

# INTERNATIONAL STANDARD



Electrical safety in low voltage distribution systems up to 1 000 V AC and  
1 500 V DC. – Equipment for testing, measuring or monitoring of protective  
measures –

Part 12: ~~Performance measuring~~ Power metering and monitoring devices (PMD)



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## ELECTRICAL SAFETY IN LOW VOLTAGE DISTRIBUTION SYSTEMS UP TO 1 000 V AC AND 1 500 V DC. – EQUIPMENT FOR TESTING, MEASURING OR MONITORING OF PROTECTIVE MEASURES –

### Part 12: ~~Performance measuring~~ Power metering and monitoring devices (PMD)

#### FOREWORD

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International Standard IEC 61557-12 has been prepared by IEC technical committee 85: Measuring equipment for electrical and electromagnetic quantities.

This second edition cancels and replaces the first edition published in 2007. This edition constitutes a technical revision.

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

- a) PMD-A has been withdrawn due the fact these devices are now mainly covered by the IEC 62586 series of standards.
- b) Three categories of PMD have been created with a list of minimum required functions for each category.
- c) Added a new Annex A explaining the different applications linked to the relevant standards and devices, and another new Annex C about the power factor conventions.

The text of this International Standard is based on the following documents:

| FDIS        | Report on voting |
|-------------|------------------|
| 85/644/FDIS | 85/649/RVD       |

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

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

A list of all parts in the IEC 61557 series, published under the general title *Electrical safety in low voltage distribution systems up to 1 000 V AC and 1 500 V DC – Equipment for testing, measuring or monitoring of protective measures*, can be found on the IEC website.

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## INTRODUCTION

~~As a complement to protection measures, it becomes more and more necessary to measure different electrical parameters, in order to monitor the required performances in energy distribution systems due to:~~

- ~~• installation standards evolutions, for instance over current detection is now a new requirement for the neutral conductor due to harmonic content;~~
- ~~• technological evolutions (electronic loads, electronic measuring methods, etc.);~~
- ~~• end-users needs (cost saving, compliance with aspects of building regulations, etc...);~~
- ~~• safety and continuity of service;~~

Energy distribution systems need to guarantee energy efficiency, availability and network performances in order to address the following challenges:

- sustainable development requirements where energy measurement, for instance, is recognised as an essential element of energy management, part of the overall drive to reduce carbon emissions and to improve the commercial efficiency of manufacturing, commercial organizations and public services;
- technological evolutions (electronic loads, electronic measuring methods, etc.);
- end-users needs (cost saving, compliance with aspects of building regulations, etc.) regarding electrical energy management as well as other energies, or fluids. Other functionalities involving several non electrical parameters are often needed in parallel;
- safety and continuity of service;
- evolution of installation standards, for instance over-current detection is now a new requirement for the neutral conductor due to harmonic content.

Monitoring electrical quantities in internal networks allows to address these challenges.

The devices on the current market have different characteristics, which need a common system of references. Therefore there is a need for this document in order to facilitate the choices of the end-users in terms of performance, safety, interpretation of the indications, etc. This document provides a basis by which such devices can be specified and described, and their performance evaluated.

In order to fulfil the requirements of the energy efficiency project, many PMD measuring electrical parameters can also collect data (water, air, gas, temperature...) coming from other sensors or meters inside building or plant areas. In order to be able to transmit all these data to a supervision software it will be relevant to equip the PMD with a communication bus. The supervision software will then manage all the collected data in order to monitor them and produce useful reports for energy usage and consumption analysis.

# ELECTRICAL SAFETY IN LOW VOLTAGE DISTRIBUTION SYSTEMS UP TO 1 000 V AC AND 1 500 V DC. – EQUIPMENT FOR TESTING, MEASURING OR MONITORING OF PROTECTIVE MEASURES –

## Part 12: ~~Performance measuring~~ Power metering and monitoring devices (PMD)

### 1 Scope

This part of IEC 61557 specifies requirements for ~~combined performance measuring~~ power metering and monitoring devices (PMD) that measure and monitor the electrical ~~parameters~~ quantities within electrical distribution systems, and optionally other external signals. These requirements also define the performance in single- and three-phase AC or DC systems having rated voltages up to 1 000 V AC or up to 1 500 V DC.

These devices are fixed ~~installed~~ or portable. They are intended to be used indoors and/or outdoors. ~~This standard is not applicable for:~~

- ~~electricity metering equipment that complies with IEC 62053-21, IEC 62053-22 and IEC 62053-23. Nevertheless, uncertainties defined in this standard for active and reactive energy measurement are derived from those defined in the IEC 62053 standards series.~~
- ~~simple remote relays or simple monitoring relays.~~

~~This standard is intended to be used in conjunction with IEC 61557-1 (unless otherwise specified), which specifies the general requirements for measuring and monitoring equipment, as required in IEC 60364-6.~~

~~The standard does not include the measurement and monitoring of electrical parameters defined in Parts 2 to 9 of IEC 61557 or in IEC 62020.~~

~~Combined performance measuring~~ Power metering and monitoring devices (PMD), as defined in this document, give additional safety information, which aids the verification of the installation and enhances the performance of the distribution systems. ~~For instance, those devices help to check if the level of harmonics is still compliant with the wiring systems as required in IEC 60364-5-52.~~

The ~~combined performance measuring~~ power metering and monitoring devices (PMD) for electrical parameters described in this document are used for general industrial and commercial applications. ~~A PMD A is a specific PMD complying with requirements of IEC 61000-4-30 class A, which may be used in "power quality assessment" applications.~~

This document does not address functional safety and cyber security aspects.

This document is not applicable for:

- electricity metering equipment that complies with IEC 62053-21, IEC 62053-22, IEC 62053-23 and IEC 62053-24. Nevertheless, uncertainties defined in this document for active and reactive energy measurement are derived from those defined in IEC 62053 (all parts);
- the measurement and monitoring of electrical parameters defined in IEC 61557-2 to IEC 61557-9 and IEC 61557-13 or in IEC 62020;
- power quality instrument (PQI) according IEC 62586 (all parts);

- devices covered by IEC 60051 (all parts) (direct acting analogue electrical measuring instrument).

NOTE 1 Generally such types of devices are used in the following applications or for the following general needs:

- energy management inside the installation, such as facilitating the implementation of documents such as ISO 50001 and IEC 60364-8-1;
- monitoring and/or measurement of electrical parameters ~~that may be required or usual~~;
- measurement and/or monitoring of the quality of energy inside commercial/industrial installations.

NOTE 2 A measuring and monitoring device of electrical parameters usually consists of several functional modules. All or some of the functional modules are combined in one device. Examples of functional modules are ~~mentioned below~~:

- measurement and ~~indication~~ monitoring of several electrical parameters simultaneously;
- energy measurement and/or monitoring, as well as sometimes compliance with aspects of building regulations;
- alarms functions;
- ~~power~~ demand side quality (current and voltage harmonics, over/under voltages, voltage dips and swells, etc.).

NOTE 3 PMD are historically called power meter, power monitor, power monitor device, power energy monitoring device, power analyser, multifunction meter, measuring multifunction equipment, energy meters.

