

INTERNATIONAL STANDARD

NORME INTERNATIONALE



**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**



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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.
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IEC 61000 4-30 edition 3.1 contains the third edition (2015-02) [documents 77A/873/FDIS and 77A/878/RVD] and its corrigendum (2016-12), and its amendment 1 (2021-03) [documents 77A/1080/CDV and 77A/1092/RVC].

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendment 1. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

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 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.

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 the base publication and its amendment 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

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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

$U_{rms(\frac{1}{2})}$

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

$I_{\text{rms}(\frac{1}{2})}$

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

$U_{\text{rms}(1)}$

value of the r.m.s. voltage measured over 1 cycle and refreshed each cycle

Note 1 to entry: In contrast to $U_{\text{rms}(\frac{1}{2})}$, 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 $U_{\text{rms}(\frac{1}{2})}$ 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.

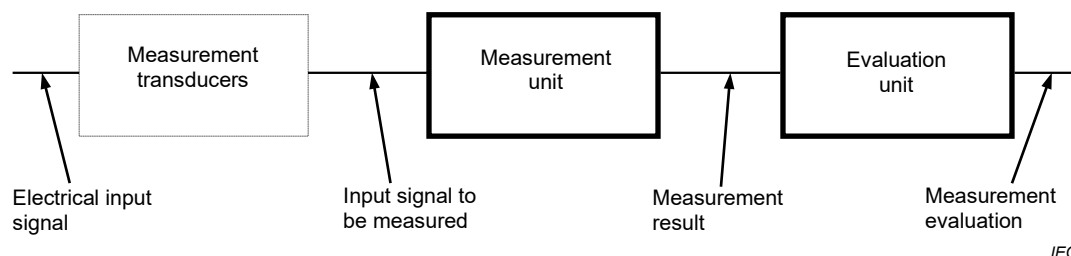


Figure 1 – Measurement chain

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_{It} 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_{It} . 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**

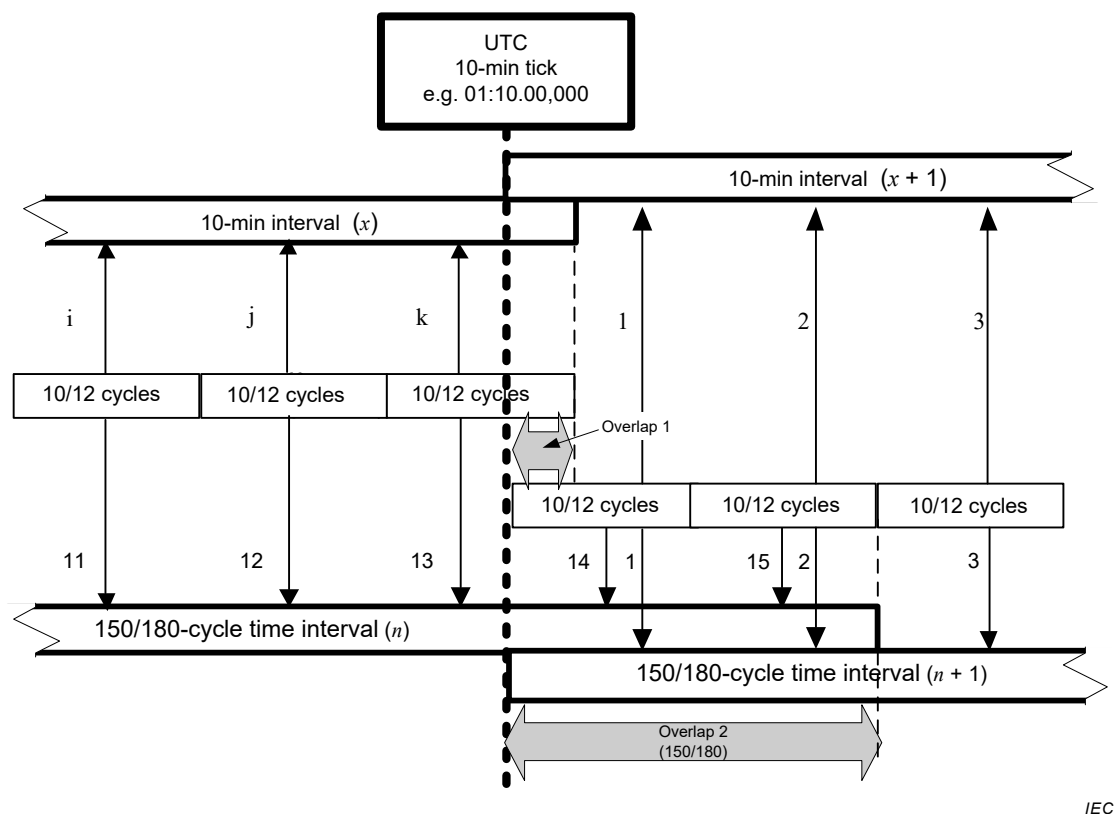
The 10-min aggregated value shall be tagged with the UTC time (for example, 01H10.00,000) at the conclusion of the 10-min aggregation interval, rounded to the nearest second.

