $U_{\mathrm{rms}(½)}$, this technique does not define when a cycle commences.

Note 2 to entry: This value is used only in Class S, and is used for voltage dip, voltage swell, and interruption detection and evaluation.

Note 3 to entry: This r.m.s. voltage value can be a phase-to-phase value or a phase-to-neutral value.

3.25
range of influence quantities
range of values of a single influence quantity

3.26
rapid voltage change
RVC
a quick transition in r.m.s. voltage occurring between two steady-state conditions, and during which the r.m.s. voltage does not exceed the dip/swell thresholds

Note 1 to entry: This note applies to the French language only.

3.27
reference channel
one of the voltage measurement channels designated as the reference channel for polyphase measurements

Note 1 to entry: In the case of a single-phase measurement, the voltage measuring channel is also the reference channel.

3.28
residual voltage
U_{res}
minimum value of $U_{\mathrm{rms}(½)}$ recorded during a voltage dip or interruption

Note 1 to entry: The residual voltage is expressed as a value in volts, or as a percentage or per unit value of the declared input voltage.

3.29
sliding reference voltage
U_{sr}
voltage magnitude averaged over one minute, representing the voltage preceding a voltage dip or swell

Note 1 to entry: It is precisely defined in 5.4.4.

Note 2 to entry: The sliding reference voltage may be used to determine the voltage change during a dip or a swell, typically for medium-voltage or high-voltage systems.

3.30
swell threshold
voltage magnitude specified for the purpose of detecting the start and the end of a swell

3.31
time aggregation
combination of several sequential values of a given parameter (each determined over identical time intervals) to provide a value for a longer time interval

Note 1 to entry: Aggregation in this document always refers to time aggregation.

3.32
underdeviation
absolute value of the difference between the measured value and the nominal value of a parameter, only when the value of the parameter is lower than the nominal value

3.33
UTC
coordinated universal time
time scale which forms the basis of a coordinated radio dissemination of standard frequencies and time signals which corresponds exactly in rate with international atomic time, but differs from it by an integral number of seconds

Note 1 to entry: Coordinated universal time is established by the International Bureau of Weights and Measures (BIPM) and the International Earth Rotation Service (IERS).

Note 2 to entry: The UTC scale is adjusted by the insertion or deletion of seconds, so called positive or negative leap seconds, to ensure approximate agreement with UT1.

Note 3 to entry: This note applies to the French language only.

[SOURCE: Recommendation ITU-R RF.686.3]

3.34
voltage dip
temporary reduction of the voltage magnitude at a point in the electrical system below a threshold

Note 1 to entry: Interruptions are a special case of a voltage dip. Post-processing may be used to distinguish between voltage dips and interruptions.

Note 2 to entry: A voltage dip is also referred to as sag. The two terms are considered interchangeable; however, this standard will only use the term voltage dip.

3.35
voltage swell
temporary increase of the voltage magnitude at a point in the electrical system above a threshold

3.36
voltage unbalance
condition in a polyphase system in which the r.m.s. values of the line voltages (fundamental component), and/or the phase angles between consecutive line voltages, are not all equal

Note 1 to entry: The degree of the inequality is usually expressed as the ratios of the negative- and zero-sequence components to the positive-sequence component.

Note 2 to entry: In this standard, voltage unbalance is considered in relation to 3-phase systems.

[SOURCE: IEC 60050-161:2002, 161-08-09, modified – notes to entry have been added]

4 General

4.1 Classes of measurement

For each parameter measured, two classes, A and S, are defined in this standard. For each class, measurement methods and appropriate performance requirements are included.

– **Class A**

This class is used where precise measurements are necessary, for example, for contractual applications that may require resolving disputes, verifying compliance with standards, etc. Any measurements of a parameter carried out with two different instruments complying with the requirements of Class A, when measuring the same signals, will produce matching results within the specified uncertainty for that parameter.

NOTE 1 Class A measurements produce matching results only if the user-selected parameters (thresholds, hysteresis, etc.) match.

– **Class S**

This class is used for statistical applications such as surveys or power quality assessment, possibly with a limited subset of parameters. Although it uses equivalent intervals of measurement as Class A, the Class S processing requirements are much lower. Some surveys may assess power quality parameters of several measurement sites on a network; other surveys assess power quality parameters at a single site over a period of time, or at locations within a building or even within a single large piece of equipment.

– **Class B**

For Class B information, see Annex E (informative) of this standard. Class B methods shall not be employed for new instruments. Class B is moved to Annex E on the basis that all new instrument designs will comply with either Class A or Class S. Class B may be relevant for legacy instruments that are still in use. Class B may be removed in the next edition of this standard.

NOTE 2 Class B measurement methods will provide useful but not necessarily comparable information. Class B was introduced in IEC 61000-4-30:2003 (edition 1) specifically to avoid making older instrument designs obsolete. IEC 61000-4-30:2008 (edition 2) warned that Class B may be removed in a future edition of this standard. IEC 61000-4-30:– (this edition 3) warns again that Class B may be removed in a future edition, and moves Class B to Informative Annex E.

NOTE 3 In this standard, “A” stands for “Advanced”, and “S” stands for “Surveys”.

Users shall select the class that they require, based on their application(s). For troubleshooting applications, depending on the type of problem either Class A or Class S methods may be selected by the user.

The instrument manufacturer should declare influence quantities which are not expressly given and which may degrade performance of the instrument.

An instrument may measure some or all of the parameters identified in this standard, and preferably uses the same class for all parameters. For guidance, see IEC 62586-1 and IEC 62586-2.

The instrument manufacturer shall declare which parameters are measured, which class is used for each parameter, the range of U_{din} for which each class is fulfilled, and all the necessary requirements and accessories (synchronization, probes, calibration period, temperature ranges, etc.) to meet each class.

4.2 Organization of the measurements

The electrical quantity to be measured may be either directly accessible, as is generally the case in low-voltage systems, or accessible via measurement transducers.

The whole measurement chain is shown in Figure 1.

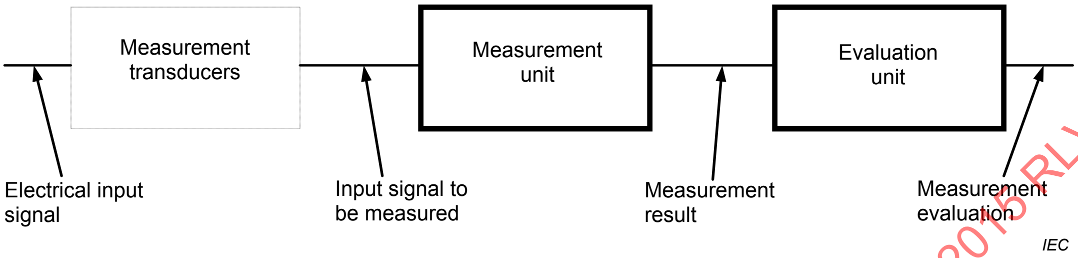


Figure 1 – Measurement chain

An "instrument" may include the whole measurement chain (see Figure 1). In this standard, the normative part does not consider any possible measurement transducers external to the instrument and their associated uncertainty, but Clause A.2 gives guidance.

4.3 Electrical values to be measured

Measurements can be performed on single-phase or polyphase supply systems. Depending on the context, it may be necessary to measure voltages between phase conductors and neutral (line-to-neutral) or between phase conductors (line-to-line) or between phase conductors or neutral and earth (phase-to-earth, neutral-to-earth). It is not the purpose of this standard to impose the choice of the electrical values to be measured. Moreover, except for the measurement of voltage unbalance, which is intrinsically polyphase, the measurement methods specified in this document are such that independent results can be produced on each measurement channel.

NOTE Phase-to-phase instantaneous values can be measured directly, or can be derived from instantaneous phase-to-neutral measured values or from phase-to-earth measured values.

Current measurements may be performed on each conductor of supply systems, including the neutral conductor and the protective earth conductor (see 5.13).

4.4 Measurement aggregation over time intervals

– **Class A**

The basic measurement time interval for parameter magnitudes (supply voltage, harmonics, interharmonics and unbalance) shall be a 10-cycle time interval for a 50 Hz power system or a 12-cycle time interval for a 60 Hz power system.

The 10/12-cycle measurement shall be re-synchronized at every UTC (coordinated universal time) 10-min tick. See Figure 2.

NOTE 1 The uncertainty of this measurement is included in the uncertainty measurement protocol of each parameter.

The 10/12-cycle values are then aggregated over 3 additional intervals:

- 150/180-cycle interval (150 cycles for 50 Hz nominal or 180 cycles for 60 Hz nominal),
- 10-min interval,
- 2-hour interval for P_{lt} flicker.

NOTE 2 A 2-hour aggregation interval is optional for all parameters, with the exception of flicker measurements which require a 2-hour aggregation interval for P_{lt}. This 2-hour aggregation interval may possibly be useful in some applications, and may possibly be necessary for measuring compliance with some national or international standards.

NOTE 3 Clauses B.1 and B.2 discuss some applications of these aggregation time intervals.

– **Class S**

Same time intervals as Class A.

4.5 Measurement aggregation algorithm

4.5.1 Requirements

Aggregations shall be performed using the square root of the arithmetic mean of the squared input values.

For flicker measurements, a different aggregation algorithm is used (see IEC 61000-4-15).

4.5.2 150/180-cycle aggregation

– **Class A**

The data for the 150/180-cycle time interval shall be aggregated without gap from fifteen 10/12-cycle time intervals.

The 150/180-cycle time interval is resynchronized upon the UTC 10-min tick as shown in Figure 2.

When a 10-min tick occurs, a new 150/180-cycle time interval begins, and the pending 150/180-cycle time interval also continues until it is completed. This may create an overlap between these two 150/180-cycle intervals (overlap 2 in Figure 2).

– **Class S**

The data for the 150/180-cycle time interval shall be aggregated from 10/12-cycle time intervals. Resynchronization with the UTC 10-min tick is permitted but not mandatory. (See Figure 3.)

Gaps are permitted but not mandatory for harmonics, interharmonics, mains signalling voltage and unbalance. A minimum of three 10/12-cycle values shall be used each 150/180-cycle time interval, i.e. at least one 10/12-cycle value shall be used each 50/60 cycles (see Figure 4). For all other parameters, the data for the 150/180-cycle time interval shall be aggregated without gap from fifteen 10/12-cycle time intervals.

4.5.3 10-min aggregation

– **Class A**

The 10-min aggregated value shall be tagged with the UTC time (for example, 01H10.00,000) at the conclusion of the 10-min aggregation interval, rounded to the nearest second.

NOTE In some circumstances, it can be useful to use local time, which can differ from UTC by a fixed offset, or an offset that can vary based on time of year. This type of time stamp often includes both a time and a date. This type of time stamp can be referred to as “absolute time”.

The data for the 10-min time interval shall be aggregated from 10/12-cycle time intervals.

Each 10-minute interval shall begin on a UTC 10-min tick. The 10-min tick is also used to re-synchronize the 10/12-cycle intervals and the 150/180-cycle intervals. See Figure 2.

The final 10/12-cycle interval(s) in a 10-min aggregation period will typically overlap in time with the UTC 10-min clock tick. Any overlapping 10/12-cycle interval (overlap 1 in Figure 2) is included in the aggregation of the previous 10-min interval.

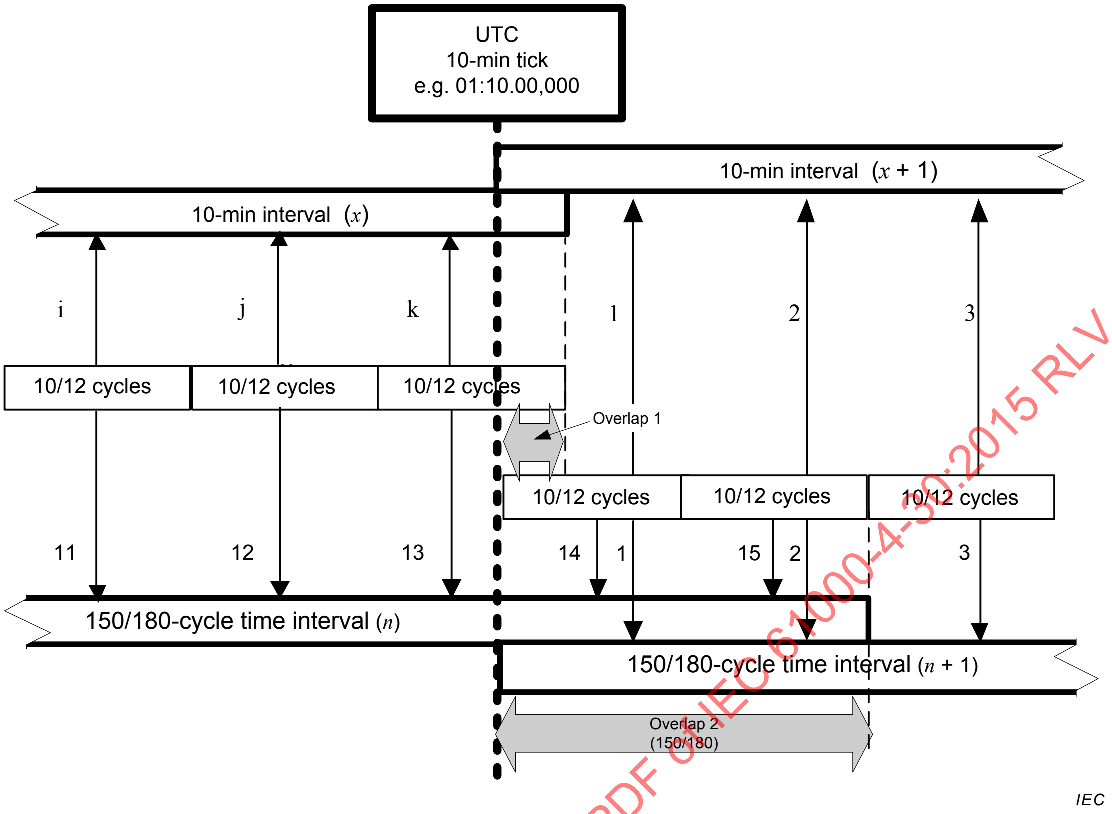


Figure 2 – Synchronization of aggregation intervals for Class A

– **Class S**

The 10-min aggregation method used for Class S shall be either the Class A method, or the following simplified method:

The data for the 10-min time interval shall be aggregated from 10/12-cycle time intervals. There is no resynchronization on the UTC 10-min tick. The 10-min intervals are free running.

The 10-min aggregated value shall be tagged with the time at the conclusion of the 10-min aggregation interval (e.g. 01h10.00,040).

There will be no overlap, as illustrated in Figure 3 and Figure 4.

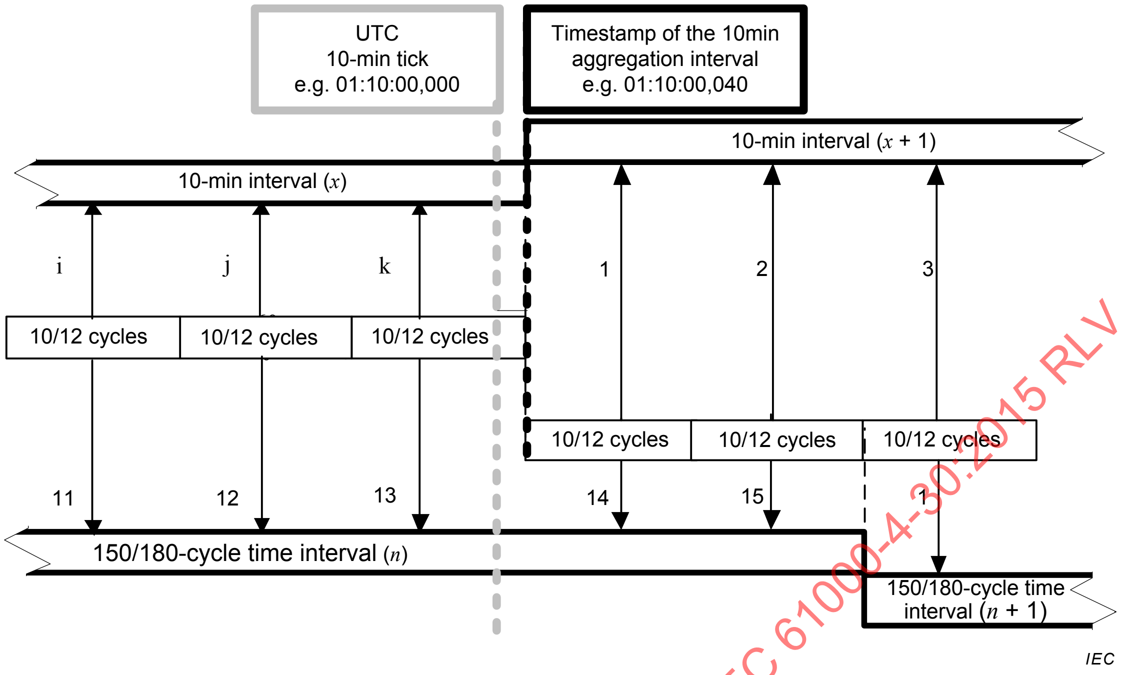


Figure 3 – Synchronization of aggregation intervals for Class S: parameters for which gaps are not permitted

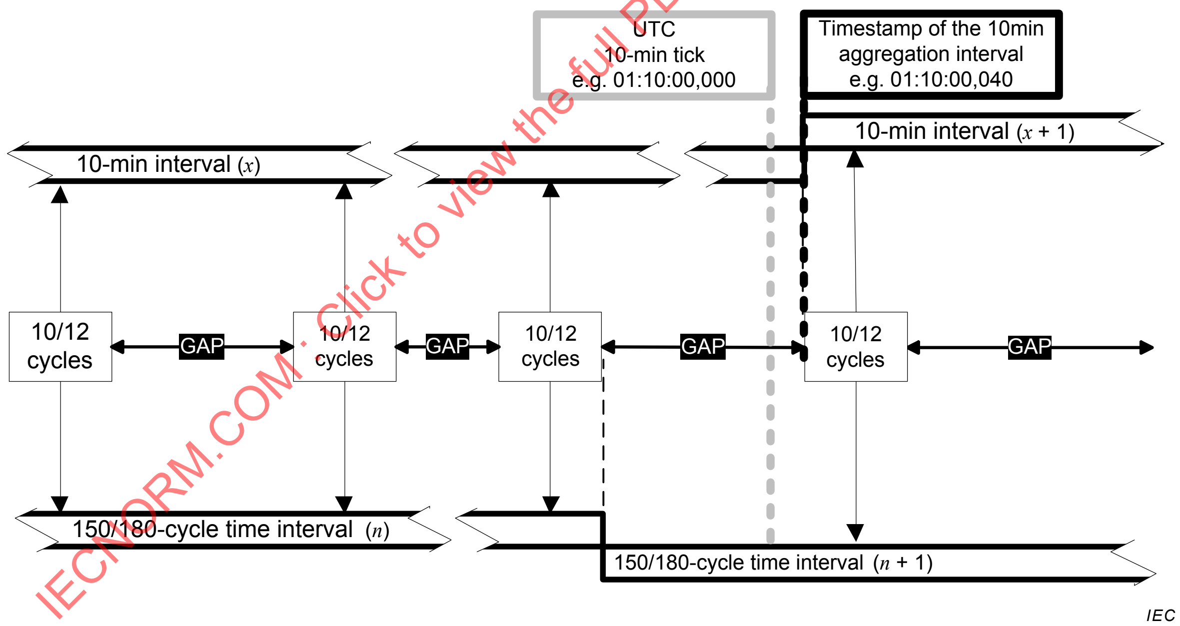


Figure 4 – Synchronization of aggregation intervals for Class S: parameters for which gaps are permitted (see 4.5.2)

4.5.4 2-hour aggregation

– **Class A**

The data for the 2-hour interval shall be aggregated from twelve 10-min intervals. The 2-hour interval shall be gapless and not overlapping.

– **Class S**

Same as Class A.

4.6 Time-clock uncertainty

Time-clock uncertainty is defined relative to coordinated universal time (UTC), which is continuously incrementing and available world-wide.

NOTE 1 The time clock may move forward or backward under certain circumstances, such as daylight savings time, external synchronization updates, etc. When the clock moves forward in time, there may be gaps in the data. When the clock moves backwards in time, data may overlap in time.

– **Class A**

The time-clock uncertainty shall not exceed ±20 ms for 50 Hz or ±16,7 ms for 60 Hz, regardless of the total time interval.

NOTE 2 This performance can be achieved, for example, through a synchronization procedure applied periodically during a measurement campaign, through a GPS receiver, or through reception of transmitted radio timing signals or by using network timing signals.

When synchronization by an external signal becomes unavailable, the time tagging tolerance shall be better than ±1 s per 24-h period; however, this exception does not eliminate the requirement for compliance with the first part of this paragraph.

NOTE 3 This performance is necessary to ensure that two instruments using Class A methods produce the same 10-min aggregation results when connected to the same signal.

– **Class S**

The time-clock uncertainty shall not exceed ±5 s per 24-h period.

4.7 Flagging concept

During a dip, swell, or interruption, the measurement algorithm for other parameters (for example, frequency measurement) might produce an unreliable value. The flagging concept avoids counting a single event more than once in different parameters (for example, counting a single dip as both a dip and a frequency variation), and indicates that an aggregated value might be unreliable.

Flagging is only triggered by dips, swells, and interruptions. The detection of dips and swells is dependent on the threshold selected by the user, and this selection will influence which data are "flagged".

The flagging concept is applicable for Class A and Class S during measurement of power frequency, voltage magnitude, flicker, supply voltage unbalance, voltage harmonics, voltage interharmonics, mains signalling and measurement of underdeviation and overdeviation parameters.

If during a given time interval any value is flagged, the aggregated value which includes that value shall also be flagged. The flagged value shall be stored and also included in the aggregation process. For example, if during a given time interval any value is flagged, then the aggregated value that includes this value shall also be flagged and stored.

NOTE 1 Information about other types of flagging, or data marking, can be found in IEC 62586-1.

NOTE 2 The user can decide how to evaluate flagged data.

5 Power quality parameters

5.1 Power frequency

5.1.1 Measurement method

– **Class A**

The frequency reading shall be obtained every 10 s. As power frequency may not be exactly 50 Hz or 60 Hz within the 10-s time clock interval, the number of cycles may not be an integer number. The fundamental frequency output is the ratio of the number of integral cycles counted during the 10-s time clock interval, divided by the cumulative duration of the integer cycles.

When a zero crossing method is used for frequency calculation, then, before the assessment, harmonics and interharmonics shall be attenuated to minimize the effects of multiple zero crossings.

The measurement time intervals shall be non-overlapping. Individual cycles that overlap the 10-s time clock are discarded. Each 10-s interval shall begin on an absolute 10-s time clock, with uncertainty as defined in 4.6.

Other techniques that provide equivalent results, such as convolution, are acceptable.

NOTE For some applications, the use of time intervals shorter than 10 s may possibly be useful, such as 10/12 cycles (wind turbines), 1 s (national standards), etc.

– **Class S**

Same as Class A.

5.1.2 Measurement uncertainty and measuring range

– **Class A**

Under the conditions described in Clause 6, the measurement uncertainty shall not exceed ±10 mHz over the measuring ranges 42,5 Hz to 57,5 Hz / 51 Hz to 69 Hz.

– **Class S**

Under the conditions described in Clause 6, the measurement uncertainty shall not exceed ±50 mHz over the measuring ranges 42,5 Hz to 57,5 Hz / 51 Hz to 69 Hz.

5.1.3 Measurement evaluation

– **Class A**

The frequency measurement shall be made on the reference channel.

The manufacturer shall specify the behaviour of frequency measurement whenever the reference channel loses voltage.

– **Class S**

Same as Class A.

5.1.4 Aggregation

Aggregation is not mandatory.

5.2 Magnitude of the supply voltage

5.2.1 Measurement method

– **Class A**

The measurement shall be the r.m.s. value of the voltage magnitude over a 10-cycle time interval for a 50 Hz power system or a 12-cycle time interval for a 60 Hz power system. Every 10/12-cycle interval shall be contiguous, and not overlapping with adjacent 10/12-cycle intervals except as shown in overlap 1 in Figure 2.

NOTE 1 This specific measurement method is used for quasi-stationary signals and is not used for the detection and measurement of disturbances: dips, swells, voltage interruptions and transients.

NOTE 2 The r.m.s. value includes, by definition, harmonics, interharmonics, mains signalling, etc.

– **Class S**

Same as Class A.

5.2.2 Measurement uncertainty and measuring range

– **Class A**

Under the conditions described in Clause 6, the measurement uncertainty shall not exceed ±0,1 % of U_{din}, over the range of 10 % to 150 % of U_{din}.

– **Class S**

Under the conditions described in Clause 6, the measurement uncertainty shall not exceed ±0,5 % of U_{din}, over the range of 20 % to 120 % of U_{din}.

5.2.3 Measurement evaluation

No requirements.

5.2.4 Aggregation

Aggregation shall be performed according to 4.4 and 4.5.

5.3 Flicker

5.3.1 Measurement method

– **Class A**

IEC 61000-4-15 Class F3 applies as the minimum requirement. Class F3 should not be used for new designs. Class F1 is recommended, and may be required in the next edition of this standard.

– **Class S**

IEC 61000-4-15 Class F3 applies as the minimum requirement.

5.3.2 Measurement uncertainty and measuring range

– **Class A**

See IEC 61000-4-15. Under the conditions described in Clause 6, the measurement uncertainty required by 61000-4-15 shall be met over the measuring range of 0,2 P_{st} to10 P_{st}.