NOTE 4 Metering, measuring and monitoring applications are explained in Annex A.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60068-2-1, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2, *Environmental testing – Part 2: Tests – Tests B: Dry heat*

IEC 60068-2-30, *Environmental testing – Part 2-30 – Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

~~IEC 60364-6, Low voltage electrical installations – Part 6: Verification~~

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

~~IEC 61000-4-5, Electromagnetic compatibility (EMC) – Part 4-5: Testing and measurement techniques – Surge immunity test~~

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

IEC 61000-4-30:2003 2015, *Electromagnetic compatibility (EMC) – Part 4-30: Testing and measurement techniques – Power quality measurement methods*

~~IEC 61010 (all parts), Safety requirements for electrical equipment for measurement, control, and laboratory use~~

IEC 61010-1:2001 2010, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements*

IEC 61010-1:2010/AMD1:2016

IEC 61010-2-030:2017, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 2-030: Particular requirements for testing and measuring circuits*

IEC 61326-1:2005 2012, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: General requirements*

~~IEC 61557-1:2007, *Electrical safety in low voltage distribution systems up to 1000 V a.c. and 1500 V d.c. – Equipment for testing, measuring or monitoring of protective measures – Part 1: General requirements*~~

~~IEC 62053-21:2003, *Electricity metering equipment (a.c.) – Particular requirements – Part 21: Static meters for active energy (classes 1 and 2)*~~

~~IEC 62053-22:2003, *Electricity metering equipment (a.c.) – Particular Requirements – Part 22: Static meters for active energy (classes 0,2 S and 0,5 S)*~~

~~IEC 62053-23:2003, *Electricity metering equipment (a.c.) – Particular requirements – Part 23: Static meters for reactive energy (classes 2 and 3)*~~

IEC 62053-31:1998, *Electricity metering equipment (a.c.) – Particular requirements – Part 31: Pulse output devices for electromechanical and electronic meters (two wires only)*

### 3 Terms, definitions and notations

For the purposes of this document, ~~the terms and definitions given in IEC 61557-1, unless otherwise specified in this standard, and~~ the following terms, definitions and notations apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

#### 3.1 General definitions

##### 3.1.1

##### ~~performance measuring~~ power metering and monitoring device

##### PMD

combination in one or more devices of several functional modules dedicated to ~~measuring~~ metering and monitoring electrical parameters in energy distribution systems or electrical installations, used for applications such as energy efficiency, power monitoring and network performance. ~~A PMD can be used in connection with sensors (see 4.3)~~

~~A PMD that complies with class B as defined in IEC 61000-4-30 is also covered by this definition.~~

Note 1 to entry: Under the generic term “monitoring” are also included functions of recording, alarm management, etc.

Note 2 to entry: These devices may include ~~power~~ demand side quality functions for monitoring inside commercial/industrial installations.

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

##### 3.1.2

##### PMD-A

~~PMD in which all power quality assessment functions comply with measurement methods and performance requirements according to class A of IEC 61000-4-30 and with complementary~~

~~requirements (safety, EMC, temperature range, complementary influence quantities, ...) of this standard~~

~~NOTE If this device is used for checking the compliance to the connection agreement with a network operator, it should be installed at the interface point between the installation and the network.~~

### 3.1.2

#### **power quality assessment function**

power quality functions whose measurement methods are defined in IEC 61000-4-30

### 3.1.3

#### **supply side**

part of the grid where electric energy is generated, transmitted and distributed to end-use customers through the public supply network

Note 1 to entry: This definition encompasses micro-grids, decentralised generators or renewable energy generators.

### 3.1.4

#### ~~**specified external sensor**~~

~~sensor that is chosen in such a way that, connected to a PMD without sensors, the system performance class complies with 4.4.2~~

### 3.1.4

#### **demand side**

part of the grid where electric energy is consumed by end-use customers within their electric distribution system

### 3.1.5

#### **point of common coupling**

##### **PCC**

point of a power supply network, electrically nearest to a particular load, at which other loads are, or may be, connected

Note 1 to entry: These loads can be either devices, equipment or systems, or distinct customer's installations.

Note 2 to entry: In some applications, the term "point of common coupling" is restricted to public networks.

[SOURCE: IEC 60050-161:1990, 161-07-15]

### 3.1.6

#### **power quality**

characteristics of the electric current, voltage and frequencies at a given point in an electric power 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 in an electric power system and the loads connected to that electric power system

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

### 3.1.7

#### **dedicated external sensor**

proprietary external sensor able to operate only with a range of PMD specified by the manufacturer

### 3.1.8

#### **current sensor**

##### **CS**

electrical, magnetic, optical or other device intended to transmit a signal corresponding to the current flowing through the primary circuit of this device

Note 1 to entry: A current transformer (CT) is in general a magnetic current sensor.

Note 2 to entry: This note applies to the French language only.

### 3.1.9

#### **compliance voltage**

value of the voltage that can be developed at the **current analog output** ~~of a current generator~~ while conforming to the requirement of the uncertainty specification for that output

Note 1 to entry: This definition applies to current analog output signals.

### 3.1.10

#### **voltage sensor**

##### **VS**

electrical, magnetic, optical or other device intended to transmit a signal corresponding to the voltage across the primary terminals of this device

Note 1 to entry: A voltage transformer (VT) is in general a magnetic voltage sensor.

Note 2 to entry: This note applies to the French language only.

### 3.1.11

#### **self-powered PMD**

equipment ~~able to work without an auxiliary~~ where measuring terminals are also used for power supply

~~NOTE 1 Self-powered PMD have no provision for power supply terminals.~~

~~NOTE 2 Self-powered PMD includes equipment powered from measurement inputs, internal batteries, or other internal power sources (internal photo-voltaic sources, etc.).~~

### 3.1.12

#### **auxiliary power supply**

external power supply, either AC or DC, that powers the PMD through dedicated terminals separated from the measurement inputs of the PMD

### 3.1.13

#### **transformer operated PMD**

PMD intended to be connected to the circuit(s) being measured via external instrument transformer(s)

Note 1 to entry: Transformer operated PMD corresponds to PMD Sx or PMD xS in this document.

### 3.1.14

#### **primary register**

register of an instrument transformer-operated meter which takes into account the ratios of all the transformers (voltage and current transformers) to which the meter is connected

Note 1 to entry: The value of the energy on the primary side of the transformers is obtainable from the direct reading of the register.

[SOURCE IEC 62053-52:2005, 3.4]

### 3.1.15

#### **half-primary register**

register of an instrument transformer-operated meter which takes into account either the ratio(s) of the current transformer(s) or the ratio(s) of the voltage transformer(s), but not both

Note 1 to entry: The value of the energy on the primary side of the transformer(s) is obtainable from the reading of the register multiplied by an appropriate factor.

[SOURCE IEC 62053-52:2005, 3.5]

## 3.2 Definitions related to uncertainty and performance

### 3.2.1

#### reference conditions

appropriate set of specified values and/or ranges of values of influence quantities under which the smallest permissible uncertainties of a measuring instrument are specified

Note 1 to entry: The ranges specified for the reference conditions, called reference ranges, are not wider, and are usually narrower, than the ranges specified for the rated operating conditions.

[SOURCE: IEC 60359:2001, 3.3.10]

### 3.2.2

#### measurand

quantity subjected to measurement, evaluated in the state assumed by the measured system during the measurement itself

[SOURCE: IEC 60359:2001, 3.1.1, modified – the notes have been removed]

### 3.2.3

#### uncertainty

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

Note 1 to entry: In this document, measurement uncertainty includes components arising from systematic effects and from random effects

### 3.2.4

#### intrinsic uncertainty

uncertainty of a measuring instrument when used under reference conditions

Note 1 to entry: In this document, it is a percentage of the measured value defined in its rated range and with the ~~other~~ influence quantities under reference conditions, unless otherwise stated.

[SOURCE: IEC 60359:2001, 3.2.10, modified – a note has been added.]

### 3.2.5

#### 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

Note 1 to entry: Influence quantities can originate from the measured system, the measuring equipment or the environment [IEV].

Note 2 to entry: As the calibration diagram depends on the influence quantities, in order to assign the result of a measurement it is necessary to know whether the relevant influence quantities lie within the specified range [IEV].

[SOURCE: IEC 60359:2001, 3.1.14, modified – note 3 has been removed.]

### 3.2.6

#### variation

< ~~due to a~~ under single influence quantity >

difference between the value measured under reference conditions and any value measured within the influence range

Note 1 to entry: The other performance characteristics and the other influence quantities should stay within the ranges specified for the reference conditions.