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.



IEC

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.

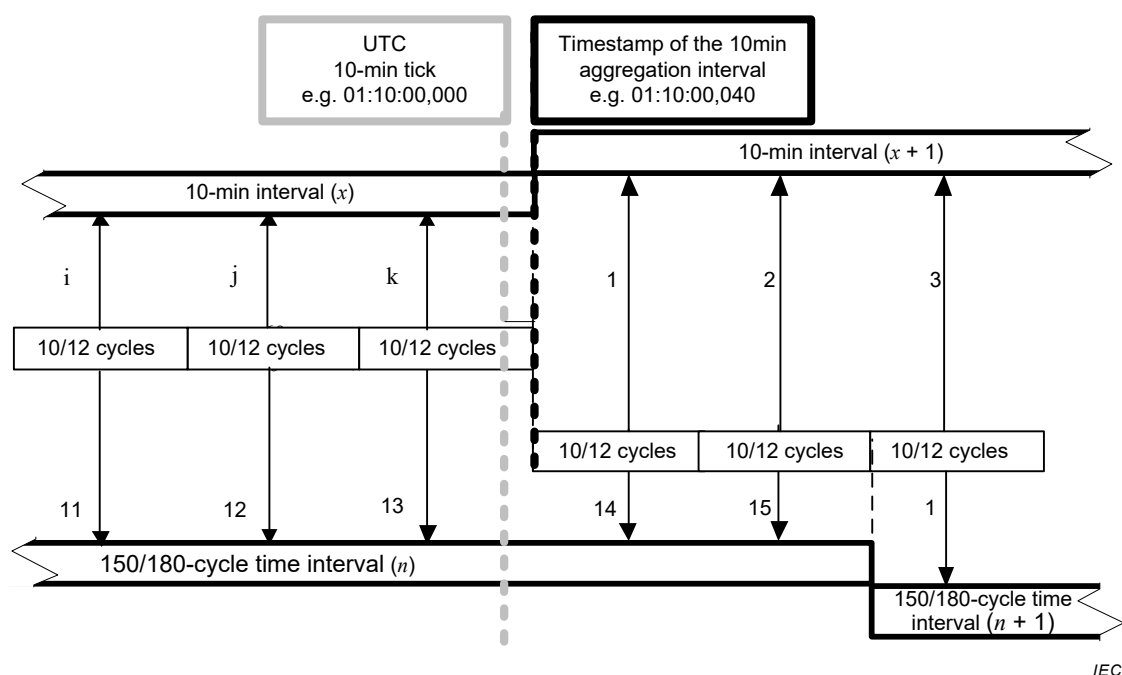


**Figure 3 – Synchronization of aggregation intervals for Class S:
parameters for which gaps are not permitted**

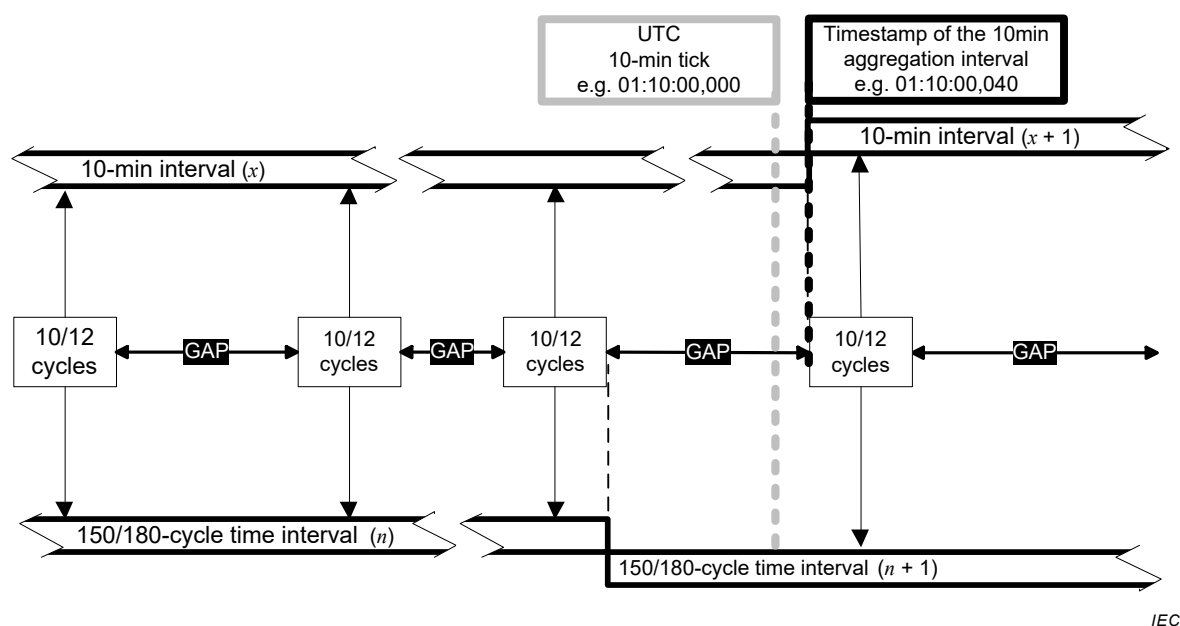


**Figure 4 – Synchronization of aggregation intervals for Class S:
parameters for which gaps are permitted (see 4.5.2)**

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 $\pm 16,7$ 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 cycles

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 $\pm 0,1$ % 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 $\pm 0,5$ % 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 $0,2 P_{\text{st}}$ to $10 P_{\text{st}}$.

– **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 $0,4 P_{\text{st}}$ to $4 P_{\text{st}}$.

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 $U_{\text{rms}(\frac{1}{2})}$ on each measurement channel (see 3.22).

The cycle duration for $U_{\text{rms}(\frac{1}{2})}$ 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 $U_{\text{rms}(\frac{1}{2})}$ 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 $U_{\text{rms}(\frac{1}{2})}$ on each measurement channel (see Clause 3.22), or the $U_{\text{rms}(1)}$ on each measurement channel (see Clause 3.23). The manufacturer shall specify which measurement is used.

NOTE 3 The $U_{\text{rms}(1)}$ 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 $U_{\text{rms}(\frac{1}{2})}$ 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

