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TECHNICAL REPORT

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Instrument transformers – The use of instrument transformers for power quality measurement

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INSTRUMENT TRANSFORMERS – THE USE OF INSTRUMENT TRANSFORMERS FOR POWER QUALITY MEASUREMENT

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IEC 61869-103, which is a technical report, has been prepared by IEC technical committee 38: Instrument transformers.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
38/402/DTR	38/409/RVC

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

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

A list of all the parts in the IEC 61869 series, published under the general title *Instrument transformers*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability dateindicated 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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INSTRUMENT TRANSFORMERS – THE USE OF INSTRUMENT TRANSFORMERS FOR POWER QUALITY MEASUREMENT

1 Scope

This part of IEC 61869 is applicable to inductive and electronic instrument transformers with analogue or digital output for use with electrical measuring instruments for measurement and interpretation of results for power quality parameters in 50/60 Hz a.c. power supply systems.

This part of IEC 61869 aims at giving guidance in the usage of HV instrument transformers for measuring power quality parameters.

The power quality parameters considered in this document are power frequency, magnitude of the supply voltage and current, flicker, supply voltage dips and swells, voltage interruptions, transient voltages, supply voltage unbalance, voltage and current harmonics and interharmonics, mains signalling on the supply voltage and rapid voltage changes.

2 Normative references

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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 TR 61869-103:2012
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IEC 60044-8:2002, *Instrument transformers – Part 8: Instrument transformers: Electronic current transformers*

IEC 61000-2-1:1990, *Electromagnetic compatibility (EMC) – Part 2-1: Environment – Description of the environment – Electromagnetic environment for low-frequency conducted disturbances and signalling in public power supply systems*

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

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

IEC 61000-4-30:2008, *Electromagnetic compatibility (EMC) – Part 4-30: Testing and measurement techniques – Power quality measurement methods*

IEC 60359:2001, *Electrical and electronic measurement equipment – Expression of performance*

IEC 61557-12:2007, *Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. – Equipment for testing, measuring or monitoring of protective measures – Part 12: Performance measuring and monitoring devices (PMD)*

EN 50160:2007, *Voltage characteristics of electricity supplied by public distribution networks*

3 Terms and definitions

For the purpose of this document, the terms and definitions given in IEC 61000-4-30:2008 and the following apply.

3.1
dip threshold
voltage magnitude specified for the purpose of detecting the start and the end of a voltage dip

3.2
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]

3.3
fundamental component
component whose frequency is the fundamental frequency

[SOURCE: IEC 60050-101:1998, 101-14-49, modified definition]

3.4
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

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[SOURCE: IEC 60050-101:1998, 101-14-50, modified definition]

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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.

3.5
harmonic component
any of the components having a harmonic frequency

[SOURCE: IEC 61000-2-2:2002, definition 3.2.4]

Note 1 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 harmonic.

3.6
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, definition 3.2.3).

3.7
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]

Note 1 to entry: This quantity is generally external to the measurement equipment.

3.8
interharmonic component
component having an interharmonic frequency

[SOURCE: IEC 61000-2-2:2002, definition 3.2.6]

Note 1 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.

3.9
interharmonic frequency
any frequency which is not an integer multiple of the fundamental frequency

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

Note 1 to entry: By extension from 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.

3.10
interruption
reduction of the voltage at a point in the electrical system below the interruption threshold

3.11
interruption threshold
voltage magnitude specified for the purpose of detecting the start and the end of a voltage interruption

3.12
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

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[SOURCE: IEC 60050-311:2001, 311-01-02, VIM 2.26]

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3.13
nominal voltage
U_n
voltage by which a system is designated or identified

3.14
overdeviation
the absolute value of the difference between the measured value and the nominal value of a parameter, only when the measured value of the parameter is greater than the nominal value

3.15
power quality
characteristics of the electricity at a given point on an electrical system, evaluated against a set of reference technical parameters

[SOURCE: IEC 60050-617:2009, 617-01-05]

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.

3.16
r.m.s. (root-mean-square) 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 60050-101:1998, 101-14-16, modified definition]

3.17
r.m.s. voltage refreshed each half-cycle
$U_{rms(1/2)}$
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 and interruption 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.

3.18
r.m.s. voltage refreshed each cycle
$U_{rms(1)}$
value of the r.m.s. voltage measured over 1 cycle and refreshed each cycle

Note 1 to entry: In contrast to $U_{rms(1/2)}$, this technique does not define when a cycle commences.

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

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

3.19
residual voltage
U_{res}
minimum value of $U_{rms(1/2)}$ or $U_{rms(1)}$ recorded during a voltage dip or interruption

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Note 1 to entry: The residual voltage is expressed as a value in volts, or as a percentage or per unit value of Udin

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3.20
sliding reference voltage
U_{sr}
voltage magnitude averaged over a specified time interval, representing the voltage preceding a voltage-change type of event (e.g. voltage dips and swells, rapid voltage changes)

3.21
supply voltage
the voltage which a distribution undertaking maintains at the consumer's point of supply

[SOURCE: IEC 60050-604:1987, 604-01-16]

Note 1 to entry: If a supply voltage is specified, for instance in the supply contract, then it is called "declared (supply) voltage".