**3.2.7****~~(rated)~~ operating conditions**

set of conditions that must be fulfilled during the measurement in order that a calibration diagram may be valid

Note 1 to entry: Beside the specified measuring range and rated operating ranges for the influence quantities, the conditions may include specified ranges for other performance characteristics and other indications that cannot be expressed as ranges of quantities.

[SOURCE: IEC 60359:2001, 3.3.13]

**3.2.8****operating uncertainty****~~uncertainty under the rated operating conditions~~**

calculated uncertainty taking into account the intrinsic uncertainty and the additional uncertainties due to the defined influence quantities

Note 1 to entry: The operating ~~instrumental~~ uncertainty, like the intrinsic one, is not evaluated by the user of the instrument, but is stated by its manufacturer or calibrator. The statement may be expressed by means of an algebraic relation involving the intrinsic ~~instrumental~~ uncertainty and the values of one or several influence quantities, but such a relation is just a convenient means of expressing a set of operating ~~instrumental~~ uncertainties under different operating conditions, not a functional relation to be used for evaluating the propagation of uncertainty inside the instrument.

Note 2 to entry: An operating uncertainty reflects the quality of the design of a device, and is not the same nature as a performance class or intrinsic uncertainty.

Note 3 to entry: Operating uncertainty can be greater than intrinsic uncertainty and greater than performance class.

Note 4 to entry: The concept of operating uncertainty is related to the concept of maximum permissible error developed in other documents, which is calculated from three influencing quantities only.

~~[IEC 60359, definition 3.2.11, modified]~~

**3.2.9****overall ~~system~~ uncertainty**

uncertainty including the ~~instrumental~~ uncertainty of several separated instruments ~~(sensors, wires, measuring instrument, etc.) under the rated operating conditions~~ (voltage sensor, current sensor and PMD)

**3.2.10****function performance class**

~~performance of a single function without external sensors, expressed as a percentage and depending on function intrinsic uncertainty and on variations due to influence quantities~~

number accounting for the performance of a single function, depending on function intrinsic uncertainty, taking into account specified measurement range and limits for variations due to the specified influence quantities

Note 1 to entry: In this document, C stands for the numerical value of the function performance class (for instance C = 0,2).

**~~3.2.9~~****~~system performance class~~**

~~performance of a single function including specified external sensors expressed as a percentage and depending on function intrinsic uncertainty and on variations due to influence quantities~~

~~NOTE In this standard, C stands also for system performance class.~~

### 3.2.11 rated frequency

$f_n$

value of the frequency ~~in accordance with which the relevant performance of the PMD is fixed~~ at which the specification of the PMD is defined

~~NOTE  $f_n$  stands for nominal frequency in IEC 61557-1.~~

### 3.2.12 rated current

$I_n$

value of the current ~~in accordance with which the relevant performance of an PMD operated by an external current sensor (PMD Sx) is fixed~~ at which the specification of a PMD operated by an external current sensor (PMD Sx) is defined

~~NOTE  $I_n$  stands for nominal current in IEC 61557-1.~~

~~[IEV 314-07-02, modified]~~

### 3.2.13 basic current

$I_b$

value of the current ~~in accordance with which the relevant performance of a direct connected PMD (PMD Dx) is fixed~~ at which the specification of a direct connected PMD (PMD Dx) is defined

~~[IEC 62052-11, definition 3.5.1.2, modified]~~

### 3.2.14 starting current

$I_{st}$

lowest value of the current at which the PMD starts and continues to register

[SOURCE: IEC 62052-11:2003, 3.5.1.1, modified – "meter" has been replaced by "PMD".]

### 3.2.15 maximum current

$I_{max}$

highest value of current at which the PMD meets the uncertainty requirements of this document

~~[IEC 62052-11, definition 3.5.2, modified]~~

### 3.2.16 rated voltage

$U_n$

value of the voltage in accordance with which the relevant performances of the PMD are fixed

**Note 1 to entry:** Depending on the distribution system and its connection to the PMD, this voltage can be either the phase to phase voltage or the phase to neutral voltage.

~~NOTE  $U_n$  stands for nominal voltage in IEC 61557-1.~~

### 3.2.17 nominal voltage

$U_{nom}$

suitable approximate value of voltage used to designate or identify a system

[SOURCE: IEC 60050-601:1985, 601-01-21]

**3.2.18****minimum voltage** $U_{\min}$ 

lowest value of voltage at which the PMD meets the uncertainty requirements of this document

**3.2.19****maximum voltage** $U_{\max}$ 

highest value of voltage at which the PMD meets the uncertainty requirements of this document

**3.2.19****declared input voltage** $U_{\text{din}}$ 

value obtained from the declared supply voltage by a transducer ratio

[IEC 61000-4-30, definition 3.2]

**3.2.20****residual voltage** $U_{\text{resid}}$ 

minimum value of  $U$  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~~ a fraction of the rated voltage.

**3.2.21****declared input voltage** $U_{\text{din}}$ 

value obtained from the declared supply voltage by a transducer ratio

[SOURCE: IEC 61000-4-30:2015, 3.25, modified 3.2]

**3.2.22****sliding reference voltage** $U_{\text{sr}}$ 

voltage magnitude averaged over one minute, representing the voltage preceding a voltage dip or swell

**3.2.23****demand value**

average value of a quantity over a specified period of time

**3.2.24****peak demand value**

highest demand value (positive or negative) since the beginning of the measurement or the last reset

**3.2.25****thermal demand**

emulation of a thermal demand meter that provides an exponentially time lagged demand, given a constant load, the indication reading 90 % of the actual demand in a specified time

Note 1 to entry: The time is specified by the manufacturer, usually 15 min.

**3.2.26****three-phase average value**

in a three- or four-wire system, the arithmetical average of ~~each~~ all phase value

### 3.2.27

#### **maximum value**

highest value measured or calculated since the beginning of the measurement or the last reset

### 3.2.28

#### **minimum value**

lowest value measured or calculated since the beginning of the measurement or last reset

### 3.2.29

#### **interval**

period of time used by the PMD to integrate RMS or instantaneous values in order to calculate demand values

## 3.3 Definitions related to electric phenomena

### 3.3.1

#### **phase current**

$I$

value of the current flowing in each phase of an electrical distribution system

### 3.3.2

#### **neutral current**

$I_N$

value of neutral current of an electrical distribution system

### 3.3.3

#### **phase to phase voltage line to line voltage**

$U$

voltage between phases

[SOURCE: IEC 60050-601:1985, 601-01-29]

### 3.3.4

#### **phase to neutral voltage line to neutral voltage**

$V$

voltage between a phase in a polyphase system and the neutral point

[SOURCE: IEC 60050-601:1985, 601-01-30]

### 3.3.5

#### **frequency**

$f$

value of measured frequency in an electrical distribution system

### 3.3.6

#### **power factor**

$PF$

under periodic conditions, ratio of the ~~absolute~~ value of the active power to the apparent power

Note 1 to entry: This power factor is not the displacement power factor. Both are not equal in presence of harmonics.

Note 2 to entry: This note applies to the French language only.

[SOURCE: IEC 60050-131:2002 131-11-46, modified – the formula in the definition has not been included, note 1 has been changed and a note 2 has been added.]

### 3.3.7

#### amplitude of harmonic current

$I_h$

value of the amplitude of the current at harmonic frequencies in the spectrum obtained from a Fourier transform of a time function

### 3.3.8

#### amplitude of harmonic voltage

$U_h$

value of the amplitude of the voltage at harmonic frequencies in the spectrum obtained from a Fourier transform of a time function

### 3.3.9

#### stationary harmonics

<voltage and current> harmonic content of the signal with the amplitude variation of each harmonic component remaining constant within  $\pm 0,1$  % of the amplitude of the fundamental

### 3.3.10

#### quasi-stationary harmonics

<voltage and current> harmonic content of the signal ~~with~~ in which the amplitude variation of each harmonic ~~component of each~~ for contiguous 10 (50 Hz systems) or 12 (60 Hz systems) cycles ~~window remaining~~ remains within  $\pm 0,1$  % of the amplitude of the fundamental

### 3.3.11

#### sub-harmonics

<voltage and current> interharmonic component of harmonic order lower than one

Note 1 to entry: In this document, sub-harmonic components are restricted to ranks being reciprocal of integers.