– **Class S**

See IEC 61000-4-15. Under the conditions described in Clause 6, twice the permitted measurement uncertainty required by 61000-4-15 shall be met over the measuring range of 0,4 P_{st} to 4 P_{st}.

5.3.3 Measurement evaluation

– **Class A**

IEC 61000-4-15 applies.

The 10-min time interval for P_{st} shall commence on a UTC 10-min tick, and shall be tagged with the time at the conclusion of the interval (see 4.5.3).

Voltage dips, swells, and interruptions shall cause P_{st} and P_{lt} output values (see IEC 61000-4-15) to be flagged.

– **Class S**

Same as Class A.

5.3.4 Aggregation

– **Class A**

Aggregation shall be performed according to IEC 61000-4-15.

– **Class S**

Same as Class A.

5.4 Supply voltage dips and swells

5.4.1 Measurement method

– **Class A**

The basic measurement U_{rms} of a voltage dip and swell shall be the $U_{rms(½)}$ on each measurement channel (see 3.22).

The cycle duration for $U_{rms(½)}$ depends on the frequency. The frequency might be determined by the last non-flagged power frequency measurement (see 4.7 and 5.1), or by any other method that yields the uncertainty requirements of Clause 6.

NOTE 1 The $U_{rms(½)}$ value includes, by definition, harmonics, interharmonics, mains signalling voltage, etc.

NOTE 2 It is important to avoid loss of data when dips and swells occur in a rapid sequence (for example, three events in one second, with up to one minute between sequences, could possibly occur when a recloser operates into a sustained fault). If, during a rapid burst, the dip/swell event characteristics cannot be recorded, then a count of events could possibly be useful.

– **Class S**

The basic measurement U_{rms} of a voltage dip and swell shall be either the $U_{rms(½)}$ on each measurement channel (see Clause 3.22), or the $U_{rms(1)}$ on each measurement channel (see Clause 3.23). The manufacturer shall specify which measurement is used.

NOTE 3 The $U_{rms(1)}$ value includes, by definition, harmonics, interharmonics, mains signalling voltage, etc.

5.4.2 Detection and evaluation of a voltage dip

5.4.2.1 Voltage dip detection

The dip threshold is a percentage of either U_{din} or the sliding voltage reference U_{sr} (see 5.4.4). The user shall declare the reference voltage in use.

NOTE The sliding voltage reference U_{sr} is generally not used in LV systems. See IEC TR 61000-2-8 for further information and advice.

– On single-phase systems a voltage dip begins when the U_{rms} voltage falls below the dip threshold, and ends when the U_{rms} voltage is equal to or above the dip threshold plus the hysteresis voltage.

– On polyphase systems a dip begins when the U_{rms} voltage of one or more channels is below the dip threshold and ends when the U_{rms} voltage on all measured channels is equal to or above the dip threshold plus the hysteresis voltage.

The dip threshold and the hysteresis voltage are both set by the user according to the application.

5.4.2.2 Voltage dip evaluation

A voltage dip is characterized by a pair of data, either residual voltage (U_{res}) or depth, and duration:

– the residual voltage of a voltage dip is the lowest U_{rms} value measured on any channel during the dip;

– the depth is the difference between the reference voltage (either U_{din} or U_{sr}) and the residual voltage. It is generally expressed in percentage of the reference voltage.

NOTE 1 During the dip it may be useful to also record the lowest $U_{rms(½)}$ on each channel, in addition to the residual voltage of the dip. The duration spent below the dip threshold on each channel may also be useful.

NOTE 2 If voltage waveforms are recorded before, during, and after a dip, useful information about phase angle changes may be available in the recorded data.

The start time of a dip shall be time stamped with the time of the end of the U_{rms} of the channel that initiated the event and the end time of the dip shall be time stamped with the time of the end of the U_{rms} that ended the event, as defined by the threshold plus the hysteresis.

The duration of a voltage dip is the time difference between the start time and the end time of the voltage dip.

NOTE 3 For polyphase measurements, the dip duration can start on one channel and terminate on a different channel.

NOTE 4 Voltage dip envelopes are not necessarily rectangular. As a consequence, for a given voltage dip, the measured duration is dependent on the selected dip threshold value. The shape of the envelope can be assessed using several dip thresholds set within the range of voltage dip and voltage interruption thresholds.

NOTE 5 Typically, the hysteresis is equal to 2 % of U_{din}.

NOTE 6 Dip thresholds are typically in the range 85 % to 90 % of the fixed voltage reference for troubleshooting or statistical applications.

NOTE 7 Residual voltage is often useful to end-users, and can be preferred because it is referenced to zero volts. In contrast, depth is often useful to electric suppliers, especially on HV systems or in cases when a sliding reference voltage is used.

NOTE 8 Phase shift can occur during voltage dips. See A.5.5.

NOTE 9 When a threshold is crossed, a time stamp can be recorded.

5.4.3 Detection and evaluation of a voltage swell

5.4.3.1 Voltage swell detection

The swell threshold is a percentage of either U_{din} or the sliding reference voltage U_{sr} (see 5.4.4). The user shall declare the reference voltage in use.

NOTE Sliding reference voltage U_{sr} is generally not used in LV systems. See IEC TR 61000-2-8 for further information and advice.

– On single-phase systems a swell begins when the U_{rms} voltage rises above the swell threshold, and ends when the U_{rms} voltage is equal to or below the swell threshold minus the hysteresis voltage.
– On polyphase systems a swell begins when the U_{rms} voltage of one or more channels is above the swell threshold and ends when the U_{rms} voltage on all measured channels is equal to or below the swell threshold minus the hysteresis voltage.

The swell threshold and the hysteresis voltage are both set by the user according to the application.

5.4.3.2 Voltage swell evaluation

A voltage swell is characterized by a pair of data: maximum swell voltage magnitude and duration:

– the maximum swell magnitude voltage is the largest U_{rms} value measured on any channel during the swell;
– the start time of a swell shall be time stamped with the time of the end of the U_{rms} of the channel that initiated the event and the end time of the swell shall be the time stamped with the time of the end of the U_{rms} that ended the event, as defined by the threshold minus the hysteresis;
– the duration of a voltage swell is the time difference between the beginning and the end of the swell.

NOTE 1 For polyphase measurements, the swell duration measurement can start on one channel and terminate on a different channel.

NOTE 2 Voltage swell envelope may possibly not be rectangular. As a consequence, for a given swell, the measured duration is dependent on the swell threshold value.

NOTE 3 Typically, the hysteresis is equal to 2 % of U_{din}.

NOTE 4 Typically, the swell threshold is greater than 110 % of U_{din}.

NOTE 5 Phase shift can also occur during voltage swells.

NOTE 6 When a threshold is crossed, a time stamp can be recorded.

5.4.4 Calculation of a sliding reference voltage

The sliding reference voltage implementation is optional, not mandatory. If a sliding reference is chosen for voltage dip or swell detection, this shall be calculated using a first-order filter with a 1-min time constant. This filter is given by

$$U_{sr(n)} = 0{,}9967 \times U_{sr(n-1)} + 0{,}0033 \times U_{(10/12)rms}$$

where

$U_{sr(n)}$ is the present value of the sliding reference voltage;

$U_{sr(n-1)}$ is the previous value of the sliding reference voltage; and

$U_{(10/12)rms}$ is the most recent 10/12-cycle r.m.s. value.

When the measurement is started, the initial value of the sliding reference voltage is set to the declared input voltage. The sliding reference voltage is updated every 10/12 cycles. If a 10/12-cycle value is flagged, the sliding reference voltage is not updated and the previous value is used.

5.4.5 Measurement uncertainty and measuring range

5.4.5.1 Residual voltage and swell voltage magnitude measurement uncertainty

– **Class A**

The measurement uncertainty shall not exceed ±0,2 % of U_{din}.

– **Class S**

The measurement uncertainty shall not exceed ±1,0 % of U_{din}.

5.4.5.2 Duration measurement uncertainty

– **Class A**

The uncertainty of a dip or swell duration is equal to the dip or swell commencement uncertainty (half a cycle) plus the dip or swell conclusion uncertainty (half a cycle).

– **Class S**

If $U_{rms(½)}$ is used, then the uncertainty of a dip or swell duration is equal to the dip or swell commencement uncertainty (half a cycle) plus the dip or swell conclusion uncertainty (half a cycle). If $U_{rms(1)}$ is used, then the uncertainty of a dip or swell duration is equal to the dip or swell commencement uncertainty (one cycle) plus the dip or swell conclusion uncertainty (one cycle).

5.4.5.3 Aggregation

Aggregation is not applicable for triggered events.

5.5 Voltage interruptions

5.5.1 Measurement method

The basic measurement of the voltage shall be as defined in 5.4.1 for each class.

5.5.2 Evaluation of a voltage interruption

The voltage interruption threshold is a percentage of U_{din}.

On single-phase systems, a voltage interruption begins when the U_{rms} voltage falls below the voltage interruption threshold and ends when the U_{rms} value is equal to, or greater than, the voltage interruption threshold plus the hysteresis.

On polyphase systems, a voltage interruption begins when the U_{rms} voltages of all channels fall below the voltage interruption threshold, and ends when the U_{rms} voltage on any one channel is equal to, or greater than, the voltage interruption threshold plus the hysteresis.

The voltage interruption threshold and the hysteresis voltage are both set by the user according to the application. The voltage interruption threshold shall not be set below the uncertainty of the residual voltage measurement plus the value of the hysteresis. Typically, the hysteresis is equal to 2 % of U_{din}.

The start time of a voltage interruption shall be time stamped with the time of the end of the U_{rms} of the channel that initiated the event and the end time of the voltage interruption shall be the time stamped with the time of the end of the U_{rms} that ended the event, as defined by the threshold plus the hysteresis.

The duration of a voltage interruption is the time difference between the beginning and the end of the voltage interruption.

NOTE 1 The voltage interruption threshold can, for example, be set to 5 % or to 10 % of U_{din}.

NOTE 2 IEC 60050-161:1990, 161-08-20, considers an interruption to have occurred when the voltage magnitude is less than 1 % of the nominal voltage. However, it is difficult to correctly measure voltages below 1 % of the nominal voltage. Therefore, the user could consider setting an appropriate voltage interruption threshold.

NOTE 3 The interruption of one or more phases on a polyphase system can be seen as an interruption of the supply to single-phase customers connected to that system, even though this would not be classified as an interruption in a polyphase measurement.

5.5.3 Measurement uncertainty and measuring range

For duration measurement uncertainty, see 5.4.5.2.

5.5.4 Aggregation

Aggregation is not applicable for triggered events.

5.6 Transient voltages

Clause A.3 provides some informative information on the significant parameters necessary to characterize transient voltages. Measurement of transient voltages can be useful but is not mandatory.

5.7 Supply voltage unbalance

5.7.1 Measurement method

Unbalance measurements apply only to 3-phase systems.

– **Class A**

  The supply voltage unbalance is evaluated using the method of symmetrical components. In addition to the positive sequence component U_1, under unbalanced conditions there also exists at least one of the following components: negative sequence component U_2 and/or zero sequence component U_0.

The fundamental component of the voltage input signal is measured over a 10-cycle time interval for 50 Hz power systems or a 12-cycle time interval for 60 Hz power systems.

NOTE 1 The effect of harmonics is minimized by the use of a filter or by using a DFT (Discrete Fourier Transform) algorithm.

NOTE 2 Algorithms that use only the r.m.s. values to calculate unbalance fail to take into account the contributions of angular displacement to unbalance, and cause unpredictable results when harmonic voltages are present. The negative sequence unbalance and zero sequence unbalance provide more precise and more directly useful values.

The negative sequence unbalance ratio u_2 expressed as a percentage is evaluated by:

$$u_2 = \frac{U_2}{U_1} \times 100\% = \frac{\text{negative sequence}}{\text{positive sequence}} \times 100\% \quad (1)$$

The zero-sequence unbalance ratio u_0 expressed as a percentage is evaluated by:

$$u_0 = \frac{U_0}{U_1} \times 100\% = \frac{\text{zero sequence}}{\text{positive sequence}} \times 100\% \quad (2)$$

NOTE 3 The zero sequence unbalance by definition is zero when phase-to-phase voltages are measured. However, the phase-to-neutral or phase-to-earth voltages can still contain the zero sequence component in that case.

NOTE 4 Any other methods that can be shown to be mathematically equivalent to Equation (1) and Equation (2) are acceptable.

– **Class S**

The manufacturer shall specify the algorithms and methods used to calculate the negative sequence ratio u_2. The evaluation of the zero-sequence unbalance ratio u_0 is optional, not mandatory.

5.7.2 Measurement uncertainty and measuring range

– **Class A**

The uncertainty shall be less than ±0,15 % for both u_2 and u_0. For example, an instrument presented with a 1,0 % negative sequence shall provide a reading x such that 0,85 % $\leq x \leq$ 1,15 % (see Figure 5).

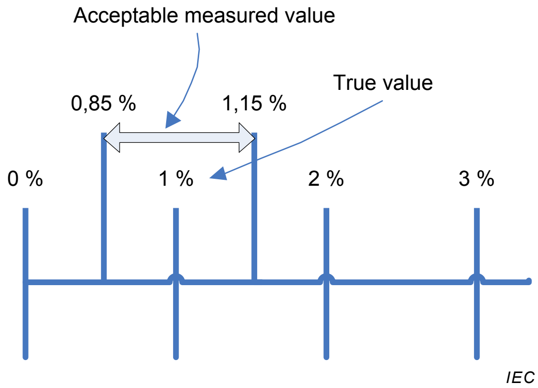


Figure 5 – Example of supply voltage unbalance uncertainty

– **Class S**

Same as Class A.

5.7.3 Measurement evaluation

No requirements.

NOTE The uncertainty of measurement transformers, if present, may have a large impact on the calculation of unbalance.

5.7.4 Aggregation

Aggregation shall be performed according to 4.4 and 4.5.

5.8 Voltage harmonics

5.8.1 Measurement method

– **Class A**

The basic measurement of voltage harmonics, for Class A, is defined in IEC 61000-4-7 Class I. IEC 61000-4-7 shall be used to determine a 10/12-cycle gapless harmonic subgroup measurement, denoted $U_{\mathrm{sg,h}}$ in IEC 61000-4-7.

NOTE 1 Other methods, including analogue and frequency domain methods, can be preferred in special cases (see, for example, IEC 61000-3-8).

Measurements shall be made at least up to the 50th order.

If the total harmonic distortion is calculated, then it shall be calculated as the subgroup total harmonic distortion ($THDS_{\mathrm{Y}}$), defined in IEC 61000-4-7.

NOTE 2 This measurement method generates a large amount of data, which, depending on the application, may need to be stored, transmitted, analysed, and/or archived. Depending on the application, the amount of data may be reduced. To reduce the amount of data, consider applying statistical methods at the measuring location, or storing only extreme and average values, or storing detailed data only when trigger thresholds are exceeded, or other methods.

NOTE 3 IEC 61000-4-7 refers to replacing the symbol '*Y*' by the symbol '*I*' for currents, and by the symbol '*U*' for voltages. $THDS_{\mathrm{U}}$ may be the preferred terminology for voltage THD. However, when searching the 61000-4-7 document for information about these parameters, search for the symbol '*Y*'.

– **Class S**

The basic measurement of voltage harmonics, for Class S, is defined in IEC 61000-4-7 Class II. Gaps are permitted (see 4.5). The manufacturer shall select either a 10/12-cycle harmonic group designated $U_{\mathrm{g,h}}$ in IEC 61000-4-7, or a 10/12-cycle subgroup measurement designated $U_{\mathrm{sg,h}}$ in IEC 61000-4-7. The manufacturer shall specify which has been selected.

Measurements shall be made at least up to the 40th order.

NOTE 4 The EN 50160 assessment requires the 40th order.

If the total harmonic distortion is calculated, then it shall be calculated either as the total harmonic distortion (THD_{Y}) if $Y_{\mathrm{g,h}}$ is selected, or as the subgroup total harmonic distortion ($THDS_{\mathrm{Y}}$) if $Y_{\mathrm{sg,h}}$ is selected, both defined in IEC 61000-4-7.

NOTE 5 IEC 61000-4-7 refers to replacing the symbol '*Y*' by the symbol '*I*' for currents, by the symbol '*U*' for voltages, so $U_{\mathrm{g,h}}$ or $U_{\mathrm{sg,h}}$ may be the preferred terminology. However, when searching the 61000-4-7 document for information about these parameters, search for the symbol '*Y*'.

5.8.2 Measurement uncertainty and measuring range

– **Class A**

The maximum uncertainty shall be the levels specified in IEC 61000-4-7 Class I.

The measuring range shall be 10 % to 200 % of Class 3 electromagnetic environment in IEC 61000-2-4.

– **Class S**

The maximum uncertainty shall be twice the levels specified in IEC 61000-4-7 Class II. The anti-aliasing low-pass filter specified in IEC 61000-4-7 shall be optional. The ±0,03 % maximum permissible error for time between leading edges requirement as specified in IEC 61000-4-7 shall be optional, but the maximum uncertainty requirement shall still be met over the range of influence quantities specified in Clause 6 of this standard.

The measuring range shall be 10 % to 100 % of Class 3 electromagnetic environment in IEC 61000-2-4.

5.8.3 Measurement evaluation

No requirements.

5.8.4 Aggregation

Aggregation shall be performed according to 4.4 and 4.5.

NOTE To minimize storage requirements, after aggregation has been completed it may be practical to discard the source data (such as 10/12-cycle or 150/180-cycle data) if it is no longer required.

5.9 Voltage interharmonics

5.9.1 Measurement method

– **Class A**

The basic measurement of voltage interharmonics, for the purpose of this standard, is defined in IEC 61000-4-7 Class I. IEC 61000-4-7 shall be used to determine a 10/12-cycle gapless centred interharmonic subgroup measurement, denoted $Y_{isg,h}$ in IEC 61000-4-7.

Measurements shall be made at least up to the 50th order.

NOTE 1 This measurement method generates a large amount of data, which, depending on the application, may need to be stored, transmitted, analysed, and/or archived. Depending on the application, the amount of data may be reduced. To reduce the amount of data, consider applying statistical methods at the measuring location, or storing only extreme and average values, or storing detailed data only when trigger thresholds are exceeded, or other methods.

NOTE 2 IEC 61000-4-7 refers to replacing the symbol 'Y' by the symbol 'I' for currents, by the symbol 'U' for voltages, so $U_{ig,h}$ or $U_{isg,h}$ may be the preferred terminology. However, when searching the 61000-4-7 document for information about these parameters, search for the symbol 'Y'.

– **Class S**

The manufacturer shall specify the measurement method.

5.9.2 Measurement uncertainty and measuring range

– **Class A**

The maximum uncertainty shall be the levels specified in IEC 61000-4-7 Class I.

The measuring range shall be 10 % to 200 % of Class 3 electromagnetic environment in IEC 61000-2-4.

– **Class S**

The manufacturer shall specify the measurement uncertainty.

The measuring range shall be 10 % to 100 % of Class 3 electromagnetic environment in IEC 61000-2-4.

5.9.3 Evaluation

No requirements.

5.9.4 Aggregation

Aggregation shall be performed according to Clause 4.4 and Clause 4.5.

NOTE To minimize storage requirements, after aggregation has been completed it may be practical to discard the source data (such as 10/12-cycle or 150/180-cycle data) if it is no longer required.

5.10 Mains signalling voltage on the supply voltage

5.10.1 General

Mains signalling voltage, called “ripple control signal” in certain applications, is a burst of signals, often applied at a non-harmonic frequency, that remotely control industrial equipment, revenue meters, and other devices.

5.10.2 Measurement method

– **Class A**

The method described here shall be used for mains signalling frequencies below 3 kHz. For mains signalling frequencies above 3 kHz, see IEC 61000-3-8.

This method measures the level of the signal voltage for a user-specified carrier frequency.

NOTE The purpose of this method is to measure the maximum level of the signal voltage, and not to diagnose mains signalling difficulties.

Mains signalling voltage measurement shall be based on:

– either the corresponding 10/12-cycle r.m.s. value interharmonic bin; or

– the root of the sum of the squares of the 4 nearest 10/12-cycle r.m.s. value interharmonic bins (for example, a 316,67 Hz ripple control signal in a 50 Hz power system shall be approximated by a root of the sum of the squares of 310 Hz, 315 Hz, 320 Hz and 325 Hz bins, available from the DFT performed on a 10/12-cycle time interval).

The first method is preferred if the user-specified frequency is in the centre of a DFT bin. The second method is preferred if the frequency is not in the centre of a bin.

The user shall select a detection threshold above 0,3 % U_{din} as well as the length of the recording period up to 120 s. The beginning of a signalling emission shall be detected when the measured value of the concerned interharmonic exceeds the detection threshold. The measured values are recorded during a period of time specified by the user, in order to give the maximum level of the signal voltage.

– **Class S**

The manufacturer shall specify the measurement technique.

5.10.3 Measurement uncertainty and measuring range

– **Class A**

The measurement range shall be at least 0 % to 15 % of U_{din}.

For mains signalling voltage between 3 % and 15 % of U_{din}, the uncertainty shall not exceed ±5 % of the measured value. For mains signalling voltage between 1 % and 3 % of U_{din}, the uncertainty shall not exceed ±0,15 % of U_{din}. For mains signalling voltage less than 1 % of U_{din}, no uncertainty requirement is given.

– **Class S**

The manufacturer shall specify the uncertainty and the measuring range.

5.10.4 Aggregation

Aggregation is not mandatory.

5.11 Rapid voltage change (RVC)

5.11.1 General

An RVC event is defined in 3.26 and is generally an abrupt transition between two r.m.s. voltages. By definition, the two r.m.s. voltages must be “steady state”, a condition that is defined in the method below.

Dips and swells often begin or end with abrupt transitions between two r.m.s. voltages. However, by definition these are not RVC events because they exceed the dip or swell thresholds. Further guidance is found in the method below.

5.11.2 RVC event detection

– **Class A**

An r.m.s. voltage is in a steady-state condition if all the immediately preceding 100/120 $U_{rms(1/2)}$ values remain within an RVC threshold from the arithmetic mean of those 100/120 $U_{rms(1/2)}$ values. ("100/120" means 100 values for 50 Hz nominal, or 120 values for 60 Hz nominal.)

The RVC threshold is set by the user according to the application, as a percentage of U_{din}.

NOTE 1 Thresholds in the range of 1 % to 6 % might be considered. In IEC TR 61000-3-7, for example, RVC thresholds of 2,5 % to 6 % of U_{din} for medium voltage are considered. In IEC 61000-3-3, RVC thresholds of 3,3 % to 6 % for low voltage are considered. In both standards, the thresholds are linked to the number of RVC events per hour or per day. In IEC 61000-4-15, a threshold of 0,2 % is considered for a similar, but not identical, parameter.

The RVC hysteresis is set by the user according to the application, and shall be less than the RVC threshold.

NOTE 2 Hysteresis in the range of 50 % of the RVC threshold might be considered.

To initiate the RVC detection method:

- An initial set of 100/120 $U_{rms(1/2)}$ values is recorded.
- The arithmetic mean of those values is calculated, then the RVC detection method below is applied.

To detect an RVC event (see Figures 6 and 7):

- A 'voltage-is-steady-state' logic signal shall be created for each voltage channel. This logic signal is true when the voltage on that channel is in steady state, and false otherwise. This logic signal is determined from the $U_{rms(1/2)}$ values of each voltage channel, as follows. It is updated for each new $U_{rms(1/2)}$ value.
- Every time a new $U_{rms(1/2)}$ value is available, the arithmetic mean of the previous 100/120 $U_{rms(1/2)}$ values, including the new value, is calculated.
- If every one of the previous 100/120 $U_{rms(1/2)}$ values, including the new value, is within the RVC threshold (including the hysteresis, if applied) of the arithmetic mean, then the 'voltage-is-steady-state' logic signal for that channel is set to true; otherwise, it is set to false.
- On a polyphase system, the combined 'voltage-is-steady-state' logic signal is the logical-AND of the 'voltage-is-steady-state' logic signal of each voltage channel.
- An RVC event begins when the 'voltage-is-steady-state' logic signal changes from true to false.
- When an RVC event begins, the RVC hysteresis is applied to the RVC threshold, and changes to the voltage-is-steady-state logic signal are disabled for 100/120 half cycles.
- An RVC event ends when the 'voltage-is-steady-state' logic signal changes from false to true. When an RVC event ends, the RVC hysteresis is removed from the RVC threshold. The time stamp of the end of the RVC event is 100/120 half cycles prior to the logic signal changing from false to true.

If a voltage dip or voltage swell is detected during an RVC event, including the disabled 100/120 half cycles, then the RVC event is discarded because the event is not an RVC event. It is a voltage dip or voltage swell.

– **Class S**

The method for Class S is the same as the method for Class A, but in Class S the use of either $U_{rms(1/2)}$ or $U_{rms(1)}$ shall be selected according to 5.4.1. If $U_{rms(1)}$ is selected for

Class S RVC, then "100/120", which refers to half-cycles, shall be replaced throughout the method with "50/60", which refers to the equivalent number of full cycles.

5.11.3 RVC event evaluation

An RVC event is characterized by four parameters: start time, duration, ΔU_{max} and ΔU_{ss}.