3.22
swell threshold
voltage magnitude specified for the purpose of detecting the start and the end of a swell

3.23
underdeviation
the 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

3.24
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.

3.25
voltage swell
temporary increase of the voltage magnitude at a point in the electrical system above a threshold

3.26
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

[SOURCE: IEC 60050-161:1990, 161-08-09, modified definition and notes]

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 document, voltage unbalance is considered in relation to 3-phase systems.

4 Nature of the problem

Instrument transformers have been used up to now for protection and metering purpose, providing a secondary signal suitable for protection relays and measurement instruments with the required accuracy.

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Attention has been focused on the measurement of current, voltage, power frequency and power: instrument transformers have been conceived, standardized, designed, manufactured, tested mainly, if not exclusively, for this purpose.

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Nowadays, there is a growing demand for investigating the characteristics of the electricity at a given point on an electrical system, evaluated against a set of reference technical parameters; in other words, for measuring the Power Quality (PQ) at that point of the system.

The development of a lot of applications sensitive to PQ issues, from domestic to industrial field, requires technical and normative criteria, in order to protect the parts involved.

Aspects related to PQ measurement methods (and relevant accuracy classes) are defined in detail in the Standard IEC 61000-4-30:2008. In low voltage applications, instruments are available, able to perform measurements with a high degree of accuracy and complying with measurement classes prescribed by IEC 61000-4-30:2008. For high voltage applications, voltage and current transformers have to be inserted in measurement chain, but the information available about their impact on the measurement is not yet consolidated.

For power frequency, a homogeneous behaviour within the whole instrument transformer population belonging to the same class is expected; however, at other frequencies, the transformers behaviour may change, not only from type to type, but even between different samples of the same type.

The present technical report aims to provide the relevant information available at the present about the subject, to give, where possible, indications about the methods and the arrangements to be used and to define the issues that have to be solved and the aspects to be investigated.

In the following chapter, power quality parameters according to IEC 61000-4-30:2008 are described. The possible impact of instrument transformers on the measurement chain is also considered.

5 Power quality parameters according to IEC 61000-4-30:2008

5.1 General

The IEC 61000 family of standards on electromagnetic compatibility standardizes most aspects of power quality. Namely, these standards provide definition for the various disturbances, acceptable emission, susceptibility and compatibility levels as well as measurement methods. The most relevant standards necessary to understand the influence of instrument transformers on power quality parameters are:

- IEC 61000-2-1:1990, *Electromagnetic compatibility (EMC) – Part 2-1: Environment – Section 1: Description of the environment – Electromagnetic environment for low-frequency conducted disturbances and signalling in public power supply systems*
- IEC 61000-2-2:2002, *Electromagnetic compatibility (EMC) – Part 2-2: Environment – Compatibility for low-frequency conducted disturbances and signalling in public low-voltage power supply systems*
- 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 61000-4-15:2010, *Electromagnetic compatibility (EMC) – Part 4-15: Testing and measurement techniques – Flickermeter – Functional and design specifications*
- IEC 61000-4-30:2008, *Electromagnetic compatibility (EMC) – Part 4-30: Testing and measurement techniques – Power quality measurement methods*
- IEC 60359:2001, *Electrical and electronic measurement equipment – Expression of performance*
- IEC 61557-12:2007, *Electrical safety in low voltage distribution systems up to 1 000 V a.c. and 1 500 V d.c. – Equipment for testing, measuring or monitoring of protective measures – Part 12: Performance measuring and monitoring devices (PMD)*

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The first two standards listed provide a definition of the power quality disturbances and their acceptable levels in power system. The remaining three documents define how these disturbances are measured. IEC 61000-4-30:2008 is the main document and is completed by IEC 61000-4-7:2002 and IEC 61000-4-15 which address the specific requirements for harmonics and flicker. It is important to note that IEC 61000-4-30:2008 addresses disturbances relevant to voltage only, while IEC 61000-4-7:2002 also includes current. This implies that, at present, voltage transformers influence has to be considered taking into account the measurement of all quantities identified by IEC 61000-4-30:2008, while the analysis of the impact of current transformers could be limited to harmonics and interharmonics.

5.2 Power quality measurement chain

To determine and quantify the influence of instrument transformers on the overall uncertainty on power quality measurements, it is necessary to simultaneously consider the electrical behaviour of an instrument transformer for a given disturbance and the measurement method as they constitute a measurement chain. This is shown schematically in Figure 1.

NOTE The measurement chain shown in Figure 1 is the same illustrated in clause 4.2 of IEC 61000-4-30:2008, where “Measurement transducers” has been replaced with “Instrument transformers”, in order to be consistent with the terminology used by IEC TC 38.