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

where

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

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

$U_{(10/12)\text{rms}}$ 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 $\pm 0,2$ % of U_{din} .

– Class S

The measurement uncertainty shall not exceed $\pm 1,0$ % 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 $U_{\text{rms}(1/2)}$ 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 $U_{\text{rms}(1)}$ 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 $\pm 0,15$ % 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).

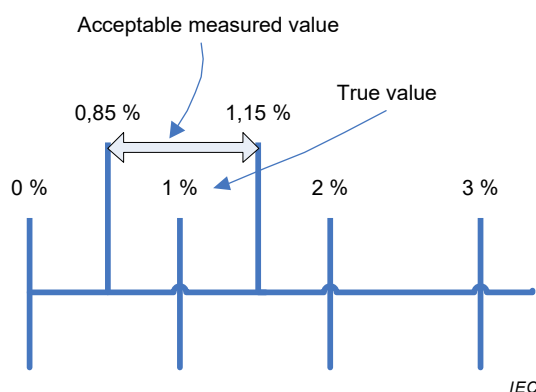


Figure 5 – Example of supply voltage unbalance uncertainty

– Class S

Same as Class A, except for the uncertainty, which shall be less than $\pm 0,3$ % for u_2 (and for u_0 if it 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 $U_{sg,h}$ 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 ($THDS_Y$), 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. $THDS_U$ 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 $U_{g,h}$ in IEC 61000-4-7, or a 10/12-cycle subgroup measurement designated $U_{sg,h}$ 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 $Y_{g,h}$ is selected, or as the subgroup total harmonic distortion ($THDS_Y$) if $Y_{sg,h}$ 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 $U_{g,h}$ or $U_{sg,h}$ 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 $\pm 0.03\%$