[SOURCE: IEC 60050-551:2001, 551-20-10, modified – the term has been changed from "sub-harmonic component" to "sub-harmonics" and the domain has been indicated.]

### 3.3.12

#### 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]

### 3.3.13

#### voltage dip

temporary reduction of the voltage at a point in the electrical distribution system below a defined 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: In some areas of the world a voltage dip is referred to as sag. The two terms are considered interchangeable; however, this document will only use the term voltage dip.

~~[IEC 61000-4-30, definition 3.30, modified]~~

### 3.3.14

#### voltage swell

temporary increase of the voltage at a point in the electrical distribution system above a defined threshold

~~[IEC 61000-4-30, definition 3.31, modified]~~

### 3.3.15

#### RMS voltage refreshed each half-cycle

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

value of the RMS 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 RMS values at successive times on different channels for polyphase systems

Note 2 to entry: This RMS voltage value may be a phase to phase value or a phase to neutral value.

### 3.3.16

#### RMS voltage refreshed each cycle

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

value of the RMS 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 RMS voltage value can be a phase to phase value or a phase to neutral value.

### 3.3.17

#### voltage interruption

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

### 3.3.18

#### amplitude and phase ~~unbalanced~~ voltage **unbalance**

condition in a three-phase system in which the RMS values of the line voltages (fundamental component), 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-sequence and zero-sequence components to the positive-sequence component.

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

~~[IEV 161-08-09, modified]~~

### 3.3.19

#### amplitude ~~unbalanced~~ voltage **unbalance**

condition in a three-phase system in which the RMS values of the line voltages (fundamental component) are not all equal.

Note 1 to entry: The relative phase between the line voltages is not taken into account.

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

~~[IEV 161-08-09, modified]~~

### 3.3.20

#### transient overvoltage

short-duration overvoltage of few milliseconds or less, oscillatory or non-oscillatory, usually highly damped.

Note 1 to entry: Transient overvoltages may be immediately followed by temporary overvoltages. In such cases the two overvoltages are considered as separate events.

Note 2 to entry: IEC 60071-1 defines three types of transient overvoltages, namely slow-front overvoltages, fast-front overvoltages and very fast-front overvoltages according to their time to peak, tail or total duration, and possible superimposed oscillations.

[SOURCE: IEC 60050-604:2016, ~~604-03-13~~ 604-03-14]

### ~~3.3.19~~

#### ~~mains signalling voltage~~

~~signals transmitted by energy suppliers on public networks for network management purposes, such as the control of some categories of load.~~

~~NOTE Technically, mains signalling is a source of interharmonics voltages. In this case, however, the signal voltage is intentionally impressed on a selected part of the supply system. The voltage and frequency of the emitted signal are pre-determined, and the signal is transmitted at particular times.~~

### 3.3.21

#### crest factor

peak to RMS ratio

## 3.4 Definitions related to measurement techniques

### 3.4.1

#### measurement window

interval during which a single measurement is performed, expressed in seconds or in number of fundamental cycles

Note 1 to entry: Depending on the measurement technique the duration of the measurement window may be fixed or variable.

### 3.4.2

#### ~~zero-blind~~ gapless measurement

measurement technique where the measurement is performed continuously without gap, that is, using contiguous measurement windows. ~~For digital techniques and for a given sampling rate, no sample shall be missing in the measurement processing.~~

Note 1 to entry: For digital techniques and for a given sampling rate, no sample is missing in the measurement processing.

Note 2 to entry: When ~~zero-blind~~ gapless measurement techniques are used, no assumption is made regarding the stability of the signal, ~~in opposition with~~ as opposed to non-~~zero-blind~~ gapless measurement techniques, where the signal is considered to be stable during the time where no measurement is done.

## 3.5 Notations

### 3.5.1 Functions

| Symbol                                                    | Function                                                                                    |
|-----------------------------------------------------------|---------------------------------------------------------------------------------------------|
| $P$                                                       | total active power                                                                          |
| $E_a$                                                     | total active energy                                                                         |
| $Q_A / Q_V$                                               | total reactive power arithmetic / total reactive power vector                               |
| $E_{rA} / E_{rV}$                                         | total reactive energy arithmetic / total reactive energy vector                             |
| $S_A / S_V$                                               | total apparent power arithmetic / total apparent power vector                               |
| $E_{apA} / E_{apV}$                                       | total apparent energy arithmetic / total apparent energy vector                             |
| $f$                                                       | frequency                                                                                   |
| $I$                                                       | phase current including $I_p$ (current on Line p)                                           |
| $I_N / I_{Ne}$                                            | measured neutral current / calculated neutral current                                       |
| $U$                                                       | voltage including $U_{pg}$ (line p to line g voltage) and $V_p$ (line p to neutral voltage) |
| $U_{din}$                                                 | declared input voltage [IEC 61000-4-30]                                                     |
| $PF_A / PF_V$                                             | power factor arithmetic / power factor vector                                               |
| NOTE $PF_V = \cos(\varphi)$ when no harmonics are present |                                                                                             |

|                                         |                                                                                                                                       |
|-----------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------|
| <del><math>P_{st} / P_{lt}</math></del> | <del>short term flicker / long term flicker</del>                                                                                     |
| <del><math>U_{dip}</math></del>         | <del>voltage dips including <math>U_{pg\ dip}</math> (line p to line g) and <math>V_{p\ dip}</math> (line p to neutral)</del>         |
| <del><math>U_{swl}</math></del>         | <del>voltage swells including <math>U_{pg\ swl}</math> (line p to line g) and <math>V_{p\ swl}</math> (line p to neutral)</del>       |
| <del><math>U_{tr}</math></del>          | <del>transients overvoltage including <math>U_{pg\ tr}</math> (line p to line g) and <math>V_{p\ tr}</math> (line p to neutral)</del> |
| <del><math>U_{int}</math></del>         | <del>voltage Interruption including <math>U_{pg\ int}</math> (line p to line g) and <math>V_{p\ int}</math> (line p to neutral)</del> |
| <del><math>U_{nb}</math></del>          | <del>voltage Unbalance phase and amplitude including <math>V_{p\ nb}</math> (line p to neutral)</del>                                 |
| <del><math>U_{nba}</math></del>         | <del>voltage Unbalance amplitude including <math>V_{p\ nba}</math> (line p to neutral)</del>                                          |
| <del><math>U_h</math></del>             | <del>voltage harmonics including <math>U_{pg\ h}</math> (line p to line g) and <math>V_{p\ h}</math> (line p to neutral)</del>        |
| <del><math>THD_u</math></del>           | <del>total harmonic distortion voltage related to fundamental</del>                                                                   |
| <del><math>THD-R_u</math></del>         | <del>total harmonic distortion voltage related to r.m.s. value</del>                                                                  |
| <del><math>I_h</math></del>             | <del>current harmonics including <math>I_{p\ h}</math> (harmonics on line p)</del>                                                    |
| <del><math>THD_i</math></del>           | <del>total harmonic current related to fundamental</del>                                                                              |
| <del><math>THD-R_i</math></del>         | <del>total harmonic current related to r.m.s. value</del>                                                                             |
| <del><math>Msv</math></del>             | <del>mains signalling voltage</del>                                                                                                   |