– **Class A**

- The start time of an RVC event shall be time stamped with the time that the 'voltage-is-steady-state' logic signal became false and initiated the RVC event.
- The RVC event duration is 100/120 half cycles shorter than the length of time during which the 'voltage-is-steady-state' logic signal is false.
- The RVC event ΔU_{max} is the maximum absolute difference between any of the $U_{rms(1/2)}$ values during the RVC event and the final arithmetic mean 100/120 $U_{rms(1/2)}$ value just prior to the RVC event. For polyphase systems, the ΔU_{max} is the largest ΔU_{max} on any channel.
- The RVC event ΔU_{ss} is the absolute difference between the final arithmetic mean 100/120 $U_{rms(1/2)}$ value just prior to the RVC event and the first arithmetic mean 100/120 $U_{rms(1/2)}$ value after the RVC event. For polyphase systems, the ΔU_{ss} is the largest ΔU_{ss} on any channel.

NOTE 1 It can be useful to count the number of RVC events in a certain period. The period can be an hour based on a fixed interval, or an hour based on a sliding interval comprising the most recent 60 minutes sliding once per minute on the minute. The period can also be a "day" and based on calendar time or based on a sliding interval comprising the most recent 24 hours, sliding once per hour on the hour.

NOTE 2 Other characteristics to evaluate an RVC event are under consideration. For example, the ΔU_{max} could be evaluated based on 10/12 cycle aggregated values.

NOTE 3 In some cases, this RVC measurement method may not fully characterize intricate variations between two steady states. Recording the sequence of U_{rms} values on each channel may be useful for deeper analysis.

– **Class S**

The RVC event evaluation for Class S is the same as the method for Class A, but in Class S the use of either $U_{rms(1/2)}$ or $U_{rms(1)}$ shall be selected according to 5.4.1 . If $U_{rms(1)}$ is selected for Class S RVC, then 100/120 half cycles shall be replaced throughout the event evaluation with 50/60 full cycles.

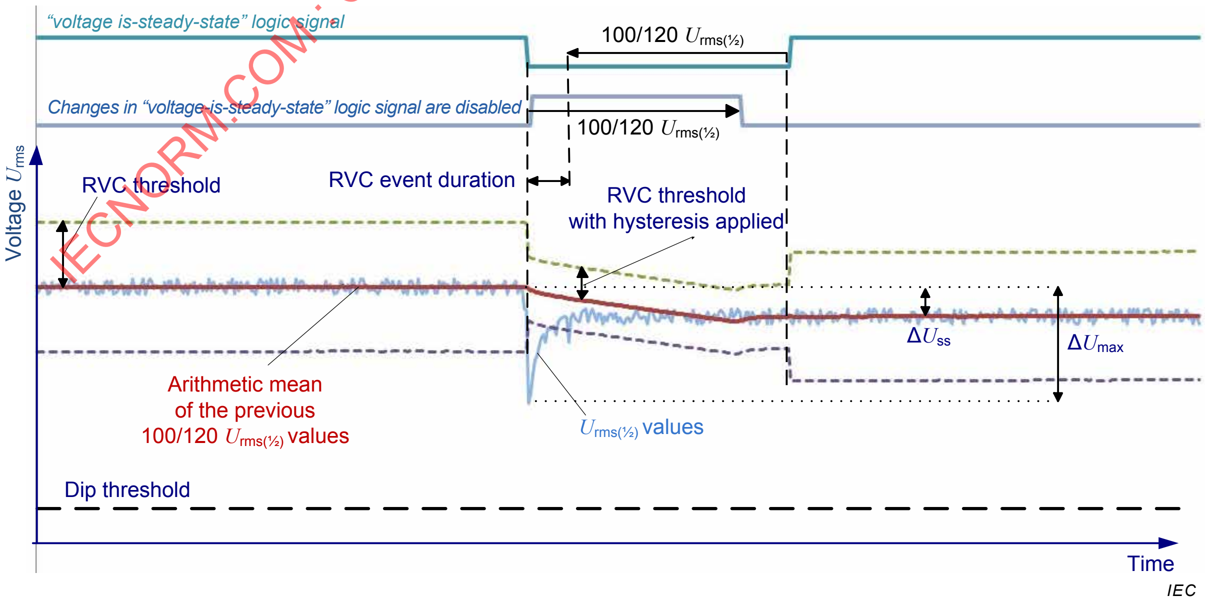


Figure 6 – RVC event: example of a change in r.m.s voltage that results in an RVC event

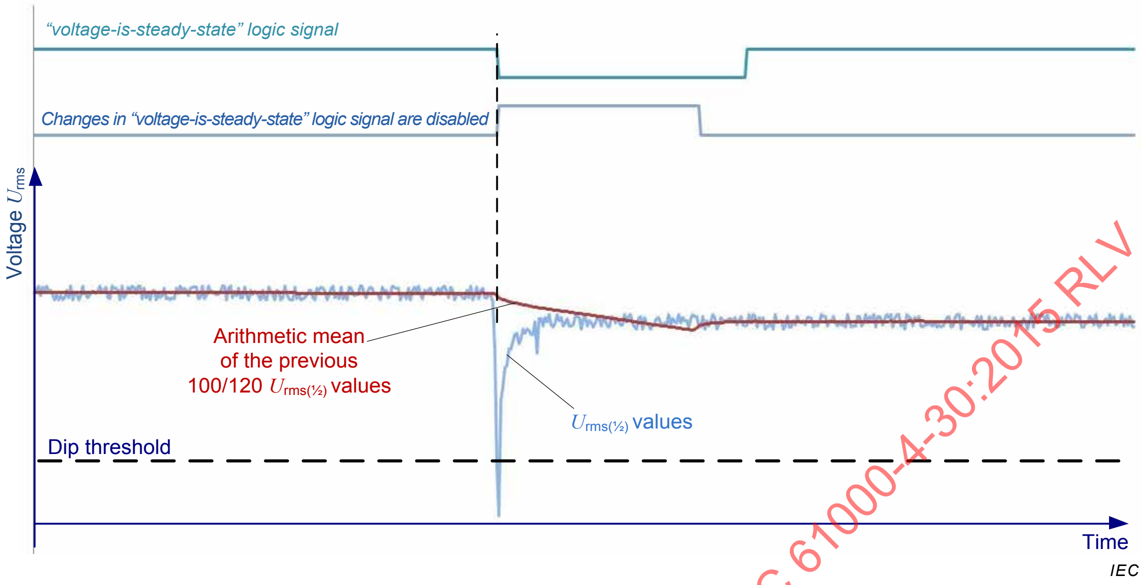


Figure 7 – Not an RVC event: example of a change in r.m.s voltage that does not result in an RVC event because the dip threshold is exceeded

5.11.4 Measurement uncertainty

The uncertainty of an RVC event characterization is determined by the uncertainty of U_{rms} measurements as described in 5.4.5.1, and on the correct implementation of the method in 5.11.1 and 5.11.2.

5.12 Underdeviation and overdeviation

See Annex D (informative).

5.13 Current

5.13.1 General

In a power quality context, current measurements are useful as a supplement to voltage measurements, especially when trying to determine the causes of events such as voltage magnitude change, dip, interruption, or unbalance.

The current waveform can further help associate the recorded event with a particular device and an action, such as a motor being started, a transformer being energized or a capacitor being switched.

Linked with voltage harmonics and interharmonics, the current harmonics and interharmonics can be useful to characterize the load connected to the network.

This standard does not define any trigger or threshold methods for current. If current changes, but the change is not sufficient to trigger one of the voltage threshold methods, then that change in current is not a power quality event.

NOTE Current transients are not considered in this standard. Some useful comments are provided in Annex A.

5.13.2 Magnitude of current

5.13.2.1 Measurement

The manufacturer shall specify a full-scale r.m.s. current, taking into account a minimum ratio between peak instantaneous value and r.m.s. value of 3,0.

NOTE This ratio is sometimes called "crest factor".

– **Class A**

  The basic measurement shall be the r.m.s. value of the current magnitude over a 10-cycle time interval for a 50 Hz power system or a 12-cycle time interval for a 60 Hz power system. The boundaries of any current measurement interval shall be determined by, and identical to, the boundaries of the interval for the corresponding voltage channel.

– **Class S**

  The manufacturer shall specify the r.m.s. measurement method and time interval used.

  NOTE More detailed requirements for Class S are under consideration.

5.13.2.2 Measurement uncertainty

– **Class A**

  The measurement uncertainty shall not exceed ±1 % of reading in the range of 10 % to 100 % of the specified full-scale r.m.s. current.

  NOTE This uncertainty requirement does not take into account uncertainties introduced by current sensors. Guidance on sensors can be found in in IEC 61557-12:2007, Annex C or Annex D.

– **Class S**

  The measurement uncertainty shall not exceed ±2 % of reading in the range of 10 % to 100 % of the specified full-scale r.m.s. current.

5.13.2.3 Measurement evaluation

NOTE For single-phase systems, there is a single r.m.s. current value. For 3-phase 3-wire systems, there are typically three r.m.s. current values; for 3-phase 4-wire systems, there are typically four current values. The earth current may be measured as well, either by measuring current in an earth conductor or by determining residual current.

– **Class A**

  Aggregation intervals as described in 4.4 and 4.5 shall be used.

  For each current channel, the current aggregation intervals shall be determined by, and identical to, the aggregation intervals of the corresponding voltage channel.

– **Class S**

  The manufacturer or the user shall specify the measurement intervals.

5.13.3 Current recording

– **Class A**

  If current measurement methods are implemented, then whenever a voltage channel is recorded, the corresponding current channel shall also be recorded with timing determined by, and identical to, the corresponding voltage channel (for example, if $U_{rms(1/2)}$ is recorded, $I_{rms(1/2)}$ shall also be recorded, with all timing aspects of the current measurement determined by the timing of the corresponding voltage channel).

– **Class S**

  The manufacturer or the user shall specify when the current will be recorded.

5.13.4 Harmonic currents

– **Class A**

The basic measurement method and accuracy of current harmonics, for the purpose of this standard, are defined in IEC 61000-4-7. Use that standard to determine a 10/12-cycle gapless harmonic sub-group measurement, denoted $Y_{\text{sg,h}}$

NOTE 1 IEC 61000-4-7 refers to replacing the symbol 'Y' by the symbol I for currents, by the symbol 'U' for voltages, so $I_{\text{sg,h}}$ may be the preferred terminology. However, when searching the 61000-4-7 document for information about these parameters, search for the symbol 'Y'. Aggregation intervals as described in 4.4 and 4.5 are used.

A 10/12-cycle current harmonic measurement is marked "flagged" if either a voltage dip or voltage swell (see 5.4) or a voltage interruption (see 5.5) occurs during this time interval.

NOTE 2 This measurement method generates a large amount of data, which, depending on the application, may need to be stored, transmitted, analysed, and/or archived. Depending on the application, the amount of data may be reduced. To reduce the amount of data, consider applying statistical methods at the measuring location, or storing only extreme and average values, or storing detailed data only when trigger thresholds are exceeded, or other methods.

– **Class S**

The manufacturer shall specify measurement and aggregation methods.

5.13.5 Interharmonic currents

– **Class A**

The basic measurement method and accuracy of current interharmonics, for the purpose of this standard, are defined in 61000-4-7. Use that standard to determine a 10/12-cycle gapless centred interharmonic sub-group measurements, denoted $Y_{\text{isg,n}}$.

Aggregation intervals as described in 4.4 and 4.5 shall be used.

A 10/12-cycle interharmonic current measurement is marked "flagged" if either a voltage dip or a voltage swell (see 5.4), or a voltage interruption (see 5.5) occurs during this time interval.

NOTE 1 This measurement method generates a large amount of data, which, depending on the application, may need to be stored, transmitted, analysed, and/or archived. Depending on the application, the amount of data may be reduced. To reduce the amount of data, consider applying statistical methods at the measuring location, or storing only extreme and average values, or storing detailed data only when trigger thresholds are exceeded, or other methods.

NOTE 2 IEC 61000-4-7 refers to replacing the symbol 'Y' by the symbol I for currents, by the symbol 'U' for voltages, so $I_{\text{sg,h}}$ may be the preferred terminology. However, when searching the 61000-4-7 document for information about these parameters, search for the symbol 'Y'.

– **Class S**

The manufacturer shall specify measurement and aggregation methods.

5.13.6 Current unbalance

– **Class A**

The basic measurement method for current unbalance shall be identical to the measurement method for supply voltage unbalance in 5.7.

Aggregation intervals as described in 4.4 and 4.5 shall be used. A 10/12-cycle current unbalance measurement is marked "flagged" if either a voltage dip or a voltage swell (see 5.4), or a voltage interruption (see 5.5) occurs during this time interval.

– **Class S**

The manufacturer shall specify measurement and aggregation methods.

6 Performance verification

Performance verification for Class A and Class S measurement methods may be found in IEC 62586-2, which includes influence quantities and performance verification tests.

Table 1 provides an informative summary of the requirements for Class A and Class S. In case of any conflict between Table 1 and the normative clauses of this document, the normative clauses prevail.

Note that compliance with the requirements in Table 1 is not sufficient for certification to this standard. The measurement and aggregation methods in this standard shall also be met.

Table 1 – Summary of requirements (see subclauses for actual requirements)

Subclause and parameter	Class	Measurement method	Uncertainty	Measuring range[a]	Influence quantity range[b]	Aggregation method
5.1 Frequency	A	See 5.1.1	±10 mHz	42,5 Hz to 57,5 Hz, 51 Hz to 69 Hz	IEC 62586-2	N/R
	S	See 5.1.1	±50 mHz	42,5 Hz to 57,5 Hz, 51 Hz to 69 Hz	IEC 62586-2	N/R
5.2 Magnitude of the supply	A	See 5.2.1	±0,1 % U_{din}	10 %to150 % U_{din}	IEC 62586-2	See 4.4 and 4.5
	S	See 5.2.1	±0,5 % of U_{din}	20 %to120 % U_{din}	IEC 62586-2	See 4.4 and 4.5
5.3 Flicker	A	IEC61000-4-15	IEC 61000-4-15	0,2 P_{st} to 10,0 P_{st}	IEC 62586-2	IEC 61000-4-15
	S	IEC61000-4-15	See 5.3.2	0,4 P_{st} to 4,0 P_{st}	IEC 62586-2	IEC 61000-4-15
5.4 Dips and swells	A	$U_{rms(1/2)}$	Amplitude ±0,2 % U_{din} Duration ± 1 cycle	N/A	N/A	N/R
	S	See 5.4.1	Amplitude ±1 % of U_{din} Duration ± 1 cycle or ± 2 cycles	N/A	N/A	N/R
5.5 Interruptions	A	$U_{rms(1/2)}$	Duration ± 1 cycle	N/A	N/A	N/R
	S	see 5.5.1	Duration ± 1 cycle or ± 2 cycles	N/A	N/A	N/R
5.7 Unbalance	A	Symmetrical components: U_2 and U_0	±0,15 %	0,5 % to 5 % u_2 0,5 % to 5 % u_0	IEC 62586-2	See 4.4 and 4.5
	S	Symmetrical components: U_2, and optionally U_0	±0,3 %	1 % to 5 % u_2 1 %to 5 % u_0 if implemented	IEC 62586-2	See 4.4 and 4.5
5.8 Voltage harmonics	A	See 5.8.1	IEC61000-4-7 Class I	10 % to 200 % of Class 3 of IEC 61000-2-4	IEC 62586-2	See 4.4 and 4.5
	S	See 5.8.1	200 % of IEC 61000-4-7 Class II	10 % to 100 % of Class 3 of IEC 61000-2-4	IEC 62586-2	See 4.4 and 4.5
5.9 Voltage inter-harmonics	A	See 5.9.1	IEC61000-4-7 Class I	10 % to 200 % of Class 3 of IEC 61000-2-4	IEC 62586-2	See 4.4 and 4.5
	S	SBM	SBM	SBM	IEC 62586-2	See 4.4 and 4.5

Subclause and parameter	**Class**	**Measurement method**	**Uncertainty**	**Measuring range**[a]	**Influence quantity range**[b]	**Aggregation method**
5.10 Mains signalling voltage	A	See 5.10.2	See 5.10.3	0 % to 15 % U_{din}	IEC 62586-2	N/R
	S	SBM	SBM	SBM	IEC 62586-2	N/R
5.11 Rapid voltage change	A	See 5.11.2	See 5.11.3	See 5.11.3	N/A	N/R
	S	See 5.11.2	See 5.11.3	See 5.11.3	N/A	N/R
5.13 Current	A	See 5.13.2. Crest factor of 3 is required	±1 %	10 % FS to 150 % FS	N/A	N/R
	S	N/R	N/R	N/R	N/A	N/R
Annex C 2 kHz to 150 kHz	A	See Annex C	±1 V	±50 V pk	N/A	See Annex C
	S	N/R	N/R	N/R	N/A	N/R
Transient voltages IEC 61180	A	N/R	N/R	N/R	6 kV pk [c]	N/A
	S	N/R	N/R	N/R	N/R	N/A
Fast transients IEC61000-4-4	A	N/R	N/R	N/R	4 kV pk [c]	N/A
	S	N/R	N/R	N/R	N/R	N/A

SBM = Specified by manufacturer

N/R = no requirement

N/A = not applicable

[a] The instrument shall meet the uncertainty requirements for signals within the measuring range.

[b] The instrument shall tolerate signals in the influence quantity range without shifting the measurement of other parameters out of their uncertainty requirement, and without instrument damage. The instrument may indicate overrange for signals greater than the measuring range, up to the influence quantity range (not including transients and fast transients).

[c] For transient voltages and fast transients, there shall be no effect on any measurement after the transient. The transients are applied to the measuring terminals, not to the instrument power terminals.

Annex A
(informative)

Power quality measurements – Issues and guidelines

A.1 General

Annex A is provided as an informative complement to the normative part of this standard.

Clauses A.2 and A.3 address general concerns and procedures for implementation of power quality measurements regardless of the purpose of the measurements:

– Clause A.2 – Installation precautions
– Clause A.3 – Transducers

Clauses A.4 and A.5 are pre-normative measurement methods:

– Clause A.4 – Transient voltages and currents
– Clause A.5 – Voltage dip characteristics

A.2 Installation precautions

A.2.1 General

During installation of power quality (PQ) measurement instruments, the safety of the installer and others, the integrity of the system being monitored and the integrity of the instrument itself have to be ensured.

While many installations are temporary in nature and consequently may not utilize the same practices as for permanent installations, local codes should never be compromised. Local codes, regulations and safety practices will cover most of the items below and will always take precedence over the precautions listed here. All local and national safety requirements shall be followed (for example, personal protective equipment requirements).

A.2.2 Test leads

A.2.2.1 General

For safety, IEC 61010, which gives the safety requirements for electrical equipment for measurement, control and laboratory use, applies.

Test lead connections made in load centre panel boards or junction boxes will be attached in a manner that does not violate the listed use of the devices to which they are attached. This generally includes returning doors, cover plates and access panels to their in-use position (i.e., closed, mounted with a full set of screws, etc.). If panels remain open during monitoring, adequate means will be provided to limit access to the area and inform others about the monitoring set-up and the responsible on-site contact.

It is for most cases recommended that the PQ measurement instrument be attached to a point in the system specifically designed for measurements or metering.

Test leads will be routed away from exposed conductors, sharp objects, low- and high-frequency electromagnetic fields, and other adverse environments. If possible, they will be strapped or tied to a solid object to prevent inadvertent disconnection.

A.2.2.2 Voltage test leads

Leads that are fused at the probe end, i.e. the end connected to the system being monitored, increase the safety of the connection. The instrument manufacturer has to specify the fuse size; this will be low enough to protect the test lead against overload conditions. Furthermore, the interrupting capacity of the fuse will be consistent with the available power-frequency fault current at the point of connection.

Voltage sense leads should not be casually twisted around existing wires or inserted in circuit- breaker connectors that are designed to receive a single conductor. Instead, a properly rated and installed mechanical connection should be used. Where clips are used for temporary installations, they should comply with IEC 61010. It is essential to ensure both that the clip is rated for the maximum voltage that may be present and that it is installed in a mechanically secure manner. During installation, the installer will consider what will happen if the clip is inadvertently dislodged, for example, by an abrupt tug on the cable.

Some test leads have insulated plugs capable of being stacked one on top of the other. Caution should be exercised so that when stacking, only intentional connections are made rather than creating an inadvertent short circuit. Always double-check the leads to ensure that short circuits have not been introduced. Also, connect the sense leads to the monitored circuit only after the leads have been connected to the PQ instrument and checked for correctness.

A.2.2.3 Current test leads

Care should be taken that the secondaries of current transformers, if used, do not become open circuit, i.e. there should be no fuse in the secondaries of such circuits, and the connection to the burden should be mechanically secure.

Clamp-on current transducers and associated leads, used for temporary installations, should be designed according to IEC 61010-2-032.

A.2.3 Guarding of live parts

Often panel covers are removed for installation, or during the monitoring period. If so, all live parts will be adequately protected and the area will be kept inaccessible. If screw terminals are used in the measurement instrument, appropriate covers will be used to insulate the terminations. All attachments to terminations will be made in accordance with the specifications and intent of the terminations. For example, multiple wires should not be connected to a screw terminal designed for a single wire.

A.2.4 Monitor placement

The PQ measurement instrument needs to be placed securely to minimize the risk of the instrument moving or loosening connections. If a paper printer is used for reporting disturbances, adequate precautions should be taken to ensure that accumulating paper does not present a hazard. Measurement instruments will not be left where excessive heat, moisture or dust may damage the instrument, or jeopardize the data collection process.

The measurement instrument will be placed so that it does not pose a hazard to those working in the area. A protective enclosure or barrier can sometimes be used to alleviate this concern. If possible, the measurement instrument will not be placed in a location where it will be exposed to many people, for example, in a heavily travelled hallway.

Also, the location should not pose an undue hazard to the person installing the PQ measurement instrument. There are many locations that are too cramped, or in other ways physically constrained, to allow suitable connection of instrument leads. In these situations, an alternative location will be selected.

A number of external environmental factors can affect the performance of a PQ measurement instrument. These environmental factors include temperature, humidity, low- and high-frequency electromagnetic fields, static discharge, mechanical shock and vibration.

A.2.5 Earthing

All instruments are capable of developing internal faults. The instruments' power supply will be properly connected to a protective earth if declared necessary by the manufacturer. Many safety regulations also require an earth connection associated with the voltage test leads. Instruments with two or more earth connections (for example, one earth connection for the power supply, and another for the test leads) can create ground loops if the earth connections are made to different physical points outside the instrument. The risk from ground loops on the measurements and on the system being measured will need to be carefully considered.

There is also a need to consider the potential hazard to personnel and the instrument due to high potentials between different points in the grounding system. The use of isolating transformers for the power supply of the instrument is in most cases useful.

In all cases, safety considerations will take the highest priority.

A.2.6 Interference

If the PQ measurement instrument is connected to a mobile phone or other radio transmitter, one should take care that the transmitter antenna is sufficiently far away from devices that could be sensitive to interference. Such sensitive devices can include protection devices, medical monitors, scientific instruments, etc.

A.3 Transducers

A.3.1 General

Power quality measurement instruments, especially those in portable packages, are generally provided with inputs designed for low-voltage applications. Some permanently installed PQ measurement instruments are mounted at a distance from the point of the circuit where the parameters are to be measured. In both cases, a suitable transducer might be needed, to step down the voltage, to isolate the input circuits from the system voltage, or to transmit the signals over some distance. To accomplish any of these functions, a transducer may be used, provided that its characteristics are suitable for the parameter of interest.

In low voltage systems, PQ measurement instruments are generally connected directly to the voltage point of interest, but transducers are often used for current measurements.

In medium and high voltage systems, transducers are used for both voltage and current PQ measurements.

There are two important concerns when using transducers:

– signal levels: signals levels should use the full scale of the instrument without distorting or clipping the desired signal;
– frequency and phase response: these characteristics are particularly important for transient and harmonic measurements.

In order to avoid incorrect measurements the full-scale rating, linearity, frequency and phase response, and burden characteristics of the transducer should be carefully considered.

NOTE Current transducers designed for protection purposes may be less accurate than metering transducers.

A.3.2 Signal levels

A.3.2.1 Voltage transducers

The most common voltage transducer is the voltage transformer. Two types of voltage transformers can be considered: those used by protective relay circuits, and those used by metering circuits. The first type is sized so as to provide a correct response even in the case of overvoltages due to an unbalanced short circuit. The second, in contrast, is designed to protect meters from network overvoltages. In the latter category, in case of saturation, distortion of the delivered signal will occur.

Where monitoring is attached to a voltage transformer which is also used for other functions (for example, metering), one should be careful that the additional burden does not affect the calibration or uncertainty of such other functions.

One should be careful when making connections to the secondary circuit of a transformer used for a protective relay. Connection errors might cause the relay to inadvertently trip.

NOTE For further details of the uncertainty of voltage transformers, see IEC 60044-2.

A.3.2.2 Current transducers

Guidance about effects of current transducers may be found in IEC 61869.

In the operation on the power system network, the value of the current can range from 0 to the short-circuit level of the network being monitored. The short-circuit current value can be well above the nominal current level. A value of 20 times nominal is not unusual.

The most common type of current transducer is the current transformer.

Some current transformers are equipped with two or more cores and/or two secondary windings: one for large current flows (20 times to 30 times the nominal current), typically for protection relays, and a second for nominal current flows. The correct secondary should be selected for the intended measurement. With direct connections, it is possible to damage the measuring instrument during faults if the wrong secondary has been selected; this damage can inadvertently provide an open circuit on the transformer secondary. Open circuits on the secondary winding of current transformers can give rise to dangerously high (and destructive) voltages.