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 $Y_{\text{isg,h}}$ 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 $U_{\text{ig,h}}$ or $U_{\text{isg,h}}$ 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 $\pm 0,15$ % 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 $U_{\text{rms}(1/2)}$ values remain within an RVC threshold from the arithmetic mean of those 100/120 $U_{\text{rms}(1/2)}$ 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 $U_{\text{rms}(1/2)}$ 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 $U_{\text{rms}(1/2)}$ values of each voltage channel, as follows. It is updated for each new $U_{\text{rms}(1/2)}$ value.
- Every time a new $U_{\text{rms}(1/2)}$ value is available, the arithmetic mean of the previous 100/120 $U_{\text{rms}(1/2)}$ values, including the new value, is calculated.
- If every one of the previous 100/120 $U_{\text{rms}(1/2)}$ values, including the new value, is within the RVC threshold (including the hysteresis, if applied) of the **newly calculated** 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 **on a given voltage channel** begins when the 'voltage-is-steady-state' logical signal of that channel changes from true to false.
- When an RVC event begins **on a given voltage channel**, the RVC hysteresis is applied to the RVC threshold of that channel, and changes to the voltage-is-steady-state logic **signal** of that voltage channel are disabled for 100/120 half cycles.
- An RVC event ends **on a given voltage channel** when the 'voltage-is-steady-state' logic signal of that channel changes from false to true. When ~~an~~ the RVC event ends, the RVC hysteresis of that channel is removed from the RVC threshold. The time stamp of the end of the RVC event for that channel 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 $U_{\text{rms}(1/2)}$ or $U_{\text{rms}(1)}$ shall be selected according to 5.4.1. If $U_{\text{rms}(1)}$ 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, $\Delta U_{\max}$ 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 $\Delta U_{\max}$ is the maximum absolute difference between any of the $U_{\text{rms}(1/2)}$ values during the RVC event and the final arithmetic mean 100/120 $U_{\text{rms}(1/2)}$ value just prior to the RVC event. For polyphase systems, the $\Delta U_{\max}$ is the largest $\Delta U_{\max}$ on any channel.
- The RVC event ΔU_{ss} is the absolute difference between the final arithmetic mean 100/120 $U_{\text{rms}(1/2)}$ value just prior to the RVC event and the first arithmetic mean 100/120 $U_{\text{rms}(1/2)}$ 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 $\Delta U_{\max}$ 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 $U_{\text{rms}(1/2)}$ or $U_{\text{rms}(1)}$ shall be selected according to 5.4.1. If $U_{\text{rms}(1)}$ is selected for Class S RVC, then 100/120 half cycles shall be replaced throughout the event evaluation with 50/60 full cycles.