| Symbol              | Function                                                                                 |
|---------------------|------------------------------------------------------------------------------------------|
| $P$                 | total active power                                                                       |
| $E_a$               | total active energy                                                                      |
| $Q_A / Q_V$         | total reactive power arithmetic / total reactive power vector                            |
| $E_{rA} / E_{rV}$   | total reactive energy arithmetic / total reactive energy vector                          |
| $S_A / S_V$         | total apparent power arithmetic / total apparent power vector                            |
| $E_{apA} / E_{apV}$ | total apparent energy arithmetic / total apparent energy vector                          |
| $f$                 | frequency                                                                                |
| $I$                 | phase current ( $I_p$ : current on line p)                                               |
| $I_N / I_{Nc}$      | measured neutral current / calculated neutral current                                    |
| $U$                 | line to line voltage ( $U_{pg}$ : line p to line g)                                      |
| $V$                 | line to neutral voltage ( $V_p$ : line p to neutral)                                     |
| $PF_A / PF_V$       | arithmetic power factor / vector power factor                                            |
|                     | NOTE $PF_V = \cos(\varphi)$ when no harmonics are present                                |
| $P_{st} / P_{lt}$   | short term flicker / long term flicker                                                   |
| $U_{dip}$           | voltage dips line to line ( $U_{pg\ dip}$ : line p to line g)                            |
| $V_{dip}$           | voltage dips line to neutral ( $V_{p\ dip}$ : line p to neutral)                         |
| $U_{swl}$           | voltage swells line to line ( $U_{pg\ swl}$ : line p to line g)                          |
| $V_{swl}$           | voltage swells line to neutral ( $V_{p\ swl}$ : line p to neutral)                       |
| $U_{tr}$            | transients overvoltage line to line ( $U_{pg\ tr}$ : line p to line g)                   |
| $V_{tr}$            | transients overvoltage line to neutral ( $V_{p\ tr}$ : line p to neutral)                |
| $U_{int}$           | voltage Interruption line to line ( $U_{pg\ int}$ : line p to line g)                    |
| $V_{int}$           | voltage interruption line to neutral ( $V_{p\ int}$ : line p to neutral)                 |
| $U_{nb}$            | amplitude and phase voltage unbalance line to line ( $U_{pg\ nb}$ : line p to line g)    |
| $V_{nb}$            | amplitude and phase voltage unbalance line to neutral ( $V_{p\ nb}$ : line p to neutral) |
| $I_{nb}$            | current unbalance phase and amplitude                                                    |
| $U_{nba}$           | amplitude voltage unbalance line to line ( $U_{pg\ nba}$ : line p to line g)             |
| $V_{nba}$           | amplitude voltage unbalance line to neutral ( $V_{p\ nba}$ : line p to neutral)          |
| $I_{nba}$           | current unbalance amplitude                                                              |
| $U_h$               | voltage harmonics line to line ( $U_{pg\ h}$ : line p to line g)                         |

|           |                                                                          |
|-----------|--------------------------------------------------------------------------|
| $V_h$     | voltage harmonics line to neutral ( $V_{ph}$ : line $p$ to neutral)      |
| $THD_U$   | total harmonic distortion voltage line to line related to fundamental    |
| $THD-R_U$ | total harmonic distortion voltage line to line related to RMS value      |
| $THD_V$   | total harmonic distortion voltage line to neutral related to fundamental |
| $THD-R_V$ | total harmonic distortion voltage line to neutral related to RMS value   |
| $THD-R$   | total harmonic current related to RMS value                              |

### 3.5.2 Symbols and abbreviations

|         |                     |
|---------|---------------------|
| $\%U_n$ | percentage of $U_n$ |
| $\%I_n$ | percentage of $I_n$ |
| $\%I_b$ | percentage of $I_b$ |

### 3.5.3 Indices

|       |                     |
|-------|---------------------|
| a     | active              |
| r     | reactive            |
| ap    | apparent            |
| n     | rated               |
| b     | basic               |
| nom   | nominal             |
| N     | neutral             |
| c     | calculated          |
| h     | harmonic            |
| i     | current             |
| u     | voltage             |
| dip   | dips                |
| swl   | swells              |
| tr    | transient           |
| int   | interruption        |
| nb    | unbalance           |
| nba   | amplitude unbalance |
| A     | arithmetic          |
| V     | vectorial           |
| min   | minimum value       |
| max   | maximum value       |
| avg   | average value       |
| peak  | peak value          |
| resid | residual            |

## 4 Requirements

### 4.1 General requirements

The following requirements ~~as well as those given in IEC 61557-1~~ shall apply unless otherwise specified hereafter.

~~For safety requirements, IEC 61010-1, applicable parts of IEC 61010 and additional requirements specified hereafter shall apply.~~

~~For electromagnetic compatibility (EMC) requirements, IEC 61326-1 shall apply unless otherwise specified hereafter. For immunity, Table 2 of IEC 61326-1 (Immunity test requirements for equipment intended for use in industrial locations) shall apply. For emission either class A or class B limits as defined in IEC 61326-1 shall apply.~~

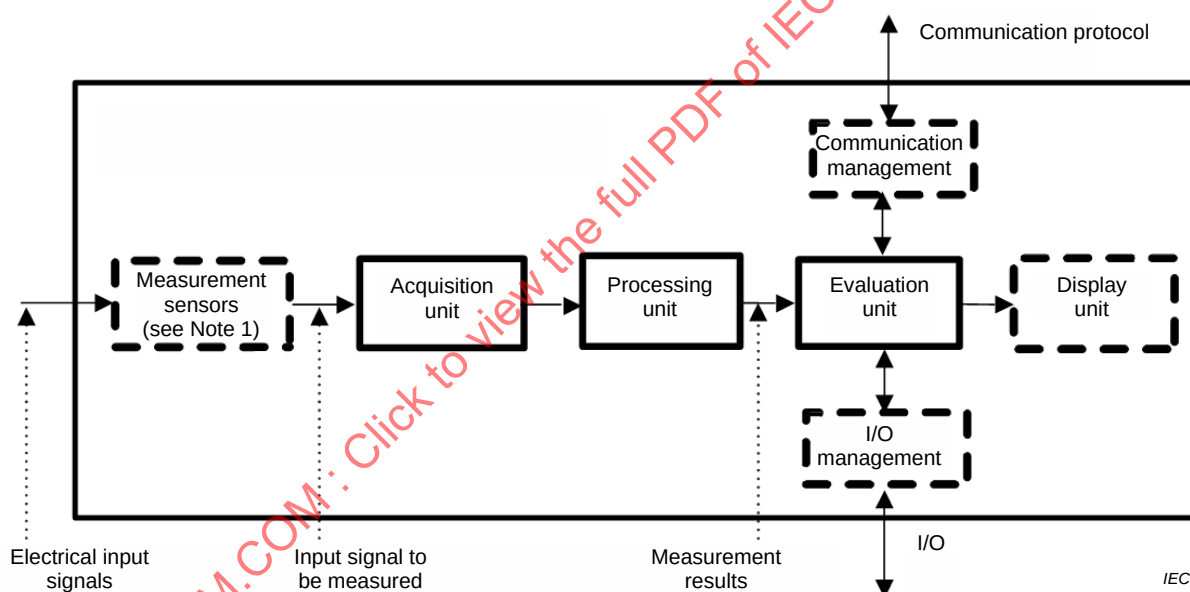
~~NOTE Guidance for requirements applicable to PMD-A or/and PMD is given in Annex E.~~

## 4.2 PMD general architecture

Organization of the measurement chain: the electrical quantity to be measured may be either directly accessible, as it is generally the case in low-voltage systems, or accessible via measurement sensors like voltage sensors (VS) or current sensors (CS).

Figure 1 shows the common organization of a PMD.

In some cases when a PMD does not include the sensors, their associated uncertainties are not considered. When a PMD includes the sensors, their associated uncertainties are considered.



NOTE 1 It is not necessary that the parts in the dotted lines be included in the PMD.

NOTE 2 I/O are analog and/or digital signals with alarms.

