

# TECHNICAL REPORT



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

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IEC TR 61869-103:2012

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

Tel.: +41 22 919 02 11  
Fax: +41 22 919 03 00  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://www.iec.ch)

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## CONTENTS

FOREWORD .....	6
1 Scope .....	8
2 Normative references .....	8
3 Terms and definitions .....	9
4 Nature of the problem .....	12
5 Power quality parameters according to IEC 61000-4-30:2008 .....	13
5.1 General .....	13
5.2 Power quality measurement chain .....	13
5.3 Signal processing according to IEC 61000-4-30:2008 .....	14
5.4 Power frequency .....	15
5.5 Magnitude of the supply voltage .....	15
5.6 Flicker .....	15
5.7 Supply voltage dips and swells .....	17
5.8 Voltage interruptions .....	18
5.9 Transient voltages .....	19
5.10 Supply voltage unbalance .....	19
5.11 Voltage harmonics .....	20
5.12 Voltage inter-harmonics .....	21
5.13 Mains Signalling Voltages on the supply voltage .....	21
5.14 Rapid voltage changes .....	21
5.15 Measurement of underdeviation and overdeviation parameters .....	21
5.16 Summary of the requirements placed by the measure of power quality parameters .....	21
6 Impact of instrument transformers on PQ measurement .....	22
6.1 General .....	22
6.2 Inductive instrument transformers .....	24
6.2.1 Inductive voltage transformers .....	25
6.2.2 Inductive CTs .....	30
6.3 Capacitive voltage transformers (CVTs) .....	35
6.3.1 Standard application .....	35
6.3.2 Special measurement techniques .....	39
6.4 Electronic instrument transformers .....	42
6.4.1 General .....	42
6.4.2 Common accuracy classes .....	42
6.4.3 Electronic VTs .....	43
6.4.4 Electronic CTs .....	55
7 Tests for power quality .....	67
7.1 Test procedure for VT frequency response .....	68
7.2 Test set-up for VT frequency response test .....	68
7.3 Test procedure for CT frequency response .....	70
7.4 Test set-up for CT frequency response test .....	70
7.5 Special considerations for test of electronic instrument transformers with digital output .....	72
7.6 Tests for electronic instrument transformers according to IEC Standard 60044-8 .....	72
7.6.1 Test arrangement and test circuit .....	73

Annex A Instrument transformers and power quality measurement – open issues .....	75
Annex B Transformer classes .....	79
Bibliography.....	81
Figure 1 – Measurement chain (From [8], modified) .....	14
Figure 2 – Contribution of instrument transformers in overall measurement uncertainty (from [9], modified) .....	14
Figure 3 – Example of voltage fluctuation causing flicker .....	16
Figure 4 – Demodulation within the IEC flickermeter .....	17
Figure 5 – Example of voltage dip (courtesy of Italian distribution network monitoring system – QuEEN) .....	18
Figure 6 – Example of voltage interruption (courtesy of Italian distribution network monitoring system – QuEEN) .....	19
Figure 7 – Example of voltage unbalance (courtesy of Italian distribution network monitoring system- QuEEN).....	20
Figure 8 – Example of voltage harmonics.....	21
Figure 9 – Voltage transformer technologies frequency range according to present experience .....	23
Figure 10 – Current transformer technologies frequency range according to present experience .....	24
Figure 11 – Example of equivalent circuit for an inductive voltage/current transformer .....	25
Figure 12 – Cross-section view of an inductive voltage transformer for voltages over 1 kV and up to 52 kV (courtesy of Schneider Electric).....	26
Figure 13 – Cross-section view of a freestanding High Voltage VT (courtesy of Trench Switzerland AG).....	28
Figure 14 – Frequency response of a typical inductive VT 420 kV (courtesy of Trench Switzerland AG).....	29
Figure 15 – First resonance peak depending on the system voltage $U_m$ (courtesy of Trench Switzerland AG) .....	29
Figure 16 – Cross-section view of a current transformer (courtesy of Schneider Electric) .....	32
Figure 17 – Results obtained for a 245 kV CT (courtesy of Trench Switzerland AG).....	34
Figure 18 – Results obtained for a 245 kV CT: detail (courtesy of Trench Switzerland AG) ...	34
Figure 19 – Cross-section view of a capacitive voltage transformer (Courtesy of Trench Switzerland AG).....	35
Figure 20 – CVT: Equivalent circuit at power frequency .....	36
Figure 21 – Simplified CVT Thevenin equivalent circuit at power frequency without compensating reactor .....	37
Figure 22 – Simplified CVT Thevenin equivalent circuit at power frequency .....	37
Figure 23 – Complete CVT Thevenin equivalent circuit at power frequency.....	38
Figure 24 – Measurements performed by means of a CVT with harmonic measurement terminal .....	40
Figure 25 – Comparison of different measurements with and without harmonic monitoring terminal (Courtesy of Trench Switzerland AG, based on [16]) .....	41
Figure 26 – Basic design for a bulk crystal producing a Pockels Effect (courtesy of Alstom Grid) .....	45
Figure 27 – Various solutions to apply voltage on the active crystal .....	46
Figure 28 – Various methods to divide the full voltage before applying on the crystal.....	46