Where practical the user should take measures to ensure that the conductor is centralised through the window of the current transducer and that the conductor is orthogonal to the window. The proximity of adjacent conductors should also be considered and the distance maximized if possible.

NOTE For further details of the uncertainty of current transformers, see IEC 61869-1 and IEC 61869-2.

Measurements of transients can be performed with shunts or current transformers designed for high-frequency response.

Coaxial shunts are routinely used in laboratory environments but have the disadvantage of requiring insertion into the current-carrying conductors, and the fact that the output signal of the shunt is not isolated from the power circuit. On the other hand, they are not susceptible to the saturation and residual magnetization that can affect measurements made with current transformers.

Current transformers operating with a suitable resistive burden deliver a voltage signal proportional to the primary current. In general, the primary consists of one or a few turns of the primary circuit fed through an opening in the core. The major advantage of these current transducers is to provide isolation from the power circuits, and a wide range of ampere-to-volt ratios. Another advantage is that some (but not all) current transformers do not require the disconnection of the power conductor from its load during installation.

Other types of current transducers are sometimes used, including optical polarization detectors and Hall-effect transducers.

A.3.3 Frequency response of transducers

A.3.3.1 Frequency and phase response of voltage transducers

In general, transformer-type electromagnetic voltage transducers have frequency and transient responses suitable up to typically 1 kHz; but the frequency range may sometimes be limited to well below 1 kHz, and sometimes may extend to a few kHz.

Simple capacitor dividers can have frequency and phase responses that are suitable up to hundreds of kHz or even higher; however, in many applications a resonant circuit is intentionally added, making the frequency response of the capacitive divider unsuitable for measurements at any frequency other than the fundamental.

Resistive voltage dividers may have frequency and phase response suitable up to hundreds of kHz. However, they may introduce other problems, for example, the capacitive load of the measurement instrument can influence the frequency and phase response of the resistive voltage dividers.

A.3.3.2 Frequency and phase response of current transducers

As current transformers are wound electromagnetic devices, the frequency response varies according to the uncertainty class, type (manufacturer), turns ratio, core material and cross-section, and the secondary circuit load.

Usually, the cut-off frequency of a current transducer ranges from 1 kHz to a few kHz, and the phase response degrades as the cut-off frequency is approached.

New concepts of current transducers with higher cut-off frequency and better linearity are being developed (optical and Hall-effect transducers). Insulation coordination, noise issues, full-scale capability, and safety conditions should be carefully considered.

A.3.4 Transducers for measuring transients

There are two important concerns that should be addressed when selecting transducers for a.c. mains transients. First, signal levels should use the full scale of the instrument without distorting or clipping the desired signal. Second, the frequency response (both amplitude and phase) of the transducer should be adequate for the expected signal.

a) Voltage transducers (VTs)
   1) VTs should be sized to prevent measured disturbances from inducing saturation. For low-frequency transients, this requires that the knee point of the transducer saturation curve be at least 200 % of the nominal system voltage.
   2) The frequency response of a standard metering class VT depends on its type and the burden applied. With a high impedance burden, the response is usually adequate to at least 2 kHz, but it can be less.
   3) Capacitively coupled voltage transformers generally do not provide accurate representation of any higher frequency components.
   4) High-frequency transient measurements require a capacitor divider or pure resistive divider. Special purpose capacitor dividers can be obtained for measurements requiring accurate characterization of transients up to at least 1 MHz.
b) Current transducers (CTs)

1) Selecting the proper transducer for currents is more difficult. The current in a distribution feeder changes more often and with greater magnitude than the voltage.
2) Standard metering-class CTs are generally adequate for frequencies up to 2 kHz (phase error can start to become significant before this limit). For higher frequencies, window type CTs with a high turns ratio (doughnut, split core, bar type, and clamp-on) should be used.
3) Additional desirable attributes for CTs are: a large turns ratio, for example, 2 000:5; less than 5 turns in the primary; small remnant flux, for example, 10 % of core saturation; large core area; minimal secondary winding resistance and leakage impedance. When using a CT to measure transients there are 2 key parameters that need to be considered, current-time product ($I{\cdot}t$ max) and rise time/droop. Typical values of the rise time (10 % to 90 %) are in the range of 2 ns to 200 ns. Typical droop values range from 0,1 %/µs to 0,5 %/ms.

In HV systems high-frequency and transient voltage measurements may sometimes be performed using capacitive taps often available on CTs and transformer bushings.

A.4 Transient voltages and currents

A.4.1 General

Clause A.4 is primarily focused on transients occurring in LV systems and does not cover transients from GIS[1] installations or HV systems.

Transients can occur on all a.c. power systems. Traditionally, they have been characterized as "transient voltages"; however, in many cases, the transient current may be more important. The detection, classification, and characterization of transient voltages are challenging subjects.

A.4.2 Terms and definitions

A.4.2.1
transient, adjective and noun
pertaining to or designating a phenomenon or a quantity which varies between two consecutive steady states during a time interval short when compared with the time-scale of interest

[SOURCE: IEC 60050-161:1990, 161-02-01]

A.4.2.2
surge
transient voltage wave propagating along a line or a circuit and characterized by a rapid increase followed by a slower decrease of the voltage

[SOURCE: IEC 60050-161:1990, 161-08-11]

A.4.3 Frequency and amplitude characteristics of a.c. mains transients

Transients in a.c. power circuits occur over a wide range of waveforms, amplitudes, and duration. It is difficult to describe these by a simple set of parameters, but obtaining their signatures allows them to be classified into a few typical waveforms that are used for test purposes. Figure A.1 shows the frequency spectrum of several representative test waveforms in general use. This information is useful in developing algorithms that will be necessary for appropriate reduction of the analogue signals into the digital recordings and data processing of these events.

1 Gas-insulated switchgear.

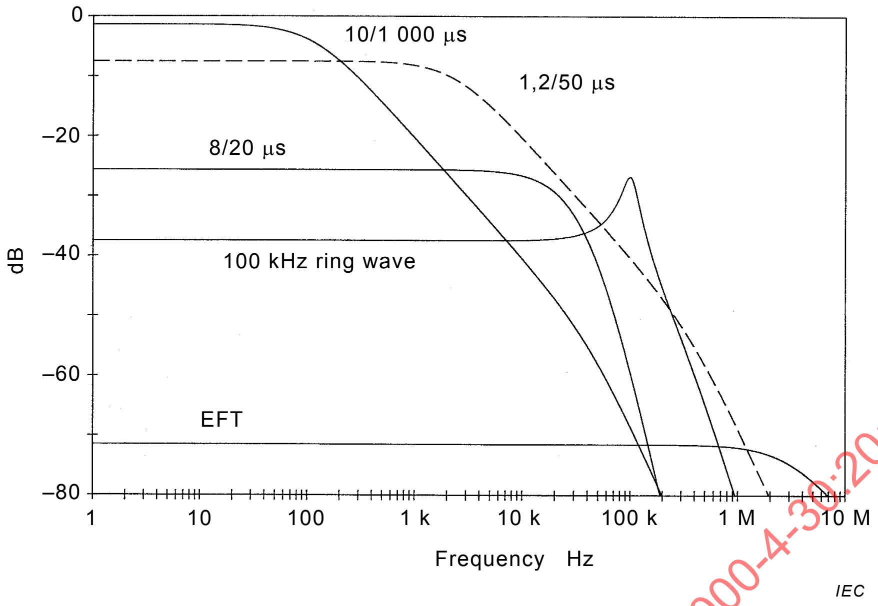


Figure A.1 – Frequency spectrum of typical representative transient test waveforms

For both voltage and current, the spectra of common test waveforms for a.c. mains transients contain frequencies that range up to approximately 10 MHz (lasting for 200 µs), with large amplitudes up to 1 MHz (lasting for 2 ms). For end-use a.c. mains connections, the amplitudes of common test waveforms range up to 6 kV, and up to 5 kA.

The sampling rate should therefore be at least twice the maximum frequency of the waveform; also, the corresponding anti-alias filter should have appropriate characteristics. See also A.3.4 for further information related to transient measurement.

A.4.4 Transient voltage detection

The results of a transient measurement depend both on the actual nature of the transient, and on the parameters selected by the user and reported by the instrument. When insulation is the main concern, transient measurements are generally made from phase-to-earth. When instrument damage is the primary concern, transient measurements are generally made from phase-to-phase or from phase-to-neutral.

Some of the detection methods and examples of application include

- the comparative method: when a fixed, absolute threshold is exceeded, a transient is detected, for example, surge protective devices (SPDs) that are sensitive to the total voltage;
- the envelope method: similar to the comparative method, but with the fundamental removed prior to analysis, for example, in cases of capacitive coupled transients;
- the sliding-window method: the instantaneous values are compared to the corresponding values on the previous cycle, for example, low-frequency switching transients associated with capacitive banks used for power factor correction;
- the dv/dt method: when a fixed, absolute threshold of dv/dt is exceeded, for example, mistrigger of power electronics circuits or non-linear distribution on inductor winding;
- the r.m.s. value: using very rapid sampling, the r.m.s. value is computed for intervals much less than one fundamental period, and compared to a threshold, for example, when further computations are desirable such as energy deposition in an SPD or charge transfer;
- other methods such as frequency versus amplitude measurements (Discrete or Fast Fourier Transform, wavelet, etc.).

A.4.5 Transient voltage evaluation

Once the transient has been detected using the methods above, it can be classified. Some classification methods and parameters include

- the peak voltage and/or current. Note that the peak value is also influenced by the measurement interval;
- the overshoot voltage;
- the rate of rise (dv/dt or di/dt) of the leading edge;
- frequency parameters;
- the duration. This is a difficult parameter to define, due to damping, irregularity of wave-forms, etc.;
- the damping coefficient;
- the frequency of occurrence;
- the energy and power, available or conveyed;
- the continuous (every cycle, such as notches) or single-shot (unpredictable) transients.

All of these numerical parameters are helpful in developing a classification system to describe the transient environment in statistical terms.

On the other hand, especially when trouble-shooting, a signature can describe in one graphic representation several of these hard-to-quantify parameters.

A.4.6 Effect of surge protective devices on transient measurements

Surge protective devices (SPDs) are shunt-connected components that conduct when a threshold voltage is exceeded. They are commonly used to limit transient voltages. They may be found in plug-in mains filtering devices, and are often included as part of a sensitive electronic device, such as a personal computer.

Because all SPDs on a mains circuit are effectively connected in parallel, the one with the lowest limiting voltage will (within its performance capabilities) limit all transient voltages to its limiting voltage and divert the largest portion of the transient current impinging on the facility. Consequently, measuring transient voltages in many environments – offices, labs, factories, etc. – is of limited use: one is simply measuring the threshold voltage of one of the many SPDs that are present.

For this reason, the transient current is often a better measure of the severity of a.c. system transients than the transient voltage.

A.5 Voltage dip characteristics

A.5.1 General

Voltage dips are generally acknowledged to be a common power quality event.

The normative part of this standard characterizes voltage dips by two characteristics, depth (or residual voltage), and duration. It derives these characteristics from one-cycle r.m.s. values that are updated each half-cycle.

However, voltage dips are rarely rectangular, i.e. the U_{rms} value often varies during the dip, and limiting the characteristics to depth and duration can obscure useful information, for example, voltage dips due to motor-starting or due to transformer energizing during which there is a smooth transition between the dip and normal operation.

Ultimately, the greatest amount of information is available in waveforms recorded during the voltage dip. But characteristics are a useful way of reducing data, interpreting and categorizing events.

Multiple dips may occur, for example, during a failed attempt to auto-reclose and re-energize a faulty line section. Events that occur at approximately the same time may be counted as a single event.

Depending on the purpose of the measurement, other characteristics in addition to depth and duration should be considered.

A.5.2 Rapidly updated r.m.s values

During a voltage dip, it may be useful to calculate 1-cycle r.m.s values that are updated more frequently than every half-cycle (as specified in the normative part of standard). For example, it may be useful to update the 1-cycle r.m.s. value 128 times each cycle. This approach allows more precise identification of the beginning and end of the voltage dip, using simple thresholds. The drawbacks are increased data and processing and introducing a possibly misleading sliding filter.

R.m.s. voltage values correctly reflect the available power into a resistive load. However, electronic loads are not directly sensitive to r.m.s. voltage, instead, they are generally sensitive to voltage near the peak of the waveform, and are insensitive to other parts of the waveform. Algorithms other than r.m.s. may be useful to evaluate the effects of a voltage dip on electronic loads.

A.5.3 Phase angle/point-on-wave

For some applications, for example, electro-mechanical contactor drop-outs, the phase angle at which a voltage dip begins is an important characteristic, which is sometimes called point-on-wave.

This phase angle can be determined by capturing the pre-dip and during-dip waveforms, then examining them for the point at which the waveform deviates from the ideal by, for example, 10 %, then backing up along the waveform with a narrower threshold, for example, 5 %, to the beginning of the dip. This algorithm is highly sensitive for finding the exact beginning of a voltage dip, without triggering on minor non-dip variations.

A similar algorithm may be used to find the end of the dip. In addition to phase-angle information, this approach also permits the dip duration to be calculated precisely, with a resolution much finer than one cycle.

Also, advanced signal-processing techniques are capable of detecting the exact beginning of a voltage dip.

A.5.4 Voltage dip unbalance

Even very brief unbalance can damage 3-phase rectified loads, or cause over-current devices to trip. Three-phase dips are often unbalanced. With the rapidly updated r.m.s values described in A.5.2, it is often useful to calculate 3-phase unbalance during a dip. The unbalance often varies during a dip, so the unbalance might be presented in a graphic form, or the maximum unbalance during a dip might be presented.

It may be useful to analyse separately the zero sequence, negative sequence, and positive sequence of the fundamental frequency during an unbalanced dip. This approach yields information about how the dip propagates through the network and can be useful in understanding simultaneous dips and swells on different phases.

A.5.5 Phase shift during voltage dip

In some applications, for example, 3-phase rectifiers, the phase shift of the voltage dip can be important. Such a phase shift may be measured by, for example, a DFT applied to the cycle prior to the commencement of the dip, and another cycle after the commencement of the dip. If this approach is taken throughout the dip, a maximum phase shift during the dip may be calculated. The phase shift at the conclusion of the dip may also be useful. In some applications, for example, phase-locked-loop stability, it may be useful to calculate the maximum slew rate ($d\Theta/dt$) of the phase angle during the dip.

The calculation of phase shift during a voltage dip may be combined with voltage dip unbalance by calculating the magnitude and phase angle of zero-sequence, negative-sequence and positive-sequence components during an unbalanced dip.

A.5.6 Missing voltage

This characteristic of a voltage dip may be calculated by subtracting the dip waveform from an ideal waveform, with amplitude, phase, and frequency based on the pre-dip data. This characteristic can be useful for analysing the effect of the dip on voltage restoration devices, for example.

A.5.7 Distortion during voltage dip

The voltage during a dip is often distorted, and the distortion may be important for understanding the effect of the dip on electronic devices. Traditional methods such as THD may be considered for describing this distortion, but THD compares the distortion to the fundamental which, by definition, is rapidly varying during a dip. For this reason, it may be more useful to evaluate distortion during a dip simply as the r.m.s. value of the non-fundamental components.

The presence of even harmonics during or after the dip may point to transformer saturation.

A.5.8 Other characteristics and references

This list of voltage dip characteristics is not exhaustive. Other characteristics, not identified here, may be useful for analysing the effects of voltage dips on various types of loads, control devices, and correction devices. For further details and examples the reader is encouraged to refer to the following publications: IEC TR 61000-2-8 and IEEE 1159.

Annex B
(informative)

Power quality measurement – Guidance for applications

B.1 Contractual applications of power quality measurements

B.1.1 General

Clause B.1 provides guidance on the measurement of power quality (PQ) for contractual purposes; it highlights factors that should be considered by the concerned parties.

NOTE The description of voltage quality parameters is discussed below.

It is recommended that B.1.2 should be consulted prior to entering into a PQ contract, whilst B.1.3 should be consulted prior to performing PQ measurements to test compliance with the contract terms.

B.1.2 General considerations

The terms specified in the contract will need to be both achievable by one party and acceptable to the other. The starting point for a PQ contract should be a PQ standard or specification. Consideration should be given to the planning and indicative values in the relevant IEC standards, for example, IEC 61000-2-2, IEC 61000-2-4, IEC 61000-2-12 and parts of IEC TR 61000-3-6 and IEC TR 61000-3-7, and IEC TR 61000-3-13.

In order to ensure that the results are representative of normal system operating conditions, the PQ measurement survey may discount but not discard data at times when the supply network is subject to severe disturbance resulting from

– exceptional weather conditions;
– third-party interference;
– acts by public authorities;
– industrial action;
– force majeure;
– power shortages resulting from external events.

The contract should specify whether flagged data, as described in the normative part (see 4.7) in this standard, should be excluded from the analysis when assessing the results for contract compliance. If flagged data are excluded, the measurement results will generally be mutually independent for each parameter, and each parameter may be more easily compared directly to a contractual value. If flagged data is included, the measurement results will generally be more directly related to the effects of power quality on sensitive loads, but will be far more difficult or even impossible to compare to any contractual values.

NOTE Flagged data indicate that a disturbance might have influenced the measurement and that consequently a single disturbance might have affected multiple parameters.

When PQ measurements are considered necessary to assess compliance of the supply against contract terms, it is the responsibility of the party that considers the measurements necessary to arrange for them to be performed, if permanent monitoring is not already available. However, this should not preclude the contract from detailing who should perform the measurements. There might be a need to consult third parties.

The contract should indicate how the financial cost of the measurements is to be borne by the concerned parties. This can be dependent upon the measurement results.

The terms of this contract should specify the duration of the contract, the measurement time interval, the PQ parameters to be measured and the electrical location of the measuring instrument(s). See B.1.3 for examples of measurement time interval and PQ parameters.

The choice of the connection mode of the measuring device (i.e. phase-to-neutral or phase-to-phase) should be coherent with the type of supply connection or should result from a common decision between the concerned parties. It should be explicitly mentioned in the contract.

The terms of the contract should specify the use of the measurement methods and the uncertainty described in the normative part of this standard.

The contract should specify the method for determining compensation, in the event of one party failing to honour the terms of the contract.

The contract may contain provisions for the resolution of disputes regarding interpretation of measurements.

The contract will need to address the subject of data access and confidentiality, for example, the party carrying out the PQ measurements might not be the same party that has to analyse the data and assess contract conformity.

B.1.3 Specific considerations

B.1.3.1 General

Power quality (PQ) is assessed by a comparison between the results of measured PQ parameters, and the limits (contractual values) given in a PQ contract. These limits are beyond the scope of this standard.

In a contract, description of each PQ parameter may include: contractual value(s), time interval to be considered, duration of the assessment time interval(s), and possibly special procedures regarding “flagged” measurements.

Many PQ parameters (voltage, harmonics, flicker) can show variations between weekday and weekends. For these, the assessment period should be for a week minimum (or an integer number of weeks).

B.1.3.2 Power frequency

Measurement interval: 1-week minimum assessment period.

Evaluation techniques: 10-s values are considered. The following techniques are suggested, but other evaluation techniques might be agreed between the parties:

– the number, or per cent, of values during the measurement interval that exceed high or low contractual values might be counted;
– the worst-case values might be compared to high and/or low contractual values (the measurement interval might be different for this possibility);
– one or more 95 % (or other percentage) probability weekly values, expressed in hertz, might be compared to high and/or low contractual values;
– the number of consecutive values that exceed high and/or low contractual values might be counted;

– the integration over the measurement interval, of values that deviate from nominal frequency might be compared to contractual values.

B.1.3.3 Magnitude of the supply voltage

Measurement interval: 1-week minimum assessment period.

Evaluation techniques: 10-min values should be considered. The following techniques are suggested, but other evaluation techniques might be agreed between the parties:

– the number, or per cent, of values during the measurement interval that exceed high or low contractual values might be counted;
– the worst-case values might be compared to high and/or low contractual values (the measurement interval might be different for this possibility);
– one or more 95 % (or other percentage) probability weekly values, expressed in volts, might be compared to high and/or low contractual values;
– the number of consecutive values that exceed high and/or low contractual values might be counted.

B.1.3.4 Flicker

Measurement interval: 1-week minimum assessment period.

Evaluation techniques: 10-min values (P_{st}) and/or 2-h values (P_{lt}) might be considered. The following techniques are suggested for both values, but other evaluation techniques might be agreed between the parties:

– the number, or per cent, of values during the measurement interval that exceed contractual values might be counted;
– 99 % (or other percentage) probability weekly values for P_{st}, or 95 % (or other percentage) probability weekly values for P_{lt}, might be compared to contractual values.

B.1.3.5 Voltage dips/swells

Measurement interval: 1-year minimum assessment period.

Evaluation techniques: the parties to the contract should agree on the declared input voltage U_{din}.

NOTE For LV customers, the declared voltage is usually equal to the nominal voltage of the supply system. For MV or HV customers, the declared voltage can be different from the nominal voltage.

The parties to the contract should agree on

– the dip and swell detection thresholds;
– time aggregation techniques;
– location aggregation techniques if more than one location is measured;
– reporting techniques such as residual voltage/duration tables,
– any other evaluation techniques that might be relevant.

B.1.3.6 Voltage interruptions

Measurement interval: 1-year minimum assessment period.

Evaluation techniques: the parties might agree on a duration that defines the borderline between "short" and "long" voltage interruptions. The count of the voltage interruptions, and the total duration of the "long" voltage interruptions during the measurement interval, might be considered. Other evaluation techniques might be agreed between the parties.

Interruptions for which the customer is informed in advance (for example, minimum 24 h) could be counted separately from interruptions for which the customer is not informed in advance.

B.1.3.7 Supply voltage unbalance

Measurement interval: 1-week minimum assessment period.

Evaluation techniques: 10-min values and/or 2-h values might be considered. The following techniques are suggested for both values, but other evaluation techniques might be agreed between the parties:

– the number, or per cent, of values during the measurement interval that exceed contractual values might be counted;
– the worst-case values might be compared to contractual values (the measurement interval might be different for this possibility, for example one year);
– one or more 95 % (or other percentage) probability weekly values, expressed in per cent, might be compared to contractual values.

B.1.3.8 Harmonic voltages

Measurement interval: one-week minimum assessment period for 10-min values, and daily assessment of 150/180-cycle values for at least 1 week.

Evaluation techniques: 150/180-cycle time interval and/or 10-min values might be considered. Contractual values may be applied to individual harmonics, or range of harmonics, or other groupings, for example, even and odd harmonics, according to agreement between the parties to the contract. The following techniques are suggested for all values, but other evaluation techniques might be agreed between the parties:

– the number, or per cent, of values during the measurement interval that exceed contractual values might be counted;
– the worst-case values might be compared to contractual values (the measurement interval might be different for this possibility, for example one year);
– one or more 95 % (or other percentage) probability weekly values for 10-min values, and/or 95 % (or other percentage) probability daily values for 150/180-cycle time interval values, expressed in per cent, might be compared to contractual values.

B.1.3.9 Interharmonic voltages

Measurement interval: 1-week minimum assessment period for 10-min values, and daily assessment of 150/180-cycle values for at least 1 week.

Evaluation techniques: 150/180-cycle time interval and/or 10-min values might be considered. Contractual values may be applied to a range of interharmonics, or other groupings, according to agreement between the parties to the contract. The following techniques are suggested for all values, but other evaluation techniques might be agreed between the parties:

– the number, or per cent, of values during the measurement interval that exceed contractual values might be counted;
– the worst-case values might be compared to contractual values (the measurement interval might be different for this possibility, for example one year);
– one or more 95 % (or other percentage) probability weekly values for 10-min values, and/or 95 % (or other percentage) probability daily values for 150/180-cycle time interval values, expressed in per cent, might be compared to contractual values.

B.1.3.10 Mains signalling voltage on the supply voltage

Measurement interval: 1-day minimum assessment period.

Evaluation techniques: the following techniques are suggested for all values, but other evaluation techniques might be agreed between the parties:

– the number, or per cent, of values during the measurement interval that exceed contractual values might be counted;
– the worst-case values might be compared to contractual values (the measurement interval might be different for this possibility, for example one week).

B.2 Statistical survey applications

B.2.1 General

These provide guidance for designing and performing statistical power quality surveys (including permanent monitoring) in support of:

1) Consumer requirements, where the aim of such surveys is to provide the consumer with information on the power quality parameters seen by the consumer referenced against a set of recognized power quality indices. These indices may relate to recognized standards, or a pre-defined set of requirements specified for a particular installation or item of equipment (e.g. contracts or equipment specifications).
2) Network operator requirements for assessing existing levels of distortion/disturbance on the network (e.g. in the assessment required for the connection of new loads).

Historically, networks have been designed and operated differently in different countries and any attempt to normalize the outputs of different national power quality surveys will be extremely complex and open to misinterpretation.

Clause B.2 explains the aim of power quality statistics and gives some guidelines.

The first objective of these techniques is to compress a large number of measured values.

The second objective is to compute power quality indices for benchmarking, either on one specific point or for a whole network in order to

– verify the compliance with contractual agreement (see Clause B.1);
– monitor the performance evolution of a network during long periods;
– compare different networks during the same interval.

B.2.2 Considerations

A statistical analysis should be done with homogeneous values: same measurement time interval, same measurement data, same network, etc.

Statistics computation is based on a classification of the measured values.