**Figure 1 – PMD generic measurement chain**

## 4.3 Classification of PMD

PMD are classified according to the applications as defined in Table 1.

**Table 1 – Functional classification of PMD with minimal required functions**

| Functionalities<br>symbol <sup>a</sup>                         | PMD type <sup>b</sup>      |                                     |                                                              |
|----------------------------------------------------------------|----------------------------|-------------------------------------|--------------------------------------------------------------|
|                                                                | PMD-I<br>Energy efficiency | PMD-II<br>Basic power<br>monitoring | PMD-III<br>Advanced power monitoring<br>/network performance |
| $P$                                                            |                            | ■                                   | ■                                                            |
| $Q$                                                            |                            | ■                                   | ■                                                            |
| $S$                                                            |                            | ■                                   | ■                                                            |
| $E_a$                                                          | ■                          | ■                                   | ■                                                            |
| $E_r$                                                          |                            | ■                                   | ■                                                            |
| $E_{ap}$                                                       |                            |                                     | ■                                                            |
| $f$                                                            |                            | ■                                   | ■                                                            |
| $I$                                                            |                            | ■                                   | ■                                                            |
| $I_N$                                                          |                            |                                     | ■                                                            |
| $U$ and/or $V$                                                 |                            | ■                                   | ■                                                            |
| $PF$                                                           |                            | ■                                   | ■                                                            |
| $THD_u$ and/or $THD_v$<br>and/or $THD-R_u$ and/or<br>$THD-R_v$ |                            |                                     | ■                                                            |
| $THD_i$ and/or $THD-R_i$                                       |                            |                                     | ■                                                            |

<sup>a</sup> Only total quantities are mandatory

<sup>b</sup> For PMD other than PMD-I, PMD-II and PMD-III, called PMD-x, other combinations of functions are allowed and shall be specified by the manufacturer.

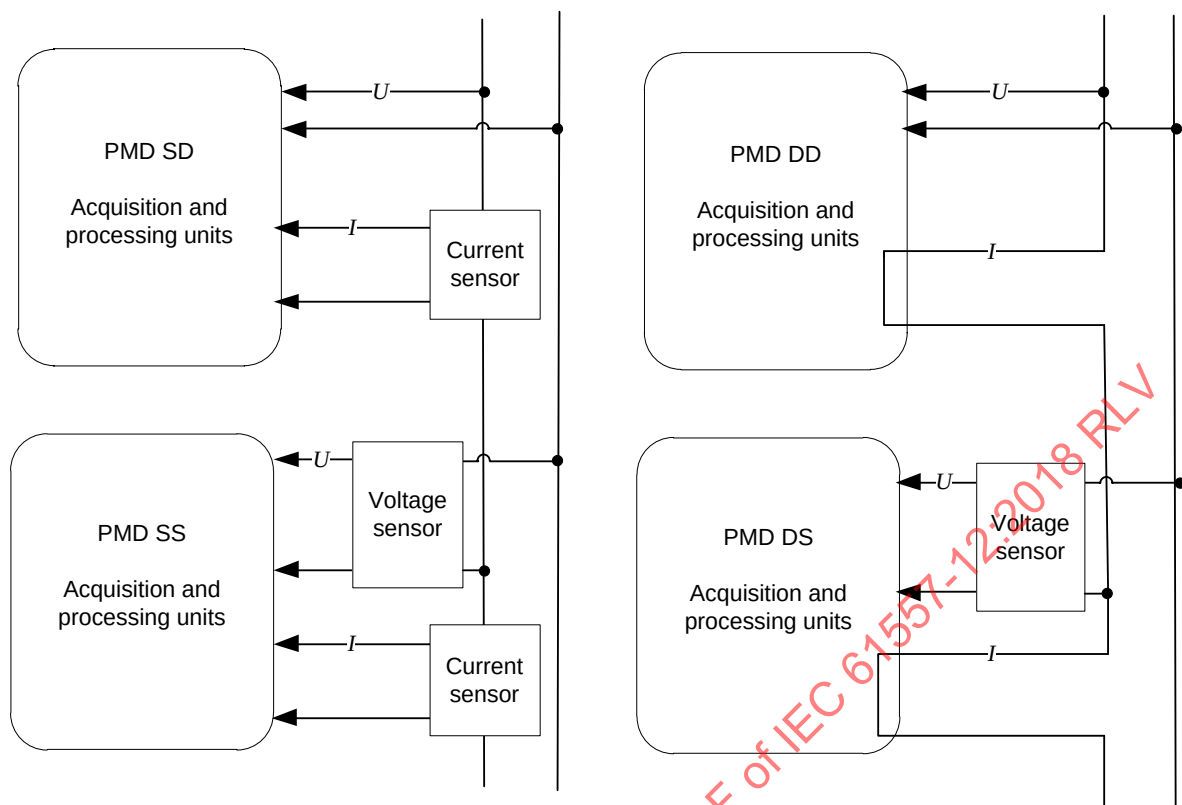
#### 4.4 Structure of PMD

##### 4.4.1 Structure of PMD related to sensors

PMD can have either an internal sensor, or may need an external sensor, as shown in Figure 2. Depending on these characteristics, PMD can be split in four categories as defined in Table 2.

**Table 2 – ~~Classification~~ Structure of PMD**

|                        |                                                                 | Current measurement                                             |                                                              |
|------------------------|-----------------------------------------------------------------|-----------------------------------------------------------------|--------------------------------------------------------------|
|                        |                                                                 | Sensor operated PMD<br>(current sensors out of PMD)<br>➔ PMD Sx | Direct connected PMD<br>(current sensors in PMD)<br>➔ PMD Dx |
| Voltage<br>measurement | Direct connected PMD<br>(voltage sensors in PMD)<br>➔ PMD xD    | PMD SD<br>(Semi-direct insertion)                               | PMD DD<br>(Direct insertion)                                 |
|                        | Sensor operated PMD<br>(voltage sensors out of PMD)<br>➔ PMD xS | PMD SS<br>(Indirect insertion)                                  | PMD DS<br>(Semi-direct insertion)                            |



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NOTE A PMD specified as a PMD Dx (respectively PMD xD) can sometimes, under certain conditions, be used as a PMD Sx (respectively PMD xS) when used with external sensors provided that it complies with both requirements of PMD Sx and Dx (respectively PMD xS and xD).

Figure 2 – Description of different types of PMD

#### 4.4.2 Requirements for self-powered PMD

Three-phase self-powered PMD shall measure within the specified accuracy limits even in the event one of the three phases or two of the three phases are disconnected.

#### 4.5 List of applicable performance classes

##### 4.4.1 List of applicable function performance classes for PMD without external sensors

Table 2 specifies the list of allowed performance classes for a PMD without external sensors:

Table 2 – List of applicable function performance classes for PMD without external sensors

|      |      |     |     |     |   |     |   |     |   |   |    |    |
|------|------|-----|-----|-----|---|-----|---|-----|---|---|----|----|
| 0,02 | 0,05 | 0,1 | 0,2 | 0,5 | 1 | 1,5 | 2 | 2,5 | 3 | 5 | 10 | 20 |
|------|------|-----|-----|-----|---|-----|---|-----|---|---|----|----|

##### 4.4.2 List of applicable system performance classes for PMD with external sensors

Table 3 specifies the list of allowed performance classes for a system including a PMD and its external sensors:

Table 3 – List of applicable system performance classes for PMD with external sensors

|      |      |     |     |     |   |     |   |     |   |   |    |    |
|------|------|-----|-----|-----|---|-----|---|-----|---|---|----|----|
| 0,02 | 0,05 | 0,1 | 0,2 | 0,5 | 1 | 1,5 | 2 | 2,5 | 3 | 5 | 10 | 20 |
|------|------|-----|-----|-----|---|-----|---|-----|---|---|----|----|

~~It is not allowed to specify a system performance class without specified external sensors.~~

~~The requirements for the system performance for a PMD with a specified external sensor are the same as for a direct connected PMD.~~

~~NOTE When a PMD Sx or a PMD xS is used with specified external sensors, the system performance class is based on the measured intrinsic uncertainty.~~

~~When the sensors are not specified, the system performance class is equal to the uncertainty calculated according to Annex D.~~

Table 3 specifies the list of allowed performance classes.