Figure 29 – Basic design for a Pockels sensor (courtesy of Alstom Grid) .....	47
Figure 30 – Industrial bulk Pockels Cell (courtesy of Alstom Grid).....	47
Figure 31 – Frequency response calculation for an optical VT (courtesy of Alstom Grid).....	48
Figure 32 – Cross-section view and electrical scheme of a resistive voltage divider (from [22]).....	49
Figure 33 – Ratio error of an MV resistive divider (courtesy of Trench Switzerland AG) .....	50
Figure 34 – Phase error of MV resistive divider (courtesy of Trench Switzerland AG).....	50
Figure 35 – Electrical scheme of a capacitive voltage divider .....	51
Figure 36 – Equivalent circuit of an RC voltage divider (from [23], [24]) .....	53
Figure 37 – Equivalent circuit of a balanced RC voltage divider (from [24]) .....	53
Figure 38 – Frequency response of an RC voltage divider (courtesy of Trench Switzerland AG).....	54
Figure 39 – Measurements done on an RC voltage divider with a voltage level of 145 kV with a cable length of 150 m (courtesy of Trench Switzerland AG) .....	54
Figure 40 – Principle of optical CT measurement (from [22]).....	56
Figure 41 – Principle of optical CT measurement (Courtesy of Alstom Grid).....	56
Figure 42 – Frequency response calculation for an optical CT (Courtesy of Alstom Grid) .....	57
Figure 43 – Typical frequency response measurement of a LPCT (Courtesy of Trench Switzerland AG).....	58
Figure 44 – Equivalent circuit for a Rogowski coils (Courtesy of Alstom Grid) .....	59
Figure 45 – Electrical scheme and picture of a Rogowski current transformer (Courtesy of Alstom Grid).....	61
Figure 46 – Electrical scheme of a shunt current measurement (Courtesy of Alstom Grid) .....	62
Figure 47 – Shunt for DC application (Courtesy of Alstom Grid) .....	63
Figure 48 – Equivalent circuit for a compensated shunt .....	63
Figure 49 – Theoretic possible bandwidth of a shunt 5 kA /150 mV (Courtesy of Alstom Grid) .....	64
Figure 50 – Hall Effect Sensor .....	65
Figure 51 – Hall Effect Sensor (Courtesy of Schneider Electric – From [38]) .....	66
Figure 52 – Hall Effect Sensor (Courtesy of Schneider Electric – From [38]) .....	66
Figure 53 – Test circuit for VT frequency response test .....	69
Figure 54 – Test circuit for VT frequency response test .....	70
Figure 55 – Test circuit for CT frequency response test .....	71
Figure 56 – Test circuit for CT frequency response test .....	72
Figure 57 – Test set-up for electronic instrument current transformers with digital output .....	73
Figure 58 – Test set-up for electronic current transformers with analogue output .....	74
Figure A.1 – Examples of “fake dips”, transients recorded at the secondary winding of MV voltage transformers due to voltage transformers saturation (courtesy of Italian distribution network monitoring system- QuEEN).....	78
Table 1 – Power quality disturbances and measurement interval as per IEC 61000-4-30:2008 .....	15
Table 2 – Transformer parameters influencing power quality measurement.....	22

Table 3 – Main components of an inductive voltage transformer for voltages over 1 kV and up to 52 kV .....	26
Table 4 – Inductive voltage transformers for voltages over 1 kV and up to 52 kV: impact on the measurements of PQ Parameters .....	27
Table 5 – Inductive voltage transformers for voltages over 52 kV and up to 1 100 kV: impact on the measurements of PQ parameters .....	30
Table 6 – Main components of an inductive current transformer for voltages over 1 kV up to 52 kV .....	31
Table 7 – Inductive CTs for voltages over 1 kV up to 52 kV: impact on the measurements of PQ parameters .....	32
Table 8 – Main components of an inductive current transformer for voltages above 52 kV up to 1 100 kV .....	33
Table 9 – Inductive CTs for voltages over 52 kV up to 1 100 kV: impact on the measurements of PQ parameters .....	35
Table 10 – Capacitive voltage transformers: impact on the measurements of PQ parameters .....	39
Table 11 – Capacitive voltage transformer with harmonic measurement terminal: impact on the measurements of PQ parameters .....	41
Table 12 – Capacitive voltage transformer with additional equipment for PQ measurement: impact on the measurements of PQ parameters .....	42
Table 13 – Accuracy classes for power metering .....	43
Table 14 – Accuracy classes for power quality metering .....	43
Table 15 – Optical voltage transformer: impact on the measurements of PQ parameters .....	48
Table 16 – MV resistive divider: impact on the measurements of PQ parameters .....	51
Table 17 – Capacitive voltage dividers: impact on the measurements of PQ parameters .....	52
Table 18 – RC voltage divider: impact on the measurements of PQ parameters .....	55
Table 19 – Optical current transformer: Impact on the measurements of PQ parameters .....	57
Table 20 – Main components of LPCTs .....	58
Table 21 – Main components of Rogowski sensors .....	61
Table 22 – Rogowski current transformer: Impact on the measurements of PQ parameters .....	62
Table 23 – Shunt: Impact on the measurements of PQ parameters .....	64
Table 24 – Hall effect sensor: Impact on the measurements of PQ parameters .....	67
Table 25 – Power quality parameters and requirements for CT and VT .....	68
Table 26 – Test currents and voltages for the common accuracy classes .....	72
Table 27 – Test currents and voltages for special accuracy classes .....	72
Table B.1 – Example of test table with possible main requirements for accuracy tests .....	80

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**INSTRUMENT TRANSFORMERS –  
THE USE OF INSTRUMENT TRANSFORMERS  
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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.

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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

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.

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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

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

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

[SOURCE: IEC 60050-311:2001, 311-01-02, VIM 2:2008]

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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

Note 1 to entry: The residual voltage is expressed as a value in volts, or as a percentage or per unit value of  $U_{din}$

**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.

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.

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)*

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.