For each parameter, the user defines a "normal range" of variation and may choose to include or not, flagged data (see 4.7), since this data by definition can be irrelevant.

The normal range of variation is then divided into several bins of equal width.

NOTE The number of bins depends on the measured parameter, on the accuracy, on the commitment. A minimum of 40 bins can be adequate for some applications; in other applications, 100 bins can be more useful.

The number of bins determines the confidence interval. Bins remain constant over a measurement period – 1-day, 1-week, 1-year, etc. – and are ordered from the lowest to the greatest bin value within the normal range of variation.

The number of measured values within each bin is counted. These counts may be used to determine cumulative curves, which in turn may be used to determine percentiles.

The statistics formula with the confidence level, for example 95 %, should be used to determine the confidence interval. When the number of statistical values is small, one should be careful about the confidence interval.

B.2.3 Power quality indices

B.2.3.1 Characterizing a single point on the network

One single measurement point may be characterized by two kinds of power quality indices depending on the phenomena concerned:

– statistical indices like percentiles, maximum or mean values over a period of time (see IEC TR 61000-3-6 for harmonics or IEC TR 61000-3-7 for flicker);
– event counting and tabulating.

Examples of power quality indices are given for each parameter in B.1.3.

B.2.3.2 Characterizing an entire network

An entire network is a collection of single points classified by type of network or customers. Weighting rules might be defined in order to get global results. Weighting rules might apply both to statistical indices and events.

B.2.4 Monitoring objectives

Power quality monitoring is necessary to characterize electromagnetic phenomena at a particular location on an electric power circuit.

The objective may be as simple as verifying steady state voltage regulation at a service entrance, or may be as complex as analysing the harmonic current flows within a distribution network.

Generally speaking power quality monitoring is carried out for one of three reasons:

1) PQ evaluation: To evaluate the electrical environment at a particular location to refine modelling techniques or to develop a power quality baseline.
2) Planning the connection of new equipment: To predict future performance of equipment or power quality mitigating devices that are planned to be connected within an installation. In any event, the most important task in any monitoring project is to define clearly the objectives of monitoring
3) Troubleshooting: To diagnose incompatibilities, if any, between the electric power source and the existing equipment connected within an installation.

The procedure for defining monitoring objectives will depend upon the reason for carrying out the monitoring. From this will come the parameters to be measured, the duration of the monitoring and the thresholds against which the parameters will be evaluated.

B.2.5 Economic aspects of power quality surveys

There are several elements that impact on the cost and overall economics of a measurement campaign. These elements include:

- measurement equipment
- transducers
- installation, including connection access
- labour
- communications
- data management (database, etc.)
- data processing and analysis
- survey duration

Of these elements, the measurement equipment cost itself is rarely the most expensive item. In electric utility substation and feeder applications, the installation and labour costs usually dominate the measurement equipment costs by a significant margin. When the total life cycle of a long term measurement campaign is considered, the communication and data analysis costs begin to dominate. It is wise therefore to choose instrumentation that is easy to install, has many communication options, and provides the data in a form that simplifies the analysis task (e.g. the data is available in a standardized format).

An obvious multiplier of measurement campaign cost, is related to the duration of a survey. This is applicable to compliance measurement campaigns such as those associated with standards such as EN 50160. The guidance in this regard is to first, comply with national standards requirements for survey durations and then second, take into consideration the context of the measurement when the duration is not explicitly mandated in a national standard. The duration of the measurement campaign should be tailored to the situation such that the survey duration can be minimized whilst obtaining enough information to properly conduct the assessment. Factors that influence the selection of the duration of a measurement campaign include:

- customer type (e.g. residential, commercial, industrial)
- reason for monitoring (see above)
- variability of the load and time frame over which that variability is expected to be experienced

Prior to installing a permanent power quality monitoring system, a business case should often be developed. Typical business cases include both tangible and intangible benefits. Direct, tangible benefits include:

- identification by signature analysis of failing equipment before total failure (e.g. tap changers, capacitor banks and their switches, transformers)
- reduction of system restoration time (e.g. fault finding)
- contract compliance
- connection requirements for new equipment

Intangible benefits include:

- identifying problem feeders to help improve reliability indices
- customer feedback to improve customer relations

The economics of a power quality measurement campaign can be improved by augmenting the system with information gathered by other equipment not specifically designed for power quality measurement. Sharing resources in this manner allows the cost of measurement to be shared with the primary cost of the device: reclosers, capacitor switch controllers, etc.

B.3 Locations and types of surveys

B.3.1 Monitoring locations

The choice of locations to install power quality monitors will be dependent upon the objective of the survey. If the monitoring objective is to diagnose an equipment performance problem then the monitor should be placed as close to the load as possible. This applies to performance problems with both sensitive electronic loads such as computers and adjustable speed drives, and electrical distribution equipment such as circuit breakers and capacitors. After the voltage fluctuations are detected, the monitor may be moved upstream on the circuit to determine the source of the disturbance.

Monitoring location may also be determined by cost and convenience as long as it does not compromise the technical, regulatory, or legal objectives. For example, it is less costly to monitor at low voltage than high voltage. Measuring in a substation is generally less expensive than part way out on a feeder on a pole.

For compliance monitoring related to service contracts, a monitoring location should be agreed to by all parties to the contract in advance. This is typically defined as the point of common coupling (PCC) between the customer and the system where the PCC is defined as: the point on a public power supply network, electrically nearest to a particular load, at which other loads are, or could be, connected.

B.3.2 Pre-monitoring site surveys

Prior to conducting a measurement campaign, it is recommended that information regarding the system environment be gathered to facilitate proper instrument placement, operation, and analysis. Elements that are common to all surveys include among others:

- electrical system data (single-line diagrams, transformer specifications, transformer connection, short-circuit levels, capacitor bank size and location, branch circuit data, load data, grounding, etc.),
- changes in installation topology over time (e.g. power factor capacitor status, loads, transformers in/out of service, etc.),
- known disturbing loads, rating and operating regime.

B.3.3 Customer side site survey

For surveys within a customer's installation, in addition to the information mentioned above, it is useful to gather information on any problems encountered, for example the nature and characteristics of sensitive equipment, the time stamp of any events that coincide with a reduction in performance. These events should be checked for coincidence with operations within the installation and on the network.

B.3.4 Network side survey

Surveys of the supply network itself require that network specific information be gathered including:

- network protection equipment and settings
  - if the settings are changed for any reason during the course of a survey, it can impact the statistics of voltage dips for example,
  - this permits evaluation of alternative protection scenarios based on survey results;
- existence and characteristics of ripple control (or other relevant telecontrol via power line carrier) that may impact measurements;
- load characteristics (e.g. industrial, commercial, residential or mixture);
- network operation protocol with regards to volt/var control – regulation.

B.4 Connections and quantities to measure

B.4.1 Equipment connection options

There are several decisions that need to be made related to connecting the measurement equipment. These decisions include:

- single-phase versus three-phase measurement,
- line-to-line versus line-to-neutral or line-to-ground connection,
- high side versus low side measurement near transformers.

These decisions will be heavily influenced by the reason for the survey. Sometimes connection requirements may be specified inherently by a particular standard against which the survey is being conducted. Whatever the case the connection should be made in a way that is consistent with the requirements or connection of the affected equipment – taking into account transformer connection issues.

A general observation can be made that when measuring steady state phenomena such as harmonics and flicker, single-phase measurements can often be made instead of three-phase measurements. This is possible because these phenomena are often reasonably balanced. This assumption should be checked by performing a temporary three-phase measurement. When voltage dips and swells are the primary reason for monitoring, it is necessary to monitor all phases powering the affected equipment.

When general surveys are being performed with a three-phase connection and/or there are several voltage transformations downstream from the monitored location, connecting the measurement equipment from line-to-neutral on grounded systems is recommended because the line-to-line values can often be derived either in the instrument or off-line.

Where this is not the case, the connection mode of the monitoring instrument should be chosen taking into account both the connection mode of the potentially affected equipment and the successive voltage transformations downstream.

B.4.2 Priorities: Quantities to measure

The quantities to measure will generally be defined by the monitoring objectives, relevant compliance standards, and other factors. For general surveys it will be necessary, in order to conserve memory space, to identify a priority order for the quantities to monitor. For example:

1) power parameters (V, I, P, Q, S, DPF, TPF, etc. – these are not generally considered to be power quality parameters)
2) voltage dips/swells
3) harmonic voltage
4) harmonic current
5) unbalance
6) transients (e.g. capacitor switching – low frequency)
7) flicker
8) interharmonic voltages and currents
9) mains signaling

NOTE DPF is the displacement power factor, or the cosine of the angle between the fundamental voltage and the fundamental current. TPF is the true power factor, or the ratio between active power and apparent power.

This ordering is an example; the actual prioritization depends on the overall goals and objectives of a particular measurement campaign.

Once the priority is established and an instrument chosen based on those priorities, it is recommended that as much information as the instrument can provide be utilized. It is generally easier to discard data after a survey rather than to derive it when a quantity is desired later that was not directly measured. Generally the only issues affecting this decision are instrument storage capabilities and communication time/cost impacts.

B.4.3 Current monitoring

In general, customers are responsible for the current that their equipment draws from or injects into the system and the supplier is responsible for the supply voltage. This fact can be used as the basis for deciding when to measure currents.

The measurement of current is important for the concept of emission assessment, however the critical point is to accurately determine the phase angle; this becomes increasingly difficult when trying to measure harmonic currents.

The measurement of current can be invaluable in determining the sources/cause of power quality events, since it can help to determine if the cause of the event is upstream or downstream of the measuring instrument. This is particularly true for voltage dips.

B.5 Selecting the monitoring thresholds and monitoring period

B.5.1 Monitoring thresholds

Monitoring thresholds may be determined by the power quality indices against which the results are to be compared, or may be determined by the load requirements. Once again, the reasons for performing the power quality survey should be consulted.

The difference between thresholds used for disturbance capture, versus thresholds used for event characterization, counting, and analysis, should be considered.

As a general recommendation, thresholds should be as tight as feasible (while avoiding continuous triggering). Wider thresholds can be effectively implemented subsequently on captured data, but data that was missed due to loose thresholds can never be recaptured.

Thresholds on sliding references should be used when measuring at an unregulated portion of the network. For example, monitors deployed on distribution feeders with load tap changers or capacitor bank based voltage regulation may be able to use fixed thresholds. Transmission systems or other portions of the network that are not directly regulated with regards to voltage should use the sliding reference method.

NOTE Thresholds are used for detecting events, e.g. dips, swells, RVC, etc. However, for statistical analysis of quasi-steady-state parameters such as harmonics, unbalance, and flicker, continuous recording without thresholds is needed.

B.5.2 Monitoring period

The monitoring period will be determined by the reasons for performing the power quality survey. For example, if the results are to be compared against power quality indices, there may be guidance in those indices regarding the monitoring period.

It is often useful to compare power quality measurements over time, for example comparing one year to the previous year. If this type of comparison is useful, the monitoring period may be permanent.

Some standards may specify minimum measurement periods. In any case, event measurements such as voltage dips and swells generally require longer measurement periods in order to capture enough events to provide meaningful statistics (months). Rarer events such as interruptions may require even longer periods; in contrast, for harmonics and other steady state measurements, meaningful information may be captured in relatively short periods of time (minimum of one week).

For compliance monitoring, the monitoring period should already be specified in the relevant standard. For practical reasons, one may need to interpret the standard – e.g. do you need to measure for one year for EN 50160 compliance? Does it need to be continuous?

B.6 Statistical analysis of the measured data

B.6.1 General

A suitable statistical analysis method should be chosen for the data. Different statistical methods may be selected, depending on the power quality parameter and measurement objectives, but the methods can be roughly divided into:

- methods that count the number of events that exceed some threshold, and
- methods that summarize large numbers of quasi-steady-state measurements into a single number, or a few numbers.

For the latter methods, various possible numbers may be chosen as the most useful summary value: maximum value, 99 % value, 95 % value, average value, minimum value, etc. In many references, the 95 % probability value has been found to be useful.

Data from multiple sites may be analysed statistically to assess network performance.

B.6.2 Indices

Prior to carrying out a measurement campaign it is necessary to understand the indices against which the results of the campaign will be compared. This information will help to determine the duration of the campaign, trigger thresholds and statistical analysis of the results. In the absence of a recognized standard it will be necessary to devise a specific set of indices for each measurement campaign.

There has been much work done by various professional bodies around the world on the subject of power quality indices. Some of the more well known of these are listed in the bibliography.

B.7 Trouble-shooting applications

B.7.1 General

Power-quality-related trouble-shooting is generally performed in response to operational incidents or problems. Consequently, it is often desirable to produce results as quickly as possible, rather than producing data of archival or contractual value. Nevertheless, this need for fast diagnosis should not lead to premature or unfounded conclusions.

Typically, raw unaggregated samples are most useful for trouble-shooting, as they permit any type of post-processing that may be desired, for example, signatures, wavelets, etc. However, to minimize the amount of data to be stored and reviewed, for trouble-shooting, it is useful for the instrument to record and present only data that were recorded just prior to, during, and after an event such as a voltage dip or transient.

B.7.2 Power quality signatures

Signatures are graphic presentations of power quality events, often accompanied by a short table of numeric characteristics.

The most common form is a time-domain plot of voltage and current. Other forms, such as histogram displays of harmonics, cumulative probability distributions, etc. may also be useful. Common time-scales for signatures range from 100 µs to 30 days. Usually an instrument determines the best time-scale for presenting a power quality event based on the event's characteristics and duration.

It is generally agreed that useful signatures show the signal before, during, and after the power quality event (pre-trigger system). Typically, one-fourth of the graph is allocated to the signal just prior to the event.

These power quality signatures are useful for trouble-shooting problems throughout electrical networks, including customers' installations. Typically, they are used to identify and locate the source of a power quality event and to select an appropriate solution.

An expert might use the signature of a voltage dip, for example, to determine that the cause is a large motor starting downstream from the monitoring location, and to select an appropriate solution. Although this example deals with voltage dips, widely available reference books set out the typical signatures for hundreds of different power quality events: switching of power factor correction capacitor, lightning strikes, utility and customer faults, loose wiring, arcing contacts, radio transmission interference, electronic loads that share circuits with motors, etc.

Although many experts can identify common power quality events from their voltage signatures alone, having current signatures as well greatly increases the range and precision of statements that can be made about a power quality event. Moreover, current signatures can assist in identifying the direction of the cause of a disturbance.

Annex C
(informative)

Conducted emissions in the 2 kHz to 150 kHz range

C.1 General

The purpose of Annex C is to consider measurement methods that could provide an overview, in a power quality context, of conducted voltage emissions in the 2 kHz to 150 kHz range. These emissions are presumed to be quasi-steady-state levels, although they may have amplitude modulation. It is emphasized that the purpose of Annex C is to describe overview measurement methods, as opposed to precision measurement methods.

Background information on emissions and sensitivity in this frequency range can be found in IEC 61000-4-19:2014, Annex A.

The understanding of measurement methods in this frequency range is still evolving, so Annex C only provides general guidance.

For applications where highly detailed measurements are required, such as type tests for emissions measurements or compliance measurements, the measurement methods found in IEC 61000-4-7 and/or CISPR 16 should be considered.

NOTE 1 Useful information about measurement in the 2 kHz to 150 kHz range can be found in IEC 61000-4-7:2002, Annex B (2 kHz to 9 kHz), and in CISPR 16 (9 kHz to 150 kHz).

NOTE 2 Immunity test methods for 2 kHz to 150 kHz emissions can be found in IEC 61000-4-19.

NOTE 3 The measurement methods for 2 kHz to 9 kHz in IEC 61000-4-7 are informative, not normative. The measurement method for this frequency range in CISPR 16 focuses on emissions from equipment under test (EUT), and does not directly address power quality investigations and surveys. In CISPR 16, the in-situ measurements are considered in terms of an EUT.

NOTE 4 This frequency range is a relatively new consideration in a power quality context, so there may be differences between standards. For example, IEC 61000-4-7 considers phase-to-neutral voltages, while CISPR 16 considers phase-to-earth voltages. (Annex C does not select a physical connection method for measurement channels.) For example, the measurement methods of CISPR 16 may not accurately record the characteristics of some immunity test waveforms in IEC 61000-4-19, due to the rapid modulation of those test waveforms. These are examples; other differences between standards may be found.

NOTE 5 Information about emission magnitudes in the 2 kHz to 9 kHz band can be found in IEC 61000-2-4:2002, Clause C.3, where, for example, on systems with U_{din}= 230 V, "few troubles were reported on networks having" emissions in the range 0,46 V to 3,45 V. For the same 2 kHz to 9 kHz band, IEC 61000-2-2:2002, B.2.3, suggests a reference level for any 200 Hz bandwidth of 0,69 V.

Users of this standard should be aware that the contents of Annex C may become normative in a future edition.

Measurements in this frequency range may be strongly affected by transducers, if present. Guidance about effects of transducers may be found in IEC TR 61869-103.

C.2 Measurement method – 2 kHz to 9 kHz

The measurement method for 2 kHz to 9 kHz, including requirements for Class A and Class S, is under consideration. The measurement methods of IEC 61000-4-7:2002, Annex B (informative) could be considered.

C.3 Measurement method – 9 kHz to 150 kHz

The measurement method for 9 kHz to 150 kHz, including requirements for Class A and Class S, is under consideration.

One method under consideration is the method of CISPR 16-1-2. CISPR 16-1-2 emphasizes immunity and emission measurements for equipment under test (EUT), and may not be optimized for in-situ power quality measurements. For the purpose of in-situ power quality investigations and surveys, the measurement methods in CISPR 16 may be complex or expensive to implement, due to their gapless measurements and accuracy requirements. The measurement methods of CISPR 16 may provide a large amount of data in an in-situ power quality context. However, the amount of data for in-situ measurements specified by CISPR 16 may be required for coordination with levels defined by various IEC standards.

A second method under consideration is to extend the method of IEC 61000-4-7:2002, Annex B, from the present 9 kHz limit up to a 150 kHz limit.

A third method under consideration is the method described in the NOTE below. This method, although less complete and less accurate than CISPR 16-1-2, may possibly be more appropriate for in-situ power quality applications, and may be less expensive to implement, and may avoid providing an overwhelming amount of data. However, it may not provide sufficient data for coordination with levels defined by various IEC standards. Also, due to intervals between the measurements, it is not an appropriate method for measuring amplitude-modulated signals that vary with a period less than twice the interval between measurements. Also, if 2 kHz segment widths are selected for this measurement method, it may be difficult to differentiate phenomena within the same frequency segment.

Other methods may be considered during development of future editions of this standard.

NOTE The third measurement method under consideration for the frequency range 9 kHz to 150 kHz is the following:

The frequency range of 9 kHz to 150 kHz could be divided into equal-width segments. The segment width could be an integer multiple of 200 Hz, preferably either 200 Hz or 2 kHz. For the purposes of this measurement method, it is acceptable to process a frequency range beyond 9 kHz to 150 kHz, for example processing the range 8 kHz to 150 kHz if a 2 kHz segment width is selected.

The minimum, average, and maximum magnitude of the r.m.s. voltage in each frequency segment in the 9 kHz to 150 kHz range could be recorded during each 10/12-cycle interval. In addition, the single maximum value in any segment, on any channel, could be recorded.

The following example design demonstrates the intent of the measurement method, measurement range, and measurement uncertainty:

a) The 9 kHz to 150 kHz measurements could be made on each channel through cascaded high pass and low pass filters. The high pass filter could have 2 poles, with a 3 dB point at 1,5 kHz or higher. The low pass filter could have 4 poles, with the 3 dB point at 200 kHz. The measurement range after the filters could be at least ±50 V instantaneous, with a resolution of 12 bits or more.

b) 9 kHz to 150 kHz measurements could be taken at the output of the cascaded filters at equally spaced time intervals such that 32 approximately equally-spaced measurements are taken each 10/12-cycle interval. Cross-channel synchronization is not necessary. Each measurement could consist of 512 samples taken at a sampling rate of 1,024 MHz.

c) For 9 kHz to 150 kHz, the 512 samples could be processed with a Discrete Fourier Transform or equivalent, yielding 256 bins spaced at 2 kHz. The lowest 4 bins and the upper 181 bins could be discarded. The magnitudes of the remaining 71 bins contain the emissions from 8 kHz to 150 kHz. These emissions could be reported as an r.m.s. value.

d) For 9 kHz to 150 kHz, at each 10/12-cycle interval, 32 sets of these 71 bins are available. At each 10/12-cycle interval, the minimum, average, and maximum value of the 32 r.m.s. magnitudes of each of these 71 bins could be reported. In addition, at each 10/12-cycle interval, a single r.m.s. maximum value of all 71 bins across all channels could be reported.

C.4 Measurement range and measurement uncertainty

The measurement range and measurement uncertainty for Class A and Class S are under consideration.

A measurement range of at least 200 % of the largest applicable immunity level specified in IEC 61000-4-19:2014, Table 1, could be considered. A measurement uncertainty of at most 10 % of the smallest applicable immunity level specified in IEC 61000-4-19:2014, Table 1, could be considered.

For conducted emissions in the range 2 kHz to 9 kHz, additional information can be found in IEC 61000-4-7.

C.5 Aggregation

The time aggregation methods, including the requirements for Class A and Class S, are under consideration.

NOTE 1 Minimum, maximum, and average values could be considered during each aggregation interval. The average r.m.s. value could be used, for example, to determine typical emissions. The maximum r.m.s. value could be used, for example, to determine worst-case emissions. The difference between the minimum and maximum values could be used, for example, to detect the presence of amplitude modulation. The single maximum r.m.s. value could be used, for example, to set worst-case 95 % limits.

NOTE 2 Measurement methods may generate a large amount of data, which, depending on the application, may need to be stored, transmitted, analysed, and/or archived. Depending on the application, the amount of data may be reduced. To reduce the amount of data, consider applying statistical methods at the measuring location such as 95 % or 99 % levels, or storing only extreme and average values, or storing detailed data only when trigger thresholds are exceeded, or other methods.

NOTE 3 In general, measurements in the 2 kHz to 150 kHz range could be aggregated using the aggregation intervals of 4.5.

Annex D
(informative)

Underdeviation and overdeviation

D.1 General

Underdeviation and overdeviation parameters may be useful when it is important to avoid, for example, having sustained undervoltages being cancelled in data by sustained overvoltages.

D.2 Measurement method

– **Class A**

The $U_{rms(10/12)}$ should be used to assess the underdeviation and overdeviation parameters in per cent of U_{din}. The underdeviation $U_{rms\text{-}under}$ and overdeviation $U_{rms\text{-}over}$ parameters are determined by Equations (D.1),(D.2), (D.3), (D.4) and (D.5) and (D.6):

Underdeviation assessment:

the following rule applies for the calculation of $U_{rms-under,i}$:

$$\text{if} \quad U_{rms(10/12),i} > U_{din} \quad \text{then} \quad U_{rms-under,i} = U_{din} \tag{D.1}$$

$$\text{if} \quad U_{rms(10/12),i} \le U_{din} \quad \text{then} \quad U_{rms-under,i} = U_{rms(10/12),i} \tag{D.2}$$

Overdeviation assessment:

the following rule applies for the calculation of $U_{rms-over,i}$:

$$\text{if} \quad U_{rms(10/12),i} < U_{din} \quad \text{then} \quad U_{rms-over,i} = U_{din} \tag{D.3}$$

$$\text{if} \quad U_{rms(10/12),i} \ge U_{din} \quad \text{then} \quad U_{rms-over,i} = U_{rms(10/12),i} \tag{D.4}$$

NOTE On single-phase systems, there is a single underdeviation assessment and overdeviation assessment value for each interval. On 3-phase 3-wire systems, there are 3 values for each interval. Either 6 values or 3 values can be measured on 4-wire systems.

– **Class S**

No requirement.

D.3 Measurement uncertainty and measuring range

The underlying $U_{rms(10/12)}$ values should be consistent with the requirements of 5.2.2.

D.4 Aggregation

– **Class A**

Underdeviation assessment:

$$U_{\text{under}} = \frac{U_{\text{din}} - \sqrt{\dfrac{\sum_{i=1}^{n} U_{\text{rms-under},i}^{2}}{n}}}{U_{\text{din}}} \quad [\%] \qquad \text{(D.5)}$$

where n = the number of 10/12-cycle r.m.s. values for under- or overdeviation during the aggregation interval

and $U_{\text{rms-under},i}$ is the i^{th} 10/12-cycle r.m.s. value

Overdeviation assessment:

$$U_{\text{over}} = \frac{\sqrt{\dfrac{\sum_{i=1}^{n} U_{\text{rms-over},i}^{2}}{n}} - U_{\text{din}}}{U_{\text{din}}} \quad [\%] \qquad \text{(D.6)}$$

where

$U_{\text{rms-over},i}$ is the i^{th} $U_{\text{rms(10/12)}}$ value

NOTE Both underdeviation and overdeviation parameter Equations (D.4) and (D.5) give positive values.

Aggregation should be performed according to 4.4 and 4.5.

– **Class S**

No requirement.

Annex E
(informative)

Class B Measurement Methods

E.1 Background for Class B

References to Class B in this edition of IEC 61000-4-30 exist only to support legacy instruments still in operation.

When IEC 61000-4-30 was first drafted in the final years of the 20th century, the goal was to provide measurement methods that would cause two compliant instruments, when connected to the same signals, to provide identical results.