**Table 3 – List of applicable performance classes**

|                             |      |      |     |     |     |   |   |     |   |
|-----------------------------|------|------|-----|-----|-----|---|---|-----|---|
| Active energy               |      |      |     | 0,2 | 0,5 | 1 | 2 |     |   |
| Active power                |      |      | 0,1 | 0,2 | 0,5 | 1 | 2 | 2,5 |   |
| Reactive energy             |      |      |     |     |     |   | 2 |     | 3 |
| Reactive power              |      |      |     |     |     | 1 | 2 |     | 3 |
| Apparent energy             |      |      |     | 0,2 | 0,5 | 1 | 2 |     |   |
| Apparent power              |      |      |     | 0,2 | 0,5 | 1 | 2 |     |   |
| Frequency                   | 0,02 | 0,05 | 0,1 | 0,2 | 0,5 |   |   |     |   |
| Phase current               |      | 0,05 | 0,1 | 0,2 | 0,5 | 1 | 2 |     |   |
| Measured neutral current    |      |      |     | 0,2 | 0,5 | 1 | 2 |     |   |
| Calculated neutral current  |      |      | 0,1 | 0,2 | 0,5 | 1 | 2 |     |   |
| Voltage                     |      | 0,05 | 0,1 | 0,2 | 0,5 | 1 | 2 |     |   |
| Power factor                |      |      |     |     | 0,5 | 1 | 2 |     | 5 |
| Flicker                     |      |      |     |     |     |   |   |     | 5 |
| Dips and swells measurement |      |      |     |     | 0,5 | 1 | 2 |     |   |
| Voltage interruption        |      |      |     |     | 0,5 | 1 | 2 |     |   |
| Voltage unbalance           |      |      |     | 0,2 | 0,5 | 1 |   |     |   |
| Voltage harmonics           |      |      |     |     |     | 1 | 2 | 3   | 5 |
| Voltage THD                 |      |      |     |     |     | 1 | 2 | 3   | 5 |
| Current unbalance           |      |      |     | 0,2 | 0,5 | 1 |   |     |   |
| Current harmonics           |      |      |     |     |     | 1 | 2 | 3   | 5 |
| Current THD                 |      |      |     |     |     | 1 | 2 | 3   | 5 |

The requirements for the performance for a PMD associated with a dedicated external sensor are the same as for a direct connected PMD. Each combination of a PMD associated with a dedicated external sensor shall be considered as a PMD DD that needs to comply with the performance requirements of this document.

**EXAMPLE** If a manufacturer provides three different types of dedicated sensors (for example, a 100 A dedicated CT, a 500 A dedicated CT and a 1 000 A dedicated CT), then the manufacturer would provide three separate performance type test reports (one for the tests related to the PMD associated with the 100 A dedicated sensor, one for the tests related to the PMD associated with the 500 A dedicated sensor and one for the tests related to the PMD associated with the 1 000 A dedicated sensor). The manufacturer shall provide proper justification (e.g. simulation results, existing tests results, design notes, schematics...) for extrapolating performance if some physical tests are not performed.

**NOTE** Guidance related to the association of a PMD with a sensor is provided in Annex E and Annex F.

## 4.6 Operating and reference conditions for PMD

### 4.6.1 Reference conditions

Table 4 gives the reference conditions for testing:

**Table 4 – Reference conditions for testing**

| Conditions                                                                                                                                                                                 | Reference conditions                                  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|
| Operating temperature                                                                                                                                                                      | 23 °C ± 2 °C or otherwise specified by manufacturer   |
| Relative humidity                                                                                                                                                                          | 40 % to 60 % RH                                       |
| Auxiliary supply voltage                                                                                                                                                                   | Rated power supply voltage ± 1 %                      |
| Phases                                                                                                                                                                                     | Three phases available <sup>a</sup>                   |
| Voltages unbalance                                                                                                                                                                         | ≤ 0,1 % <sup>a</sup>                                  |
| External continuous magnetic field                                                                                                                                                         | ≤ 40 A/m DC<br>≤ 3 A/m AC at 50/60 Hz                 |
| DC component on voltage and current                                                                                                                                                        | None                                                  |
| Waveform                                                                                                                                                                                   | Sinusoidal                                            |
| Frequency                                                                                                                                                                                  | Rated frequency (50 Hz or 60 Hz) ± 0,2 % <sup>b</sup> |
| <sup>a</sup> Required only in the case of three-phase systems.                                                                                                                             |                                                       |
| <sup>b</sup> PMD should use the standard rated frequencies of 50 Hz or 60 Hz, where possible, although other rated frequencies, or rated frequency ranges, including DC, may be specified. |                                                       |

### 4.6.2 Rated operating conditions

#### 4.6.2.1 General

Tables 5 to 7 give the conditions in which functions shall be performed according to their specifications.

#### 4.6.2.2 Rated temperature operating conditions for portable equipment

Table 5 gives the rated operating temperature for portable PMD:

**Table 5 – Rated operating temperatures for portable equipment**

|                                                    | K40 temperature class of PMD |
|----------------------------------------------------|------------------------------|
| Rated operating range (with specified uncertainty) | 0 °C to +40 °C               |
| Limit range of operation (no hardware failures)    | –10 °C to +55 °C             |
| Limit range for storage and shipping               | –25 °C to +70 °C             |

#### 4.6.2.3 Rated temperature operating conditions for fixed installed equipment

Table 6 gives the rated operating temperature for fixed installed PMD:

**Table 6 – Rated operating temperatures for fixed installed equipment**

|                                                                                                                                                                                                                                                           | <b>K55 temperature class of PMD</b> | <b>K70 temperature class of PMD</b> | <b>Kx<sup>b</sup> temperature class of PMD</b>         |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|-------------------------------------|--------------------------------------------------------|
| Rated operating range <sup>c</sup><br>(with specified uncertainty)                                                                                                                                                                                        | –5 °C to +55 °C                     | –25 °C to +70 °C                    | Above +70 °C and/or under –25 °C <sup>a</sup>          |
| Limit range of operation<br>(no hardware failures)                                                                                                                                                                                                        | –5 °C to +55 °C                     | –25 °C to +70 °C                    | Above +70 °C and/or under –25 °C <sup>a</sup>          |
| Limit range for storage and shipping                                                                                                                                                                                                                      | –25 °C to +70 °C                    | –40 °C to +85 °C                    | According to manufacturer's specification <sup>a</sup> |
| <sup>a</sup> Limits are to be defined by the manufacturer according to the application.<br><sup>b</sup> Kx stands for extended conditions.<br><sup>c</sup> The operating temperature is the highest temperature of the air in close proximity to the PMD. |                                     |                                     |                                                        |