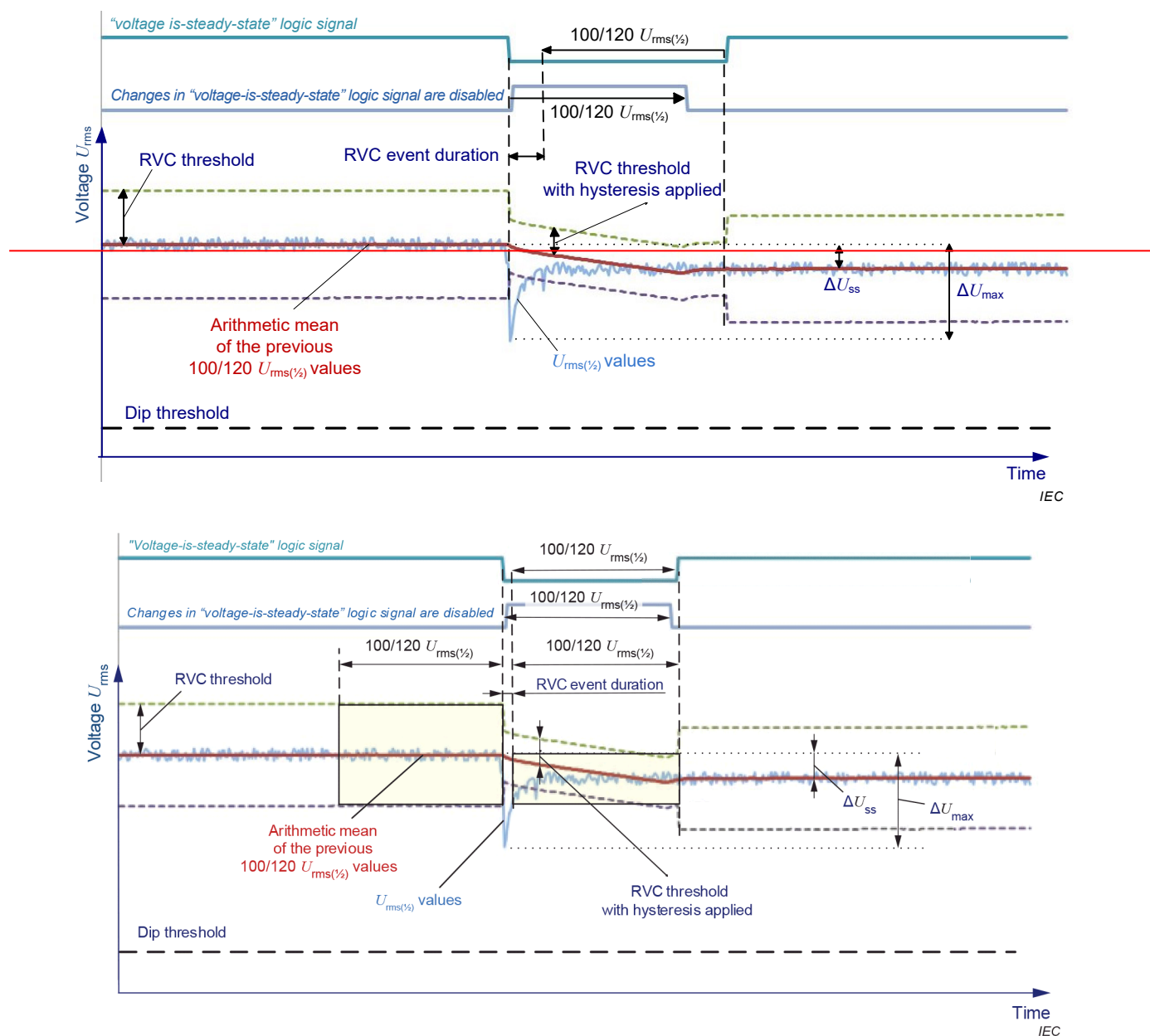


Figure 6 – RVC event: example of a change in r.m.s voltage that results in an RVC event