It was realized at the time that such a standard could make existing, useful instruments obsolete, and this was not the result that was desired. So two classes were defined: Class A, which achieved the goal above, and Class B, which would avoid making existing instruments obsolete. (Class S, for Survey instruments that produce statistically useful but not necessarily identical results, was added later in IEC 61000-4-30:2008 (edition 2).)

Class B instruments existed in 2003 when this standard was first published. IEC 61000-4-30:2008 (edition 2) made it clear that Class B methods are not recommended for new designs. In the present edition, Class B has now been moved from the normative section of this standard to Annex E (informative).

Because Class B exists only to support legacy instruments still in operation but becoming obsolete, it is expected that Class B will be removed from the next edition of this standard.

E.2 Class B – Measurement aggregation over time intervals

The manufacturer should specify the number and duration of aggregation time intervals.

E.3 Class B – Measurement aggregation algorithm

The manufacturer should specify the method of aggregation.

E.4 Class B – Real time clock (RTC) uncertainty

E.4.1 General

The manufacturer should specify the RTC uncertainty and the method to determine aggregation intervals, if any.

E.4.2 Class B – Frequency – Measurement method

The manufacturer should specify the process used for frequency measurement.

E.4.3 Class B – Frequency – Measurement uncertainty

The manufacturer should specify the uncertainty over the measuring ranges 42,5 Hz to 57,5 Hz/51 Hz to 69 Hz.

E.4.4 Class B – Frequency – Measurement evaluation

The manufacturer should indicate the process used for frequency measurement evaluation.

E.4.5 Class B – Magnitude of the supply – Measurement method

The measurement should be the r.m.s. value of the voltage over a period specified by the manufacturer.

E.4.6 Class B – Magnitude of the supply – Measurement uncertainty and measuring range

The measurement uncertainty should be specified by the manufacturer, in such a way as not to exceed ±1 % of U_{din} , over a range specified by the manufacturer.

E.5 Class B – Flicker

E.5.1 General

Not applicable.

E.5.2 Class B – Supply voltage dips and swells – Measurement method

E.5.2.1 General

The manufacturer should specify the method used for U_{rms}.

E.5.2.2 Class B – Supply voltage dips and swells – Magnitude uncertainty

The manufacturer should specify the uncertainty which shall not exceed ±2,0 % of U_{din}.

E.5.2.3 Class B – Supply voltage dips and swells – Duration uncertainty

The manufacturer should specify the duration measurement uncertainty.

E.6 Class B – Voltage interruptions

E.6.1 General

All of 5.5 should apply.

E.6.2 Class B – Supply voltage unbalance – Measurement method

The manufacturer should specify the algorithms and methods used to calculate unbalance.

E.6.3 Class B – Supply voltage unbalance –Uncertainty

Should be the same as 5.7.2, Class A, except for the uncertainty which is less than 0,3 % for any unbalance parameter that is evaluated.

E.6.4 Class B – Voltage harmonics – Measurement method

The manufacturer should specify the measurement method.

E.6.5 Class B –Voltage harmonics – Measurement uncertainty and range

The manufacturer should specify the measurement uncertainty and measurement range.

E.6.6 Class B – Voltage interharmonics – Measurement method

The manufacturer should specify the measurement method.

E.6.7 Class B –Voltage interharmonics – Measurement uncertainty and range

The manufacturer should specify the measurement uncertainty and measurement range.

E.6.8 Class B – Mains signalling voltage – Measurement method

The manufacturer should specify the measurement method.

E.6.9 Class B –Mains signalling voltage – Measurement uncertainty and range

The manufacturer should specify the measurement uncertainty and measurement range.

E.6.10 Class B – Current – Measurement method

No requirement. If included, the manufacturer should specify the measurement method.

E.6.11 Class B – Current – Measurement uncertainty and range

No requirement. If included, the manufacturer should specify the measurement uncertainty and measurement range.

Bibliography

IEC 60044-1:1996, *Instrument transformers – Part 1: Current transformers*

IEC 60044-2:1997, *Instrument transformers – Part 2: Inductive voltage transformers*

IEC 60050-161, *International Electrotechnical Vocabulary (IEV) – Part 161: Electromagnetic compatibility*

IEC 60050-300, *International Electrotechnical Vocabulary (IEV) – Part 300: Electrical and electronic measurements and measuring instruments*

IEC 60050-311, *International Electrotechnical Vocabulary (IEV) – Part 311: General terms relating to measurements*

IEC 60050-312, *International Electrotechnical Vocabulary (IEV) – Part 312: General terms relating to electrical measurements*

IEC 60050-313, *International Electrotechnical Vocabulary (IEV) – Part 313: Types of electrical measuring instruments*

IEC 60050-314, *International Electrotechnical Vocabulary (IEV) – Part 314: Specific terms according to the type of instruments*

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

IEC TR 61000-2-8, *Electromagnetic compatibility (EMC) – Part 2-8: Environment – Voltage dips and short interruptions on public electric power supply systems with statistical measurement results*

IEC 61000-2-12, *Electromagnetic compatibility (EMC) – Part 2-12: Environment – Compatibility levels for low-frequency conducted disturbances and signalling in public medium-voltage power supply systems – Basic EMC publication*

IEC TR 61000-3-6:1996, *Electromagnetic compatibility (EMC) – Part 3: Limits – Section 6: Assessment of emission limits for distorting loads in MV and HV power systems – Basic EMC publication*

IEC TR 61000-3-7:1996, *Electromagnetic compatibility (EMC) – Part 3: Limits – Section 7: Assessment of emission limits for fluctuating loads in MV and HV power systems – Basic EMC publication*

IEC TR 61000-3-13, *Electromagnetic compatibility (EMC) – Part 3-13: Limits – Assessment of emission limits for the connection of unbalanced installations to MV, HV and EHV power systems*

IEC 61000-4-19, *Electromagnetic compatibility (EMC) – Part 4-19: Testing and measurement techniques – tests for immunity to conducted, differential mode disturbances and signalling in the frequency range 2 kHz to 150 kHz at a.c. power ports*

IEC 61010 (all parts), *Safety requirements for electrical equipment for measurement, control and laboratory use*

IEC 61010-2-032, *Safety requirements for electrical equipment for measurement, control and laboratory use – Part 2-032: Particular requirements for hand-held current clamps for electrical measurement and test*

IEC 61869-1, *Instrument transformers – Part 1: General requirements*

IEC 61869-2, *Instrument transformers – Part 2: Additional requirements for current transformers*

CISPR 16-1-1, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus*

CISPR 16-1-2, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-2: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Conducted disturbances*

CISPR 16-2-1, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-1: Methods of measurement of disturbances and immunity – Conducted disturbance measurements*

EN 50160:2000, *Voltage characteristics of electricity supplied by public distribution systems*

IEEE 1159:1995, *IEEE Recommended Practice on Monitoring Electrical Power Quality*

Recommendation ITU-R TF.686-3, *Glossary and definitions of time and frequency terms*

____

SOMMAIRE

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

COMPATIBILITÉ ÉLECTROMAGNÉTIQUE (CEM) –

Partie 4-30: Techniques d'essai et de mesure – Méthodes de mesure de la qualité de l'alimentation

AVANT-PROPOS

1) La Commission Electrotechnique Internationale (IEC) est une organisation mondiale de normalisation composée de l'ensemble des comités électrotechniques nationaux (Comités nationaux de l'IEC). L'IEC a pour objet de favoriser la coopération internationale pour toutes les questions de normalisation dans les domaines de l'électricité et de l'électronique. A cet effet, l'IEC – entre autres activités – publie des Normes internationales, des Spécifications techniques, des Rapports techniques, des Spécifications accessibles au public (PAS) et des Guides (ci-après dénommés "Publication(s) de l'IEC"). Leur élaboration est confiée à des comités d'études, aux travaux desquels tout Comité national intéressé par le sujet traité peut participer. Les organisations internationales, gouvernementales et non gouvernementales, en liaison avec l'IEC, participent également aux travaux. L'IEC collabore étroitement avec l'Organisation Internationale de Normalisation (ISO), selon des conditions fixées par accord entre les deux organisations.
2) Les décisions ou accords officiels de l'IEC concernant les questions techniques représentent, dans la mesure du possible, un accord international sur les sujets étudiés, étant donné que les Comités nationaux de l'IEC intéressés sont représentés dans chaque comité d'études.
3) Les Publications de l'IEC se présentent sous la forme de recommandations internationales et sont agréées comme telles par les Comités nationaux de l'IEC. Tous les efforts raisonnables sont entrepris afin que l'IEC s'assure de l'exactitude du contenu technique de ses publications; l'IEC ne peut pas être tenue responsable de l'éventuelle mauvaise utilisation ou interprétation qui en est faite par un quelconque utilisateur final.
4) Dans le but d'encourager l'uniformité internationale, les Comités nationaux de l'IEC s'engagent, dans toute la mesure possible, à appliquer de façon transparente les Publications de l'IEC dans leurs publications nationales et régionales. Toutes divergences entre toutes Publications de l'IEC et toutes publications nationales ou régionales correspondantes doivent être indiquées en termes clairs dans ces dernières.
5) L'IEC elle-même ne fournit aucune attestation de conformité. Des organismes de certification indépendants fournissent des services d'évaluation de conformité et, dans certains secteurs, accèdent aux marques de conformité de l'IEC. L'IEC n'est responsable d'aucun des services effectués par les organismes de certification indépendants.
6) Tous les utilisateurs doivent s'assurer qu'ils sont en possession de la dernière édition de cette publication.
7) Aucune responsabilité ne doit être imputée à l'IEC, à ses administrateurs, employés, auxiliaires ou mandataires, y compris ses experts particuliers et les membres de ses comités d'études et des Comités nationaux de l'IEC, pour tout préjudice causé en cas de dommages corporels et matériels, ou de tout autre dommage de quelque nature que ce soit, directe ou indirecte, ou pour supporter les coûts (y compris les frais de justice) et les dépenses découlant de la publication ou de l'utilisation de cette Publication de l'IEC ou de toute autre Publication de l'IEC, ou au crédit qui lui est accordé.
8) L'attention est attirée sur les références normatives citées dans cette publication. L'utilisation de publications référencées est obligatoire pour une application correcte de la présente publication.
9) L'attention est attirée sur le fait que certains des éléments de la présente Publication de l'IEC peuvent faire l'objet de droits de brevet. L'IEC ne saurait être tenue pour responsable de ne pas avoir identifié de tels droits de brevets et de ne pas avoir signalé leur existence.

La Norme internationale IEC 61000-4-30 a été établie par le sous-comité 77A: CEM – Phénomènes basse fréquence, du comité d'études 77 de l'IEC: Compatibilité électromagnétique.

La présente norme constitue la partie 4-30 de l'IEC 61000. Elle a le statut de publication fondamentale en CEM conformément au guide 107 de l'IEC.

Cette troisième édition annule et remplace la deuxième édition, parue en 2008. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

a) la méthode de mesure du courant, précédemment informative, est désormais normative et comporte quelques modifications;

b) la méthode de mesure de RVC (rapid voltage change – variations rapides de tension) a été ajoutée;

c) la méthode de mesure des émissions conduites dans la plage de 2 kHz à 150 kHz a été ajoutée dans l'Annexe informative C;

d) les paramètres de valeur basse et de valeur haute ont été déplacés dans l'Annexe informative D;

e) les méthodes de mesure de Classe A et de Classe S sont définies et clarifiées, tandis que la Classe B a été déplacée dans l'Annexe informative E en vue d'un retrait ultérieur;

f) les méthodes de mesure se poursuivent dans la présente Norme, mais les responsabilités pour les grandeurs d'influence, les performances et les procédures d'essai ont été transférées dans l'IEC 62586-2.

Le texte de cette norme est issu des documents suivants:

FDIS	Rapport de vote
77A/873/FDIS	77A/878/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette norme.

Cette publication a été rédigée selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série IEC 61000, publiées sous le titre général *Compatibilité électromagnétique (CEM)*, peut être consultée sur le site web de l'IEC.

Le comité a décidé que le contenu de cette publication ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives à la publication recherchée. À cette date, la publication sera

- reconduite,
- supprimée,
- remplacée par une édition révisée, ou
- amendée.

Le contenu du corrigendum de décembre 2016 a été pris en considération dans cet exemplaire.

IMPORTANT – Le logo *"colour inside"* qui se trouve sur la page de couverture de cette publication indique qu'elle contient des couleurs qui sont considérées comme utiles à une bonne compréhension de son contenu. Les utilisateurs devraient, par conséquent, imprimer cette publication en utilisant une imprimante couleur.

INTRODUCTION

L'IEC 61000 est publiée sous forme de plusieurs parties conformément à la structure suivante:

Partie 1: Généralités

Considérations générales (introduction, principes fondamentaux)

Définitions, terminologie

Partie 2: Environnement

Description de l'environnement

Classification de l'environnement

Niveaux de compatibilité

Partie 3: Limites

Limites d'émission

Limites d'immunité (dans la mesure où elles ne relèvent pas de la responsabilité des comités de produits)

Partie 4: Techniques d'essai et de mesure

Techniques de mesure

Techniques d'essai

Partie 5: Guide d'installation et d'atténuation

Guide d'installation

Méthodes et dispositifs d'atténuation

Partie 6: Normes génériques

Partie 9: Divers

Chaque partie est ensuite subdivisée en plusieurs parties, publiées soit comme Normes internationales, soit comme Spécifications Techniques ou Rapports Techniques, dont certaines ont déjà été publiées en tant que sections. D'autres seront publiées avec le numéro de la partie, suivi d'un tiret et complété d'un second chiffre identifiant la subdivision (exemple: 61000-6-1).

COMPATIBILITÉ ÉLECTROMAGNÉTIQUE (CEM) –

**Partie 4-30: Techniques d'essai et de mesure –
Méthodes de mesure de la qualité de l'alimentation**

1 Domaine d'application

La présente partie de l'IEC 61000-4 définit les méthodes de mesure des paramètres de qualité de l'alimentation des réseaux d'énergie électrique en courant alternatif à une fréquence fondamentale déclarée de 50 Hz ou 60 Hz et la façon d'interpréter les résultats.

Les méthodes de mesure sont décrites pour chaque paramètre applicable en des termes qui fournissent des résultats fiables et répétitifs indépendamment de la mise en œuvre de la méthode. La présente norme porte sur les méthodes de mesure destinées aux mesurages in situ.

Le mesurage des paramètres couverts par la présente norme se limite aux phénomènes conduits sur les réseaux d'énergie électrique. Les paramètres de qualité de l'alimentation pris en compte dans la présente norme sont la fréquence industrielle, l'amplitude de la tension d'alimentation, le papillotement («flicker»), les creux et les surtensions temporaires d'alimentation, les coupures de tension, les tensions transitoires, le déséquilibre de tension d'alimentation, les harmoniques et interharmoniques de tension, les signaux transmis sur la tension d'alimentation, les variations rapides de tension et les mesurages de courant. Les émissions dans la plage comprise entre 2 kHz et 150 kHz sont prises en compte dans l'Annexe C (informative), et les valeurs hautes et valeurs basses sont prises en compte dans l'Annexe D (informative). En fonction de l'objet du mesurage, les mesurages peuvent porter soit sur une partie des phénomènes de cette liste, soit sur l'ensemble.

NOTE 1 Les méthodes d'essai concernant la vérification de la conformité à la présente norme se trouvent dans l'IEC 62586-2.

NOTE 2 Les effets des transducteurs lorsqu'ils sont placés entre le réseau et l'appareil de mesure sont pris en compte mais non traités en détail dans la présente norme. Des lignes directrices sur les effets des transducteurs peuvent être consultées dans l'IEC TR 61869-103.

2 Références normatives

Les documents suivants sont cités en référence de manière normative, en intégralité ou en partie, dans le présent document et sont indispensables pour son application. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60050 (toutes les parties), *Vocabulaire Électrotechnique International (VEI)* (disponible à l'adresse http://www.electropedia.org)

IEC 61000-2-4, *Compatibilité électromagnétique (CEM) – Partie 2-4: Environnement – Niveaux de compatibilité dans les installations industrielles pour les perturbations conduites à basse fréquence*

IEC 61000-3-8, *Compatibilité électromagnétique (CEM) – Partie 3: Limites – Section 8: Transmission de signaux dans les installations électriques à basse tension – Niveaux d'émission, bandes de fréquences et niveaux de perturbations électromagnétiques*

IEC 61000-4-7:2002, *Compatibilité électromagnétique (CEM) – Partie 4-7: Techniques d'essai et de mesure – Guide général relatif aux mesures d'harmoniques et d'interharmoniques, ainsi qu'à l'appareillage de mesure, applicable aux réseaux d'alimentation et aux appareils qui y sont raccordés*
IEC 61000-4-7:2002/AMD1:2008

IEC 61000-4-15:2010, *Compatibilité électromagnétique (CEM) – Partie 4-15: Techniques d'essai et de mesure – Flickermètre – Spécifications fonctionnelles et de conception*

IEC 61180 (toutes les parties), *Techniques des essais à haute tension pour matériels à basse tension*

IEC 62586-1, *Mesure de la qualité de l'alimentation dans les réseaux d'alimentation – Partie 1: Instruments de mesure de la qualité de l'alimentation*

IEC 62586-2, *Mesure de la qualité de l'alimentation dans les réseaux d'alimentation – Partie 2: Essais fonctionnels et exigences d'incertitude*

3 Termes et définitions

Pour les besoins du présent document, les termes et définitions donnés dans l'IEC 60050-161, ainsi que les suivants, s'appliquent.

3.1
voie (de mesure)
ensemble des dispositifs de mesure associés à une mesure individuelle

Note 1 à l'article: «Voies» et «phases» n'ont pas la même signification. Une voie de mesure correspond par définition à une différence de potentiel entre deux conducteurs. Une phase correspond à un simple conducteur. Dans les réseaux polyphasés, une voie de mesure peut être entre deux phases ou entre une phase et le neutre, ou entre une phase et la terre, ou entre le neutre et la terre.

3.2
tension d'entrée déclarée
U_{din}
valeur obtenue à partir de la tension d'alimentation déclarée d'un rapport de transformation

3.3
tension d'alimentation déclarée
U_c
généralement, tension nominale U_n du réseau

Note 1 à l'article: Si, par suite d'un accord entre l'opérateur de réseau et le client, la tension d'alimentation appliquée à ses bornes diffère de la tension nominale, alors, cette tension correspond à la tension d'alimentation déclarée U_c.

3.4
seuil de creux
valeur de tension spécifiée pour permettre de détecter le début et la fin d'un creux de tension

3.5
données marquées
pendant tout intervalle de mesure au cours duquel se produisent des coupures, des creux de tension ou des surtensions temporaires, résultats marqués des mesures de tous les autres paramètres réalisées pendant cet intervalle de temps

Note 1 à l'article: Dans certaines applications, ces données marquées peuvent être exclues par une analyse plus approfondie, par exemple. Voir 4.7 pour des explications supplémentaires.

3.6
papillotement
flicker
impression d'instabilité de la sensation visuelle due à un stimulus lumineux dont la luminance ou la répartition spectrale fluctue dans le temps

[SOURCE: IEC 60050-161:1990, 161-08-13]

3.6.1
P_{st}
évaluation de papillotement de courte durée basée sur une période d'observation de 10 min

[SOURCE: IEC 61000-4-15]

3.6.2
P_{lt}
évaluation de papillotement de longue durée

[SOURCE: IEC 61000-4-15]

3.7
composante fondamentale
composante dont la fréquence est la fréquence fondamentale

3.8
fréquence fondamentale
fréquence du spectre obtenue à partir d'une transformée de Fourier d'une fonction temporelle, servant de référence à toutes les autres fréquences du spectre

Note 1 à l'article: S'il subsiste un risque d'ambiguïté, la fréquence fondamentale peut être déterminée à partir du nombre de pôles et de la vitesse de rotation du ou des générateurs synchrones alimentant le réseau.

3.9
composante harmonique
n'importe laquelle des composantes ayant une fréquence harmonique

Note 1 à l'article: Sa valeur est normalement exprimée sous la forme d'une valeur efficace. Pour des raisons de simplicité, cette composante peut simplement être appelée harmonique.

[SOURCE: IEC 61000-2-2:2002, 3.2.4]

3.10
fréquence harmonique
fréquence qui est un multiple entier de la fréquence fondamentale

Note 1 à l'article: Le rapport entre la fréquence harmonique et la fréquence fondamentale est le rang harmonique (notation recommandée: n) (IEC 61000-2-2:2002, 3.2.3).

3.11
hystérésis
différence d'amplitude entre les valeurs aller et retour de seuils

Note 1 à l'article: Cette définition de l'hystérésis est relative aux paramètres de mesure de la qualité de l'alimentation (PQ) et est différente de celle de l'IEC 60050 qui concerne la saturation des noyaux métalliques.

Note 2 à l'article: Le but de l'hystérésis dans le contexte de mesure de la qualité de l'alimentation est d'éviter de compter de multiples événements lorsque l'amplitude du paramètre oscille près de la valeur de seuil.

3.12
grandeur d'influence
grandeur qui n'est pas l'objet de la mesure et dont la variation affecte la relation entre l'indication et la mesure

[SOURCE: IEC 60050-311:2001, 311-06-01]

3.13
composante interharmonique
composante spectrale ayant une fréquence entre deux fréquences harmoniques consécutives

Note 1 à l'article: La définition est dérivée de l'IEC 61000-4-7.

Note 2 à l'article: Sa valeur est normalement exprimée sous la forme d'une valeur efficace. Pour des raisons de concision, cette composante peut être simplement appelée interharmonique.

3.14
fréquence interharmonique
toute fréquence qui n'est pas un multiple entier de la fréquence fondamentale

Note 1 à l'article: Par extension du rang harmonique, le rang interharmonique est le rapport d'une fréquence interharmonique à la fréquence fondamentale. Ce rapport n'est pas un entier (notation recommandée m).

Note 2 à l'article: Lorsque $m < 1$, le terme fréquence sous-harmonique peut être utilisé.

[SOURCE: IEC 61000-2-2:2002, 3.2.5]

3.15
coupure
réduction de la tension en un point du réseau d'énergie électrique en dessous du seuil de coupure

3.16
seuil de coupure
valeur de tension spécifiée pour permettre de détecter le début et la fin d'une coupure

3.17
incertitude de mesure
paramètre, associé au résultat d'un mesurage, qui caractérise la dispersion des valeurs qui pourraient être raisonnablement attribuées au mesurande

[SOURCE: IEC 60050-311:2001 311-01-02]

3.18
tension nominale
U_n
tension par laquelle un réseau est désigné ou identifié

3.19
valeur haute
différence entre la valeur mesurée et la valeur nominale d'un paramètre, uniquement lorsque la valeur mesurée du paramètre est supérieure à la valeur nominale

3.20
qualité de l'alimentation
caractéristiques de l'électricité en un point donné d'un réseau d'énergie électrique, évaluées par rapport à un ensemble de paramètres techniques de référence

Note 1 à l'article: Ces paramètres peuvent, dans certains cas, tenir compte de la compatibilité entre l'électricité fournie par un réseau et les charges connectées à ce réseau.

3.21
moyenne quadratique
valeur efficace
racine carrée de la moyenne arithmétique des carrés des valeurs instantanées d'une grandeur durant un intervalle de temps spécifié et une largeur de bande spécifiée

[SOURCE: IEC 60050-103:2009, 103-02-03]

3.22
tension efficace rafraîchie par demi-période
$U_{\mathrm{eff}(½)}$
valeur de la tension efficace mesurée sur une période, commençant à un passage par zéro de la composante fondamentale, et rafraîchie à chaque demi-période

Note 1 à l'article: Cette technique est indépendante sur chaque voie de mesure et produira des valeurs efficaces à des instants successifs sur chaque voie en cas de réseaux polyphasés.

Note 2 à l'article: Cette valeur n'est utilisée que pour la détection et l'évaluation, dans la classe A, des creux de tension, des surtensions temporaires à fréquence industrielle, des coupures et des variations rapides de tension (RVC).

Note 3 à l'article: Cette valeur efficace de la tension peut être une valeur entre phases ou entre phase et neutre.

3.23
courant efficace rafraîchi par demi-période
$I_{\mathrm{eff}\ (½)}$
valeur du courant efficace mesurée sur une période, commençant à un passage par zéro de la composante fondamentale sur une voie de mesure de tension associée, et rafraîchie à chaque demi-période

Note 1 à l'article: À titre indicatif, la voie de mesure de tension associée peut être la voie de mesure correspondante entre phase et neutre sur des réseaux monophasés ou en étoile. En l'absence de voie de mesure de tension correspondante, par exemple, pour des mesurages de courants sur des réseaux en triangle ou de courant de terre ou de courant de neutre, la voie de référence (voir 5.1.3) utilisée pour les mesurages de fréquence peut être utilisée.

3.24
tension efficace rafraîchie par période
$U_{\mathrm{eff}(1)}$
valeur de la tension efficace mesurée sur 1 période et rafraîchie à chaque période

Note 1 à l'article: Au contraire de $U_{\mathrm{eff}(1/2)}$, cette technique ne définit pas l'instant de début de période.

Note 2 à l'article: Cette valeur n'est utilisée que dans la Classe S et pour la détection et l'évaluation des creux de tension, des surtensions temporaires à fréquence industrielle et des coupures.

Note 3 à l'article: Cette valeur efficace de la tension peut être une valeur entre phases ou entre phase et neutre.