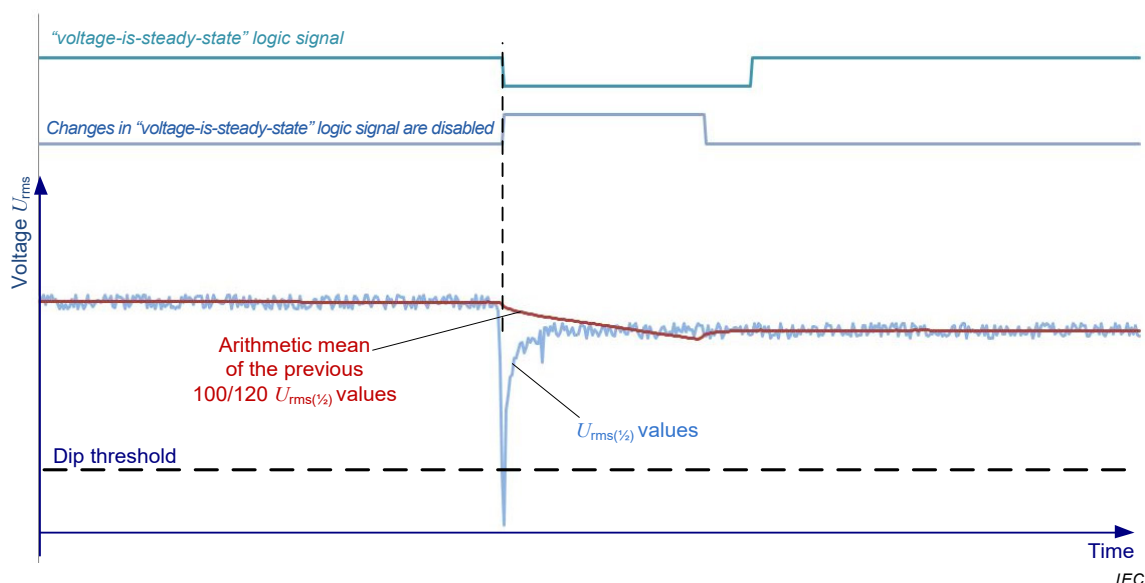


Figure 7 – Not an RVC event: example of a change in r.m.s voltage that does not result in an RVC event because the dip threshold is exceeded

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 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 $Y_{sg,h}$.

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 $I_{sg,h}$ 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 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 % to 150 % U_{din}	IEC 62586-2	See 4.4 and 4.5
	S	See 5.2.1	±0,5 % of U_{din}	20 % to 120 % 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	$U_{\text{rms}(1/2)}$	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	$U_{\text{rms}(1/2)}$	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~~	$\pm 1\%$	~~10 % FS to 150 % FS~~	N/A	N/R
	S	N/R	N/R	N/R	N/A	N/R
5.13 Current	A	See 5.13.2. Crest factor of 3 is required	$\pm 1\%$	10 % FS to 100 % FS	N/A	N/R
	S	See 5.13.2, Crest factor of 3 is required	$\pm 2\%$	10 % FS to 100 % FS	N/A	N/R
Annex C 2 kHz to 150 kHz	A	See Annex C	$\pm 1\text{ V}$	$\pm 50\text{ V pk}$	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 %/ μ s 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 GIS¹ 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.

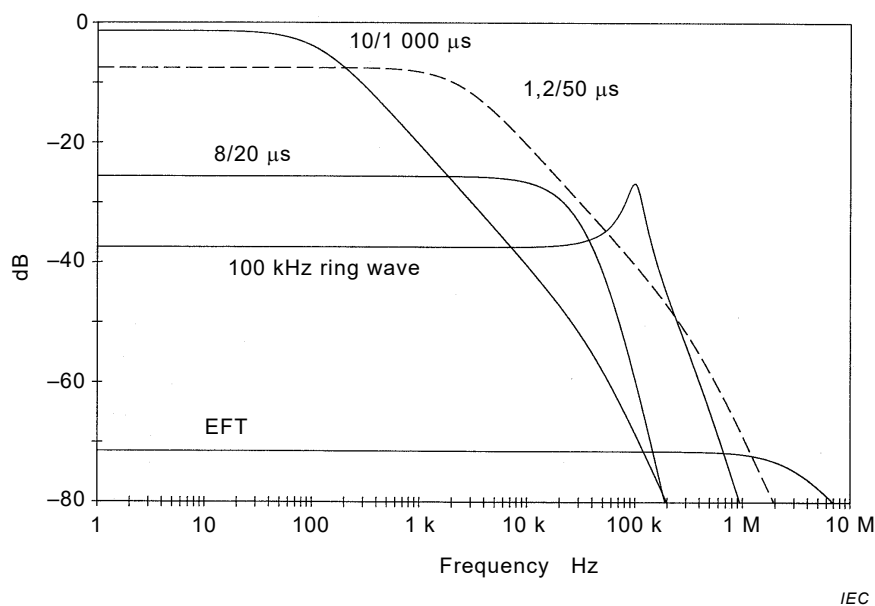


Figure A.1 – Frequency spectrum of typical representative transient test waveforms

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 μ s), 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.).