3.25
domaine des grandeurs d'influence
domaine de variation des valeurs d'une grandeur d'influence donnée

3.26
variations rapides de tension
RVC
transition rapide de la valeur efficace d'une tension se produisant entre deux conditions de régime établi et au cours de laquelle la valeur efficace de tension ne dépasse pas les seuils de creux/de surtension temporaire à fréquence industrielle

Note 1 à l'article: L'abréviation RVC est dérivée du terme anglais développé correspondant "rapid voltage change".

3.27
voie de référence
pour les mesurages polyphasés, une des voies de mesure de la tension, désignée comme voie de référence

Note 1 à l'article: Dans le cas d'un mesurage monophasé, la voie de mesure de la tension est également la voie de référence.

3.28
tension résiduelle
U_{res}
valeur minimale de $U_{eff(½)}$ enregistrée au cours d'un creux ou d'une coupure de tension

Note 1 à l'article: La tension résiduelle est exprimée sous la forme d'une valeur, exprimée en volts, ou d'un pourcentage ou par unité de la tension d'entrée déclarée.

3.29
tension de référence glissante
U_{sr}
valeur de tension moyennée sur une minute, représentant la tension précédant un creux de tension ou une surtension temporaire à fréquence industrielle

Note 1 à l'article: Elle est définie avec précision en 5.4.4.

Note 2 à l'article: La tension de référence glissante peut être utilisée pour déterminer la variation de tension pendant un creux ou une surtension temporaire à fréquence industrielle, généralement pour des réseaux de moyenne tension et de haute tension.

3.30
seuil de surtension temporaire à fréquence industrielle
valeur de tension spécifiée pour permettre de détecter le début et la fin d'une surtension temporaire à fréquence industrielle

3.31
agrégation temporelle
combinaison en séquence de plusieurs valeurs d'un paramètre donné (chacun d'eux étant déterminé sur des périodes de temps identiques) destinée à produire une valeur sur une période de temps plus longue

Note 1 à l'article: Dans le présent document, le terme agrégation est utilisé pour agrégation temporelle.

3.32
valeur basse
pour un paramètre donné, valeur absolue de la différence entre valeur mesurée et valeur nominale, uniquement lorsque la valeur du paramètre est inférieure à la valeur nominale

3.33
UTC
temps universel coordonné
échelle de temps qui constitue la base d'une diffusion radioélectrique coordonnée des fréquences étalon et des signaux horaires., qui a la même marche que le temps atomique international, mais qui en diffère d'un nombre entier de secondes

Note 1 à l'article: Le temps universel coordonné est établi par le Bureau international des poids et mesures (BIPM) et le Service international de la rotation de la Terre (IERS).

Note 2 à l'article: On ajuste l'échelle UTC par insertion ou omission de secondes dites secondes intercalaires positives ou négatives pour assurer sa concordance approximative avec l'échelle UT1.

Note 3 à l'article: L'abréviation UTC est dérivée du terme anglais développé correspondant "coordinated universal time".

[SOURCE: Recommendation ITU-R RF.686.3]

3.34
creux de tension
baisse temporaire de l'amplitude de la tension en un point du réseau d'énergie électrique en dessous d'un seuil donné

Note 1 à l'article: Les coupures sont un cas particulier des creux de tension. Les traitements ultérieurs permettent de faire la distinction entre creux de tension et coupures.

Note 2 à l'article: Cette note ne s'applique qu'à la version anglaise. Les deux termes sont utilisés indifféremment. Toutefois, la présente Norme utilise uniquement le terme "creux de tension".

3.35
surtension temporaire à fréquence industrielle
augmentation temporaire de l'amplitude de la tension en un point du réseau d'énergie électrique au-dessus d'un seuil donné

3.36
déséquilibre de tension
dans un réseau d'énergie électrique polyphasé, état dans lequel les valeurs efficaces des tensions entre conducteurs (composante fondamentale) et/ou les différences de phase entre conducteurs successifs, ne sont pas toutes égales

Note 1 à l'article: Le taux de déséquilibre s'exprime habituellement par le rapport de la composante inverse ou homopolaire à la composante directe.

Note 2 à l'article: Dans la présente norme, le déséquilibre de tension est relatif aux réseaux triphasés.

[SOURCE: IEC 60050-161:2002, 161-08-09, modifié – des notes à l'article ont été rajoutées]

4 Généralités

4.1 Classes de mesure

Pour chaque paramètre mesuré, deux classes (A et S) sont définies dans la présente norme. Pour chaque classe, les méthodes de mesure et les exigences de performance appropriées sont incluses.

– **Classe A**

Cette classe est utilisée lorsque des mesurages précis sont nécessaires, par exemple pour des applications contractuelles qui peuvent nécessiter la vérification de la conformité à des normes, la résolution de litiges, etc. Les mesurages d'un paramètre effectués avec deux appareils de mesure différents conformes aux exigences de la Classe A, lors du mesurage du même signal, produiront des résultats concordants dans la plage d'incertitude spécifiée pour ce paramètre.

NOTE 1 Les mesurages de Classe A produisent des résultats concordants uniquement si les paramètres sélectionnés par l'utilisateur (seuils, hystérésis, etc.) concordent.

– **Classe S**

Cette classe est utilisée pour les applications statistiques comme les campagnes de mesure de grande ampleur ou les évaluations de la qualité de l'alimentation, avec potentiellement un sous-ensemble limité de paramètres. Bien qu'elles utilisent des intervalles de mesure équivalents à ceux de la Classe A, les exigences de traitement de la classe S sont beaucoup plus souples. Certaines études peuvent évaluer les paramètres de qualité de l'alimentation de plusieurs sites de mesure sur un réseau. D'autres études évaluent les paramètres de qualité de l'alimentation sur un seul site et sur une certaine période ou dans des endroits à l'intérieur d'un bâtiment, voire même d'une seule partie volumineuse de l'appareillage.

– **Classe B**

Pour des informations sur la Classe B, voir l'Annexe E (informative) de la présente norme. Les méthodes de Classe B ne doivent pas être appliquées pour de nouveaux appareils de mesure. La Classe B a été déplacée dans l'Annexe E du fait que tous les nouveaux modèles d'appareil de mesure sont conformes à la Classe A ou à la Classe S. La Classe B peut être pertinente pour les appareils de mesure traditionnels qui sont toujours utilisés. La Classe B pourra être supprimée dans la prochaine édition de la présente norme.

NOTE 2 Les méthodes de mesure de Classe B peuvent fournir des informations utiles mais pas nécessairement comparables. La Classe B a été introduite dans l'IEC 61000-4-30:2003 (édition 1) plus particulièrement afin d'éviter de rendre obsolètes des modèles d'appareils de mesure plus anciens. L'IEC 61000-4-30:2008 (édition 2) informait qu'il était possible que la Classe B soit supprimée dans une future édition de la présente norme. L'IEC 61000-4-30:– (la présente édition 3) informe de nouveau qu'il est possible que la Classe B soit supprimée dans une future édition et déplace la Classe B dans l'Annexe informative E.

NOTE 3 Dans la présente norme, "A" signifie "Advanced" et "S" signifie "Surveys".

Les utilisateurs doivent sélectionner la classe dont ils ont besoin, basée sur leur(s) application(s). Pour les applications de recherche de pannes, l'utilisateur peut sélectionner les méthodes de Classe A ou de Classe S en fonction du type de problème.

Il convient que le constructeur de l'appareil de mesure déclare les grandeurs d'influence non expressément données et qui peuvent dégrader les performances de l'appareil de mesure.

Un appareil de mesure peut mesurer tout ou partie des paramètres identifiés dans la présente norme et utilise de préférence la même classe pour tous les paramètres. Pour les lignes directrices, voir l'IEC 62586-1 et l'IEC 62586-2.

Le constructeur d'appareil de mesure doit déclarer quels paramètres sont mesurés, quelle classe est utilisée pour chacun des paramètres, la plage de U_{din} pour laquelle chacune des classes est satisfaite, et toutes les exigences nécessaires ainsi que les accessoires (synchronisation, sondes, durée d'étalonnage, gammes de températures, etc.) pour satisfaire chacune des classes.

4.2 Organisation des mesurages

La grandeur électrique à mesurer peut être soit directement accessible, ce qui est en général le cas sur les réseaux basse tension, soit accessible via des transducteurs de mesure.

La chaîne de mesure complète est illustrée à la Figure 1.

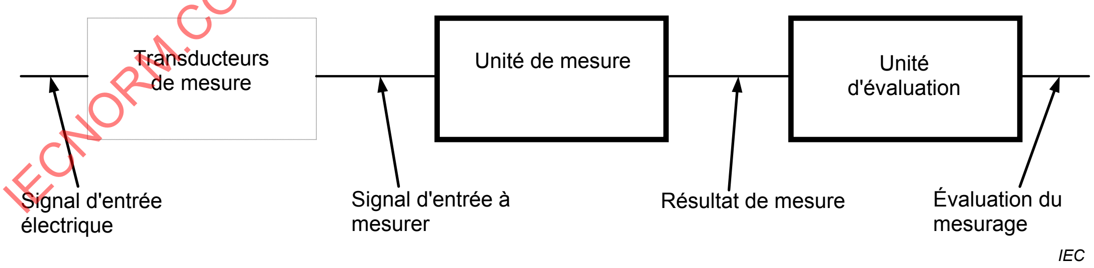


Figure 1 – Chaîne de mesure

Un "appareil de mesure" peut comprendre l'ensemble de la chaîne de mesure (voir Figure 1). Dans la présente norme, la partie normative ne prend en compte ni les éventuels transducteurs de mesure externes à l'appareil de mesure, ni l'incertitude de mesure qu'ils introduisent, mais l'Article A.2 fournit des lignes directrices sur ces sujets.

4.3 Valeurs électriques à mesurer

Des mesurages peuvent être effectués sur les réseaux monophasés ou polyphasés. En fonction du contexte, il peut être nécessaire de mesurer des tensions entre les conducteurs de phase et le neutre (phase-neutre) ou entre les conducteurs de phase (entre phases) ou entre les conducteurs de phase ou le neutre et la terre (phase-terre, neutre-terre). La présente norme n'a pas pour objet d'imposer le choix des valeurs électriques à mesurer. En outre, excepté pour le mesurage du déséquilibre de tension qui est intrinsèquement polyphasé, les méthodes de mesure spécifiées dans le présent document sont de nature à permettre l'obtention de résultats indépendants sur chaque voie de mesure.

NOTE Les valeurs instantanées entre phases peuvent être mesurées directement ou peuvent être dérivées des valeurs mesurées instantanées phase-neutre ou des valeurs mesurées phase-terre.

Des mesurages de courant peuvent être effectués sur chaque conducteur des réseaux électriques, y compris le neutre et la terre de protection (voir 5.13).

4.4 Agrégation des intervalles de temps de mesure

– **Classe A**

L'intervalle de temps de mesure de base des amplitudes (tension du réseau, harmoniques, interharmoniques et déséquilibre) des paramètres doit être de 10 périodes pour un réseau 50 Hz ou de 12 périodes pour un réseau 60 Hz.

Le mesurage sur 10/12 périodes doit être resynchronisé toutes les impulsions UTC (temps universel coordonné) de 10 min. Voir Figure 2.

NOTE 1 L'incertitude de ce mesurage est incluse dans le protocole de mesure de l'incertitude de chaque paramètre.

Les valeurs sur 10/12 périodes sont ensuite agrégées sur trois intervalles supplémentaires:

- intervalle de 150/180 périodes (150 périodes pour une fréquence nominale de 50 Hz ou 180 périodes pour une fréquence nominale de 60 Hz),
- intervalle de 10 min,
- intervalle de 2 h pour le papillotement P_{lt}.

NOTE 2 Un intervalle d'agrégation de 2 heures est facultatif pour tous les paramètres, sauf pour les mesurages de papillotement qui nécessitent un intervalle d'agrégation de 2 heures pour P_{lt}. Cet intervalle d'agrégation de 2 heures peut éventuellement être utile dans certaines applications, et peut éventuellement être nécessaire pour mesurer la conformité avec certaines normes nationales ou internationales.

NOTE 3 Les Articles B.1 et B.2 décrivent quelques applications d'agrégation d'intervalles de temps.

– **Classe S**

Mêmes intervalles de temps que pour la classe A.

4.5 Processus d'agrégation des mesures

4.5.1 Exigences

Les agrégations doivent être calculées par la racine carrée de la moyenne arithmétique du carré des valeurs d'entrée.

Pour le mesurage du papillotement, un algorithme d'agrégation différent est utilisé (voir l'IEC 61000 4-15).

4.5.2 Agrégation sur 150/180 périodes

– **Classe A**

Les données de l'intervalle de 150/180 périodes doivent être agrégées sans discontinuité à partir de quinze intervalles de 10/12 périodes.

L'intervalle de temps de 150/180 périodes est resynchronisé toutes les impulsions UTC de 10 min comme indiqué à la Figure 2.

Lorsqu'une impulsion de 10 min se produit, un nouvel intervalle de temps de 150/180 périodes commence, et l'intervalle de temps en cours de 150/180 périodes se poursuit jusqu'à ce qu'il soit terminé. Cela peut engendrer un recouvrement entre ces deux intervalles de 150/180 périodes (recouvrement 2 dans la Figure 2).

– **Classe S**

Les données de l'intervalle de 150/180 périodes doivent être agrégées à partir des intervalles de 10/12 périodes. La resynchronisation avec les impulsions UTC de 10 min est autorisée mais n'est pas obligatoire. (Voir la Figure 3).

Les discontinuités sont autorisées mais non obligatoires pour les harmoniques, les interharmoniques, les tensions de transmissions de signaux et le déséquilibre. Un minimum de trois intervalles de 10/12 périodes doit être utilisé tous les intervalles de temps de 150/180 périodes, c'est-à-dire au moins un intervalle de 10/12 périodes doit être utilisé toutes les 50/60 périodes (voir la Figure 4). Pour tous les autres paramètres, les données de l'intervalle de 150/180 périodes doivent être agrégées sans discontinuité à partir des quinze intervalles de 10/12 périodes.

4.5.3 Agrégation sur 10 min

– **Classe A**

Les valeurs agrégées sur 10 min doivent être marquées avec le temps UTC (01H10.00,000, par exemple) à l'issue de l'intervalle d'agrégation de 10 min, arrondi à la seconde la plus proche.

NOTE Dans certaines circonstances, il peut être utile d'utiliser l'heure locale, qui peut différer du temps UTC selon un décalage fixe ou un décalage qui peut varier en fonction de la période de l'année. Ce type d'horodatage inclut souvent une heure et une date. Ce type d'horodatage peut être appelé "datation absolue".

Les données de l'intervalle de 10 min doivent être agrégées à partir des intervalles de temps de 10/12 périodes.

Chaque intervalle de 10 min doit débuter sur une impulsion UTC de 10 min. L'impulsion de 10 min est aussi utilisée pour resynchroniser les intervalles de 10/12 périodes et les intervalles de 150/180 périodes. Voir Figure 2.

Le ou les intervalles finaux de 10/12 périodes pendant une période d'agrégation de 10 min présenteront vraisemblablement un recouvrement avec les impulsions d'horloge UTC de 10 min. Tous les intervalles de 10/12 périodes en recouvrement (recouvrement 1 dans la Figure 2) sont inclus dans l'agrégation de l'intervalle de 10 min précédent.

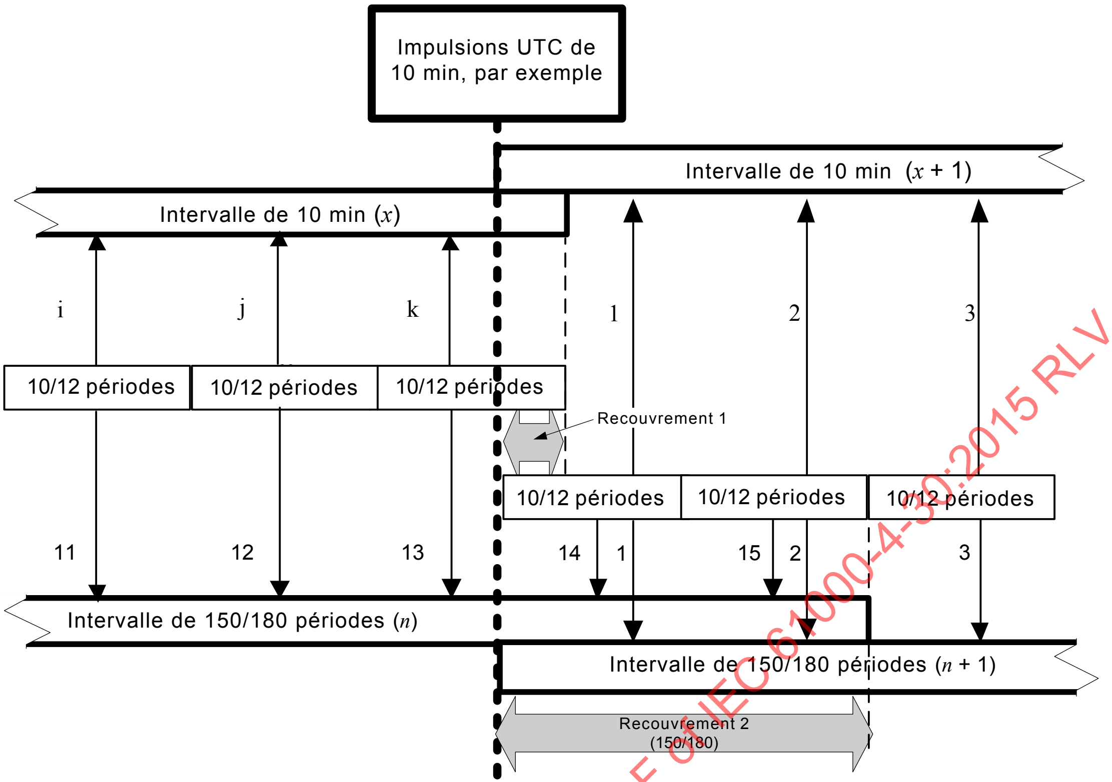


Figure 2 – Synchronisation des intervalles d'agrégation pour la classe A

– **Classe S**

La méthode d’agrégation sur 10 min utilisée pour la Classe S doit être soit la méthode de la classe A soit la méthode simplifiée suivante:

Les données de l’intervalle de 10 min doivent être agrégées à partir des intervalles de temps de 10/12 périodes. Il n’y a pas de resynchronisation avec les impulsions UTC de 10 min. Les intervalles de 10 min se déroulent indépendamment (les uns des autres).

Les valeurs agrégées sur 10 min doivent être marquées avec le temps à l'issue de l'intervalle d'agrégation de 10 min (01h10.00,040, par exemple).

Il n’y aura pas de recouvrement, comme illustré à la Figure 3 et à la Figure 4.

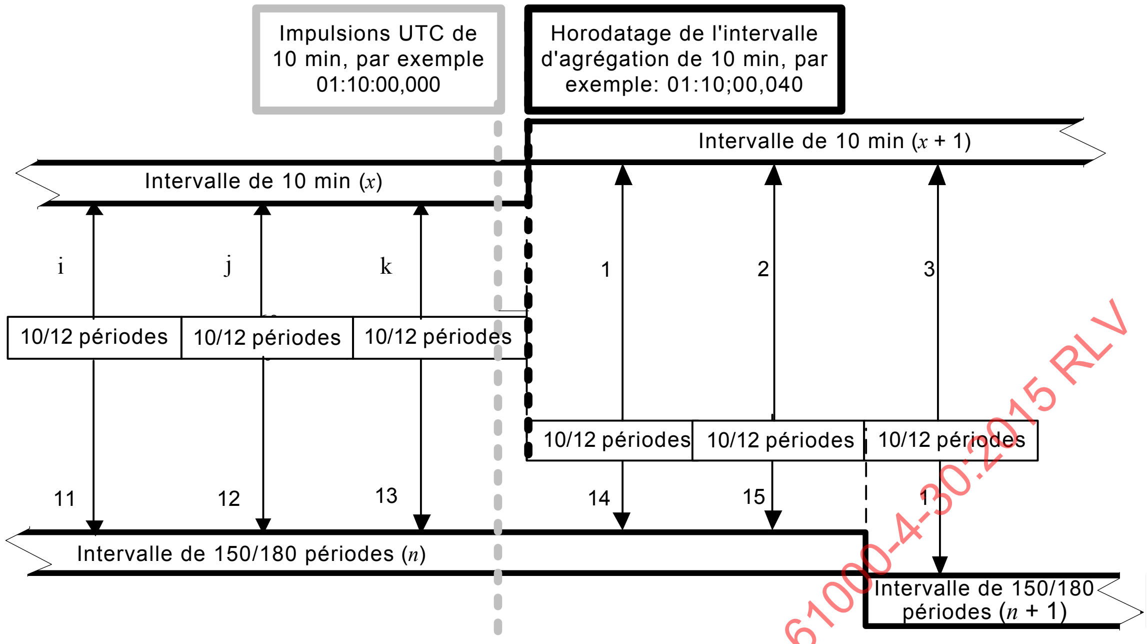


Figure 3 – Synchronisation des intervalles d'agrégation pour la classe S: paramètres pour lesquels les discontinuités ne sont pas autorisées

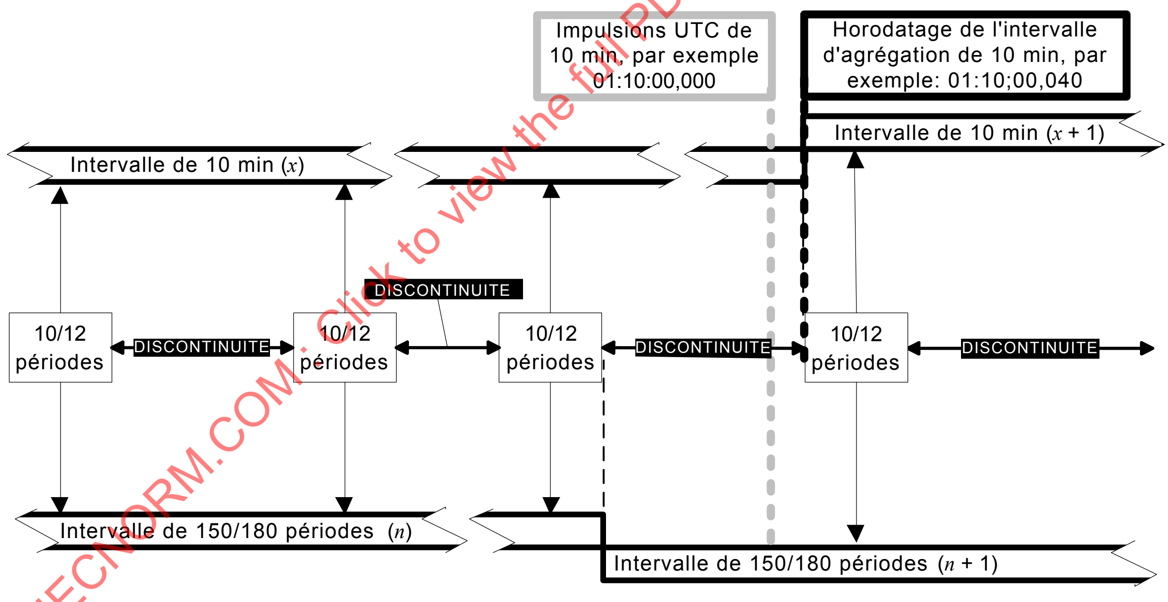


Figure 4 – Synchronisation des intervalles d'agrégation pour la classe S: paramètres pour lesquels les discontinuités sont autorisées (voir 4.5.2)

4.5.4 Agrégation sur 2 heures

– **Classe A**

Les données de l'intervalle de 2 h doivent être agrégées à partir de douze intervalles de 10 min. L'intervalle de 2 h ne doit pas présenter de discontinuité ni de recouvrement.

– **Classe S**

Identique à la Classe A.

4.6 Incertitude de temps d'horloge

L'incertitude de temps d'horloge est définie par rapport au temps universel coordonné (UTC) qui s'incrémente de manière continue et qui est disponible dans le monde entier.

NOTE 1 Le temps d'horloge peut avancer ou reculer dans certaines circonstances telles que le passage à l'heure d'été, les mises à jour de synchronisation externe, etc. Lorsque l'horloge avance dans le temps, des discontinuités peuvent se produire dans les données. Lorsque l'horloge recule dans le temps, les données peuvent se chevaucher dans le temps.

– **Classe A**

L'incertitude de temps d'horloge ne doit pas dépasser ± 20 ms pour 50 Hz ou ± 16,7 ms pour 60 Hz, indépendamment de la durée totale de l'intervalle.

NOTE 2 Ces performances peuvent par exemple être obtenues par une procédure de synchronisation appliquée périodiquement au cours d'une campagne de mesure, via un récepteur GPS, ou encore par la réception de signaux de synchronisation transmis par radio ou en utilisant des signaux de synchronisation de réseau.

Lorsque la synchronisation par un signal externe devient indisponible, la tolérance sur le marquage temporel doit être inférieure à ± 1 s par période de 24 h, cependant, cette exception n'affranchit pas de l'exigence de conformité avec la première partie de cet alinéa.

NOTE 3 Ces performances sont nécessaires pour que deux appareils de mesure utilisant des méthodes de Classe A produisent les mêmes résultats agrégés sur 10 min lorsqu'ils sont raccordés au même signal.

– **Classe S**

L'incertitude de temps d'horloge ne doit pas dépasser ± 5 s par période de 24 h.

4.7 Concept de "flagging" (marquage)

Pendant un creux de tension, une surtension temporaire à fréquence industrielle ou une coupure, les algorithmes de mesure des autres paramètres (par exemple, mesurage de variation de la fréquence) peuvent produire des valeurs douteuses. Le concept de marquage permet d'éviter de comptabiliser un événement donné plusieurs fois dans différents paramètres (compter un seul creux de tension d'une part comme un creux et d'autre part comme une variation de fréquence, par exemple) et indique que la valeur agrégée risque d'être douteuse.

Le marquage n'est déclenché que par les creux, les surtensions temporaires à fréquence industrielle et les coupures. La détection de creux et de surtensions temporaires à fréquence industrielle dépend du seuil défini par l'utilisateur, et ce choix peut influencer les données qui sont "marquées".

Le concept de marquage est applicable à la Classe A et à la Classe S lors du mesurage de la fréquence industrielle, de l'amplitude de la tension, du papillotement, du déséquilibre de la tension d'alimentation, des harmoniques de tension, des interharmoniques de tension, de la transmission de signaux et du mesurage des paramètres de valeur basse et de valeur haute de la tension.

Si, pendant un intervalle de temps donné, une valeur est marquée, les valeurs agrégées, qui incluent cette valeur, doivent également être marquées. La valeur marquée doit être enregistrée et incluse également dans le processus d'intégration. Par exemple, si, pendant un intervalle de temps donné, une valeur est marquée, alors les valeurs agrégées qui incluent cette valeur, doivent également être marquées et enregistrées.

NOTE 1 Des informations relatives à d'autres types de marquage ou au marquage de données peuvent être consultées dans l'IEC 62586-1.

NOTE 2 L'utilisateur peut décider de la manière d'évaluer les données marquées.

5 Paramètres de qualité de l'alimentation

5.1 Fréquence industrielle

5.1.1 Méthode de mesure

– **Classe A**

L'indication de fréquence doit être obtenue toutes les 10 s. Du fait que la fréquence industrielle peut ne pas être exactement 50 Hz ou 60 Hz au cours de l'intervalle de temps d'horloge de 10 s, le nombre de périodes peut ne pas être un nombre entier. La mesure de la fréquence fondamentale est le rapport du nombre de périodes entières comptées au cours de l'intervalle de temps d'horloge de 10 s divisé par la durée cumulée des périodes entières.

Lorsqu'une méthode de passage par zéro est appliquée pour le calcul de la fréquence, avant chaque évaluation, les harmoniques et interharmoniques doivent être atténués afin de minimiser les effets de multiples passages par zéro.

Les intervalles de temps de mesure ne doivent pas se recouvrir. Les périodes individuelles chevauchant temporellement la frontière d'un intervalle de 10 s sont rejetées. Chaque intervalle de 10 s doit commencer sur un top 10 s d'horloge, avec l'incertitude définie en 4.6.

D'autres techniques permettant d'obtenir des résultats équivalents, telles que la convolution, sont acceptables.

NOTE Pour certaines applications, l'utilisation d'intervalles de temps plus courts que 10 s peut éventuellement être utile, tels que sur 10/12 périodes (éoliennes), sur 1 s (étalons nationaux), etc.

– **Classe S**

Identique à la Classe A.

5.1.2 Incertitude de mesure et étendue de mesure

– **Classe A**

Dans les conditions décrites à l'Article 6, l'incertitude de mesure ne doit pas dépasser ± 10 mHz sur les étendues de mesure 42,5 Hz à 57,5 Hz / 51 Hz à 69 Hz.

– **Classe S**

Dans les conditions décrites à l'Article 6, l'incertitude de mesure ne doit pas dépasser ± 50 mHz sur les étendues de mesure 42,5 Hz à 57,5 Hz / 51 Hz à 69 Hz.

5.1.3 Évaluation du mesurage

– **Classe A**

Le mesurage de fréquence doit être réalisé sur la voie de référence.

Le constructeur doit spécifier le comportement du mesurage de fréquence en cas de perte de tension sur la voie de référence.

– **Classe S**

Identique à la Classe A

5.1.4 Agrégation

L'agrégation n'est pas obligatoire.

5.2 Amplitude de la tension d'alimentation

5.2.1 Méthode de mesure

– **Classe A**

Le mesurage doit être la valeur efficace de l'amplitude de tension sur un intervalle de temps de 10 périodes pour un réseau 50 Hz ou de 12 périodes pour un réseau 60 Hz. Les intervalles de temps de 10/12 périodes doivent être contigus et ne pas présenter de recouvrement avec les intervalles de temps de 10/12 périodes adjacents, excepté comme indiqué sur le recouvrement 1 de la Figure 2.

NOTE 1 Cette méthode de mesure particulière est utilisée pour les signaux quasi stationnaires et ne l'est pas pour la détection et le mesurage des perturbations: creux, surtensions temporaires à fréquence industrielle, coupures et transitoires de tension.

NOTE 2 La valeur efficace comprend par définition les harmoniques, les interharmoniques, les signaux de télécommande centralisée, etc.

– **Classe S**

Identique à la Classe A.

5.2.2 Incertitude de mesure et étendue de mesure

– **Classe A**

Dans les conditions décrites à l'Article 6, l'incertitude de mesure ne doit pas dépasser ± 0,1 % de U_{din}, sur la plage de 10 % à 150 % de U_{din}.

– **Classe S**

Dans les conditions décrites à l'Article 6, l'incertitude de mesure ne doit pas dépasser ± 0,5 % de U_{din}, sur la plage de 20 % à 120 % de U_{din}.

5.2.3 Évaluation du mesurage

Pas d'exigences.

5.2.4 Agrégation

L'agrégation doit être réalisée conformément à 4.4 et 4.5.

5.3 Papillotement («flicker»)

5.3.1 Méthode de mesure

– **Classe A**

La classe F3 de l'IEC 61000-4-15 s'applique en tant qu'exigence minimale. Il convient de ne pas utiliser la classe F3 pour de nouveaux modèles. La classe F1 est recommandée et peut être exigée dans la prochaine édition de la présente norme.

– **Classe S**

La classe F3 de l'IEC 61000-4-15 s'applique en tant qu'exigence minimale.

5.3.2 Incertitude de mesure et étendue de mesure

– **Classe A**

Voir l'IEC 61000-4-15. Dans les conditions décrites à l'Article 6, l'incertitude de mesure exigée par l'IEC 61000-4-15 doit être satisfaite sur l'étendue de mesure de 0,2 P_{st} à 10 P_{st}.

– **Classe S**

Voir l'IEC 61000-4-15. Dans les conditions décrites à l'Article 6, deux fois l'incertitude de mesure admise par l'IEC 61000-4-15 doit être satisfaite sur l'étendue de mesure de 0,4 P_{st} à 4 P_{st}.

5.3.3 Évaluation du mesurage

– **Classe A**

L'IEC 61000-4-15 s'applique.

L'intervalle de temps de 10 min pour P_{st} doit commencer sur une impulsion UTC de 10 min et doit être marqué avec la datation à l'issue de l'intervalle (voir 4.5.3).

Les creux de tension, les surtensions temporaires à fréquence industrielle et les coupures doivent entraîner un marquage des valeurs de sortie du P_{st} et du P_{lt} (voir IEC 61000-4-15).

– **Classe S**

Identique à la Classe A.

5.3.4 Agrégation

– **Classe A**

L'agrégation doit être réalisée conformément à l'IEC 61000-4-15.

– **Classe S**

Identique à la Classe A.

5.4 Creux de la tension d'alimentation et surtensions temporaires à fréquence industrielle

5.4.1 Méthode de mesure

– **Classe A**

Le mesurage de base U_{eff} d'un creux de tension et des surtensions temporaires à fréquence industrielle doit être le mesurage de $U_{eff(½)}$ sur chaque voie de mesure (voir 3.22).

La durée de la période pour $U_{eff(½)}$ dépend de la fréquence. La fréquence peut être déterminée par le dernier mesurage de fréquence industrielle non «marqué» (voir 4.7 et 5.1) ou par toute autre méthode permettant de satisfaire aux exigences d'incertitude spécifiées à l'Article 6.

NOTE 1 La valeur $U_{eff(½)}$ inclut par définition les harmoniques, les interharmoniques, les tensions de transmission des signaux, etc.

NOTE 2 Il est important d'éviter toute perte de données lorsque des creux et des surtensions temporaires à fréquence industrielle se produisent dans une séquence rapide (par exemple, trois événements en une seconde, avec jusqu'à une minute entre les séquences, pourraient probablement se produire en cas de réenclenchement au cours d'une panne durable). Lorsque, au cours d'une salve rapide, il n'est pas possible d'enregistrer les caractéristiques des événements de creux/surtension, alors un comptage des événements peut être utile.

– **Classe S**

Le mesurage de base U_{eff} des creux de tension et des surtensions temporaires à fréquence industrielle doit être le mesurage de $U_{eff(½)}$ sur chaque voie de mesure (voir 3.22) ou le mesurage de $U_{eff(1)}$ sur chaque voie de mesure (voir 3.23). Le constructeur doit spécifier quel mesurage est utilisé.

NOTE 3 La valeur $U_{eff(1)}$ inclut par définition les harmoniques, les interharmoniques, les tensions de transmission des signaux, etc.

5.4.2 Détection et évaluation d'un creux de tension

5.4.2.1 Détection d'un creux de tension

Le seuil de creux est un pourcentage soit de U_{din} soit de la référence de tension glissante U_{sr} (voir 5.4.4). L'utilisateur doit déclarer la tension de référence utilisée.

NOTE La référence de tension glissante U_{sr} n'est en général pas utilisée dans les réseaux basse tension. Voir l'IEC TR 61000-2-8 pour plus d'informations et de conseils.

– Dans les réseaux monophasés, un creux de tension commence lorsque la tension U_{eff} tombe en dessous du seuil de creux, et se termine lorsque la tension U_{eff} est égale ou supérieure au seuil de creux plus la tension d'hystérésis.
– Dans les réseaux polyphasés, un creux commence lorsque la tension U_{eff} d'une ou plusieurs voies tombe en dessous du seuil de creux et se termine lorsque la tension U_{eff} sur toutes les voies mesurées est égale ou supérieure au seuil de creux plus la tension d'hystérésis.

Le seuil de creux et la tension d'hystérésis sont tous deux déterminés par l'utilisateur en fonction de l'application.

5.4.2.2 Évaluation d'un creux de tension

Un creux de tension est caractérisé par une paire de données, la tension résiduelle (U_{res}) ou la profondeur d'une part et la durée d'autre part:

– la tension résiduelle d'un creux de tension est la plus petite valeur de U_{eff} mesurée sur n'importe quelle voie au cours du creux;
– la profondeur est la différence entre la tension de référence (U_{din} ou U_{sr}) et la tension résiduelle. Elle s'exprime en général en pourcentage de la tension de référence.

NOTE 1 Pendant le creux, il peut également être utile d'enregistrer la plus petite valeur de $U_{eff(½)}$ sur chaque voie de mesure, en plus de celle de la tension résiduelle du creux. La durée écoulée sous le seuil de creux sur chaque voie de mesure peut également être utile.

NOTE 2 Si les formes d'onde de tension sont enregistrées avant, pendant et après un creux, des informations utiles sur les variations d'angle de phase peuvent être disponibles dans les données enregistrées.

L'instant de début d'un creux doit être horodaté avec l'heure de fin de U_{eff} de la voie à l'origine de l'événement, et l'instant de fin du creux doit être horodaté avec l'heure de fin de la valeur U_{eff} qui a terminé l'événement, tel que défini par le seuil plus l'hystérésis.

La durée d'un creux de tension est la différence de temps entre l'instant de début et l'instant de fin du creux de tension.

NOTE 3 Pour les mesurages polyphasés, le mesurage de la durée du creux peut commencer sur une voie et se terminer sur une voie différente.

NOTE 4 L'enveloppe des creux de tension peut ne pas être rectangulaire. En conséquence, pour un creux de tension donné, la durée mesurée dépend de la valeur de seuil de creux sélectionnée. La forme de l'enveloppe peut être évaluée au moyen de plusieurs seuils de creux dans la plage de détection des seuils de creux de tension et de coupure de tension.

NOTE 5 L'hystérésis est en général égale à 2 % de U_{din}.

NOTE 6 Les seuils de creux sont généralement dans la plage de 85 % à 90 % de la référence de tension fixe pour des applications de recherche de pannes ou statistiques.

NOTE 7 La tension résiduelle est souvent utilisée par l'utilisateur final, et peut être préférentielle car elle est référencée par rapport à zéro volt. En revanche, la profondeur est souvent utilisée par les opérateurs de réseau d'électricité, en particulier dans les réseaux à haute tension ou en cas d'utilisation de la tension de référence glissante.

NOTE 8 Un saut de phase peut se produire pendant un creux de tension. Voir A.5.5.

NOTE 9 Lorsqu'un seuil est franchi, un horodatage peut être enregistré.

5.4.3 Détection et évaluation d'une surtension temporaire à fréquence industrielle

5.4.3.1 Détection d'une surtension temporaire à fréquence industrielle

Le seuil de surtension temporaire à fréquence industrielle est un pourcentage soit de U_{din} soit de la tension de référence glissante U_{sr} (voir 5.4.4). L'utilisateur doit déclarer la tension de référence utilisée.

NOTE La tension de référence glissante U_{sr} n'est en général pas utilisée dans les réseaux basse tension. Voir l'IEC TR 61000-2-8 pour plus d'informations et de conseils.

– Sur les réseaux monophasés, une surtension temporaire à fréquence industrielle commence lorsque la tension U_{eff} s'élève au-dessus du seuil de surtension temporaire à fréquence industrielle, et se termine lorsque la tension U_{eff} est égale ou inférieure au seuil de surtension temporaire à fréquence industrielle moins la tension d'hystérésis.

– Dans les réseaux polyphasés, une surtension temporaire à fréquence industrielle commence lorsque la tension U_{eff} d'une ou plusieurs voies passe au-dessus du seuil de surtension temporaire à fréquence industrielle et se termine lorsque la tension U_{eff} sur toutes les voies mesurées est égale ou inférieure au seuil de surtension temporaire à fréquence industrielle moins la tension d'hystérésis.

Le seuil de surtension temporaire à fréquence industrielle et la tension d'hystérésis sont tous deux déterminés par l'utilisateur en fonction de l'application.

5.4.3.2 Évaluation d'une surtension temporaire à fréquence industrielle

Une surtension temporaire à fréquence industrielle est caractérisée par une paire de données: amplitude maximale de la tension de surtension et sa durée:

– la tension maximale de surtension temporaire à fréquence industrielle est la plus grande valeur de U_{eff} mesurée sur n'importe quelle voie pendant la surtension temporaire à fréquence industrielle;
– l'instant de début d'une surtension temporaire à fréquence industrielle doit être horodaté avec l'heure de fin de U_{eff} de la voie à l'origine de l'événement et l'instant de fin de la surtension temporaire à fréquence industrielle doit être horodaté avec l'heure de fin de la valeur U_{eff} qui a terminé l'événement, tel que défini par le seuil moins l'hystérésis;
– la durée d'une surtension temporaire à fréquence industrielle est la différence de temps entre le début et la fin de la surtension temporaire à fréquence industrielle.

NOTE 1 Pour les mesurages polyphasés, le mesurage de la durée de la surtension temporaire à fréquence industrielle peut commencer sur une voie et se terminer sur une voie différente.

NOTE 2 L'enveloppe d'une surtension temporaire à fréquence industrielle peut éventuellement ne pas être rectangulaire. En conséquence, pour une surtension temporaire à fréquence industrielle donnée, la durée mesurée dépend de la valeur du seuil de surtension temporaire à fréquence industrielle.

NOTE 3 L'hystérésis est en général égale à 2 % de U_{din}.

NOTE 4 Le seuil de surtension temporaire à fréquence industrielle est en général supérieur à 110 % de U_{din}.

NOTE 5 Un saut de phase peut également se produire pendant une surtension temporaire à fréquence industrielle.

NOTE 6 Lorsqu'un seuil est franchi, un horodatage peut être enregistré.

5.4.4 Calcul de la tension de référence glissante

La mise en œuvre de la tension de référence glissante est optionnelle et n'est pas obligatoire. Si une référence glissante est choisie pour détecter les creux de tension et les surtensions temporaires à fréquence industrielle, elle doit être calculée au moyen d'un filtre du premier ordre avec une constante de temps de 1 min. Ce filtre est donné par

$$U_{sr(n)} = 0{,}9967 \times U_{sr(n-1)} \quad 0{,}0033 \times U_{(10/12)eff}$$

où

$U_{sr(n)}$ est la valeur courante de la tension de référence glissante;

$U_{sr(n-1)}$ est la valeur précédente de la tension de référence glissante; et

$U_{(10/12)eff}$ est la valeur efficace 10/12 périodes la plus récente.

Au début du mesurage, la valeur initiale de la tension de référence glissante est fixée à la tension d'entrée déclarée. La tension de référence glissante est mise à jour toutes les 10/12 périodes. Si une valeur sur 10/12 périodes est «marquée», la tension de référence glissante n'est pas mise à jour et la valeur précédente est utilisée.

5.4.5 Incertitude de mesure et étendue de mesure

5.4.5.1 Incertitude de mesure de la tension résiduelle et de l'amplitude de la tension de surtension temporaire à fréquence industrielle

– **Classe A**

L'incertitude de mesure ne doit pas dépasser ± 0,2 % de U_{din}.

– **Classe S**

L'incertitude de mesure ne doit pas dépasser ± 1,0 % de U_{din}.

5.4.5.2 Incertitude de mesure de durée

– **Classe A**

L'incertitude sur la durée d'un creux ou d'une surtension temporaire à fréquence industrielle est égale à l'incertitude sur le début du creux ou de la surtension temporaire à fréquence industrielle (demi-période) plus l'incertitude sur la fin du creux ou de la surtension temporaire à fréquence industrielle (demi-période).

– **Classe S**

Si $U_{eff(½)}$ est utilisée, alors l'incertitude sur la durée d'un creux ou d'une surtension temporaire à fréquence industrielle est égale à l'incertitude sur le début du creux ou de la surtension temporaire à fréquence industrielle (demi-période) plus l'incertitude sur la fin du creux ou de la surtension temporaire à fréquence industrielle (demi-période). Si $U_{eff(1)}$ est utilisée, alors l'incertitude sur la durée d'un creux ou d'une surtension temporaire à fréquence industrielle est égale à l'incertitude sur le début du creux ou de la surtension temporaire à fréquence industrielle (une période) plus l'incertitude sur la fin du creux ou de la surtension temporaire à fréquence industrielle (une période).

5.4.5.3 Agrégation

L'agrégation n'est pas applicable aux événements déclenchés.

5.5 Coupures de la tension d'alimentation

5.5.1 Méthode de mesure

Le mesurage de base de la tension doit être tel que défini en 5.4.1 pour chacune des classes.

5.5.2 Évaluation d'une coupure de tension

Le seuil de coupure de tension est un pourcentage de U_{din}.

Sur les réseaux monophasés, une coupure de tension commence lorsque la tension U_{eff} est en dessous du seuil de coupure de tension et se termine lorsque la valeur de U_{eff} est égale ou supérieure au seuil de coupure de tension plus l'hystérésis.

Sur les réseaux polyphasés, une coupure de tension commence lorsque la tension U_{eff} de toutes les voies est en dessous du seuil de coupure de tension et se termine lorsque la tension U_{eff} de n'importe quelle voie est égale ou supérieure au seuil de coupure de tension plus l'hystérésis.

Le seuil de coupure de tension et la tension d'hystérésis sont fixés par l'utilisateur en fonction de l'application. Le seuil de coupure de tension ne doit pas être fixé en dessous de l'incertitude de mesure de la tension résiduelle plus la valeur de l'hystérésis. En général, l'hystérésis est égale à 2 % de U_{din}.

L'instant de début d'une coupure de tension doit être horodaté avec l'heure de fin de U_{eff} de la voie à l'origine de l'événement et l'instant de fin de la coupure de tension doit être horodaté avec l'heure de fin de la valeur U_{eff} qui a terminé l'événement, tel que défini par le seuil plus l'hystérésis.

La durée d'une coupure de tension est la différence de temps entre le début et la fin d'une coupure de tension.

NOTE 1 Le seuil de coupure de tension peut par exemple être fixé à 5 % ou 10 % de U_{din}.

NOTE 2 La définition IEC 60050-161:1990, 161-08-20 considère qu'une coupure se produit lorsque la valeur de la tension est inférieure à 1 % de la tension nominale. Cependant, il est difficile de mesurer correctement des tensions inférieures à 1 % de la tension nominale. En conséquence, l'utilisateur pourrait envisager de fixer un seuil approprié de coupure de tension.

NOTE 3 La coupure d'une ou plusieurs phases d'un réseau polyphasé peut être considérée comme une coupure de l'alimentation chez les clients monophasés raccordés à ce réseau, même si cela n'est pas répertorié comme une coupure dans un mesurage polyphasé.

5.5.3 Incertitude de mesure et étendue de mesure

Pour l'incertitude de mesure de durée, voir 5.4.5.2.

5.5.4 Agrégation

L'agrégation n'est pas applicable aux événements déclenchés.

5.6 Tensions transitoires

L'Article A.3 donne des informations sur les paramètres importants nécessaires à la caractérisation des tensions transitoires. Le mesurage des tensions transitoires peut être utile mais n'est pas obligatoire.

5.7 Déséquilibre de la tension d'alimentation

5.7.1 Méthode de mesure

Les mesurages de déséquilibre s'appliquent uniquement aux réseaux triphasés.

– **Classe A**

Le déséquilibre de la tension d'alimentation est évalué par la méthode des composantes symétriques. Outre la composante directe U_1, en cas de déséquilibre s'ajoute au moins une des composantes suivantes: composante inverse U_2 et/ou composante homopolaire U_0.

La composante fondamentale de la valeur des tensions d'entrée est mesurée sur un intervalle de temps de 10 périodes pour les réseaux 50 Hz ou sur un intervalle de temps de 12 périodes pour les réseaux 60 Hz.

NOTE 1 L'effet des harmoniques est atténué en utilisant un filtre ou un algorithme de TFD (transformée de Fourier discrète).

NOTE 2 Les algorithmes qui utilisent uniquement les valeurs efficaces pour calculer le déséquilibre échouent dans la prise en compte des contributions des décalages angulaires au déséquilibre, et sont la cause de résultats imprévisibles lorsque des tensions harmoniques sont présentes. La composante inverse du déséquilibre ainsi que la composante homopolaire du déséquilibre fournissent des valeurs plus précises et plus facilement utilisables.

La composante inverse u_2 est évaluée sous forme d'un pourcentage et se calcule par:

$$u_2 = \frac{U_2}{U_1} \times 100\% = \frac{\text{tension inverse}}{\text{tension directe}} \times 100\% \tag{1}$$

La composante homopolaire u_0 est évaluée sous forme d'un pourcentage et se calcule par:

$$u_0 = \frac{U_0}{U_1} \times 100\% = \frac{\text{tension homopolaire}}{\text{tension directe}} \times 100\% \qquad (2)$$

NOTE 3 La composante homopolaire du déséquilibre est nulle par définition lors de mesurages de tension entre phases. Toutefois, les tensions phase-neutre ou phase-terre peuvent contenir une composante homopolaire dans ce cas.

NOTE 4 Toutes les autres méthodes qui peuvent se révéler équivalentes d'un point de vue mathématique à l'Équation (1) et à l'Équation (2) sont acceptables.

– **Classe S**

Le constructeur doit spécifier les algorithmes et méthodes utilisés pour calculer le taux de composante inverse u_2. L'évaluation de la composante homopolaire u_0 est optionnelle, non obligatoire.

5.7.2 Incertitude de mesure et étendue de mesure

– **Classe A**

L'incertitude doit être inférieure à ± 0,15 % à la fois pour u_2 et u_0. Par exemple, un appareil de mesure soumis à une composante inverse de 1,0 % doit fournir une indication x telle que 0,85 % ≤ x ≤ 1,15 %.Voir la Figure 5 (voir la Figure 5).

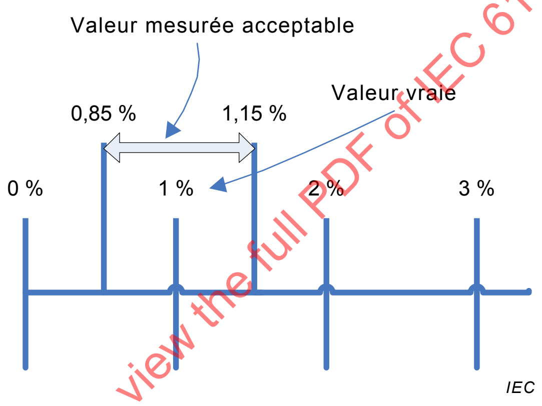


Figure 5 – Exemple d'incertitude de déséquilibre de tension d'alimentation

– **Classe S**

Identique à la Classe A.

5.7.3 Évaluation du mesurage

Pas d'exigences.

NOTE L'incertitude des transformateurs de mesure, s'ils sont présents, peut avoir un impact considérable sur le calcul du déséquilibre.

5.7.4 Agrégation

L'agrégation doit être réalisée conformément à 4.4 et 4.5.

5.8 Harmoniques de tension

5.8.1 Méthode de mesure

– **Classe A**

Le mesurage de base des harmoniques de tension pour la classe A est défini dans l'IEC 61000-4-7 Classe I. Cette norme doit être utilisée pour déterminer un mesurage de sous-groupe d'harmoniques sans discontinuité sur 10/12 périodes, appelé $U_{sg,h}$ dans l'IEC 61000-4-7.