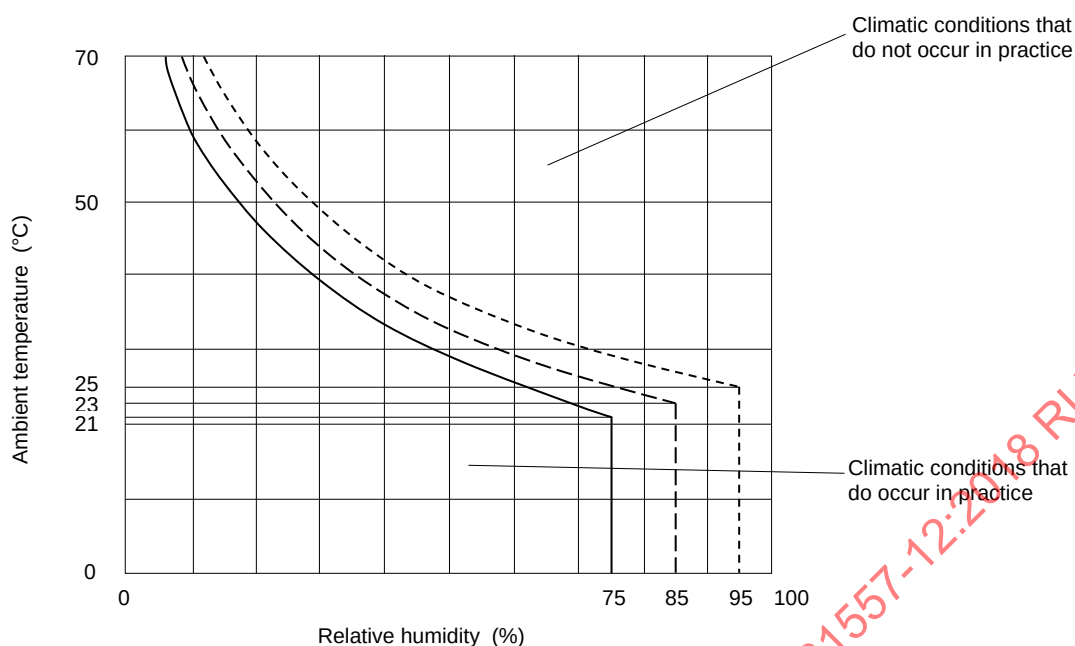
**4.6.2.4 Rated humidity and altitude operating conditions**

Table 7 gives the rated operating humidity and altitude conditions for portable and fixed installed PMD:

**Table 7 – Humidity and altitude operating conditions**

|                                                                                                                                                                  | <b>Standard conditions</b>  | <b>Extended conditions</b>          |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|-------------------------------------|
| Rated operating range<br>(with specified uncertainty)                                                                                                            | 0 % to 75 % RH <sup>b</sup> | 0 % to above 75 % RH <sup>a b</sup> |
| Limit range of operation for 30 days/year                                                                                                                        | 0 % to 90 % RH <sup>b</sup> | 0 % to above 90 % RH <sup>a b</sup> |
| Limit range for storage and shipping                                                                                                                             | 0 % to 90 % RH <sup>b</sup> | 0 % to above 90 % RH <sup>a b</sup> |
| Altitude                                                                                                                                                         | 0 m to 2 000 m              | 0 m to above 2 000 m <sup>a</sup>   |
| <sup>a</sup> Limits are to be defined by manufacturer according to the application.<br><sup>b</sup> Relative humidity values are specified without condensation. |                             |                                     |

The limits of relative humidity as a function of ambient temperature are shown in Figure 3.



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**Figure 3 – Relationship between ambient air temperature and relative humidity**

#### 4.7 Start-up conditions

Measurement readings shall be available via a communication or local user interface 15 s after applying power supply. If the start-up is longer than 15 s, manufacturers shall specify the maximum time until measurement quantities shall be available via a communication or local user interface after power supply is applied.

When no communication or local user interface is available, this requirement shall be verified according to the test procedure given in 6.2.17.

#### 4.8 Requirements for PMD functions ~~(except PMD-A)~~

##### 4.8.1 General requirements

##### 4.8.1.1 Coverage requirements

Subclause 4.8 describes a list of functions. Depending on the purpose of the measurement, all or a subset of the functions listed shall be measured.

All functions implemented in the product and covered by this document shall comply with the requirements of this document.

##### 4.8.1.2 Requirements for the measurement window

Unless specified otherwise, the measurement window of a measured quantity shall not be longer than 3 s or 150/180 cycles at rated frequency.

For THD and harmonics, this requirement may not be met. In such case the measurement window for THD and harmonics shall be declared by the manufacturer.

This requirement does not apply to energies and demands, which are obtained by integrating or averaging basic quantities measured on the measurement window.

#### 4.8.1.3 Requirements for the line to neutral voltage quantities

Unless specified otherwise, if line to neutral voltage functions are implemented they shall comply with the same requirements as the line to line voltage functions.

#### 4.8.1.4 Requirement on variation limits under influence quantities

For practical reasons, if a calculated variation limit requirement is less than 0,02 %, the requirement shall be set at 0,02 %.

#### 4.8.1.5 Maximum current

When the PMD is operated from (a) current transformer(s), attention is drawn to the need to match the current range of the PMD in relation to that of the secondary of the current transformer(s). The maximum current of the PMD shall be 120 %  $I_n$  at least.

### 4.8.2 Active power ( $P$ ) and active energy ( $E_a$ ) measurements

#### 4.8.2.1 Techniques

See Annex B.

~~Zero blind~~ Gapless measurement is required.

#### 4.8.2.2 Rated range of operation

The intrinsic uncertainty requirements shall apply within the following ~~rated~~ range:

$$80 \% U_n < U < 120 \% U_n$$

#### 4.8.2.3 Intrinsic uncertainty table

The intrinsic uncertainty under reference conditions shall not exceed limits given in Table 8:

**Table 8 – Intrinsic uncertainty table for active power and active energy measurement**

| Specified measuring range                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                             | Power factor <sup>c</sup>       | Intrinsic uncertainty limits for PMD of function performance class C <sup>a b e</sup> |                                                          | Unit |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|---------------------------------|---------------------------------------------------------------------------------------|----------------------------------------------------------|------|
| Value of current for direct connected PMD Dx                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Value of current for sensor operated PMD Sx |                                 | for $C < 1$                                                                           | for $C \geq 1$                                           |      |
| $2 \% I_b \leq I < 10 \% I_b$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | $1 \% I_n \leq I < 5 \% I_n$                | 1                               | $\pm 2,0 \times C$                                                                    | No requirement                                           | %    |
| $5 \% I_b \leq I < 10 \% I_b$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | $2 \% I_n \leq I < 5 \% I_n$                | 1                               | No requirement                                                                        | $\pm (1,0 \times C + 0,5)$                               | %    |
| $10 \% I_b \leq I \leq I_{max}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | $5 \% I_n \leq I \leq I_{max}$              | 1                               | $\pm 1,0 \times C$                                                                    | $\pm 1,0 \times C$                                       | %    |
| $5 \% I_b \leq I < 20 \% I_b$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | $2 \% I_n \leq I < 10 \% I_n$               | 0,5 inductive<br>0,8 capacitive | $\pm (1,7 \times C + 0,15)$<br>$\pm (1,7 \times C + 0,15)$                            | No requirement<br>No requirement                         | %    |
| $10 \% I_b \leq I < 20 \% I_b$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   | $5 \% I_n \leq I < 10 \% I_n$               | 0,5 inductive<br>0,8 capacitive | No requirement<br>No requirement                                                      | $\pm (1,0 \times C + 0,5)$<br>$\pm (1,0 \times C + 0,5)$ | %    |
| $20 \% I_b \leq I \leq I_{max}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | $10 \% I_n \leq I \leq I_{max}$             | 0,5 inductive<br>0,8 capacitive | $\pm (1,0 \times C + 0,1)$<br>$\pm (1,0 \times C + 0,1)$                              | $\pm 1,0 \times C$<br>$\pm 1,0 \times C$                 | %    |
| <del><sup>a</sup> The permitted values for active energy function performance class C are: 0,2 – 0,5 – 1 – 2, the permitted values for active power function performance class C are: 0,1 – 0,2 – 0,5 – 1 – 2 – 2,5.</del><br><del><sup>b</sup> The permitted values and formula to calculate the system performance class of a PMD with an external current sensor or voltage sensor are given in Annex D.</del><br><sup>a</sup> Applicable performance classes are listed in Table 3.<br><sup>b</sup> For active energy measurement classes 1 and 2 of this document, the uncertainty limits of classes 1 and 2 defined in Table 6 of IEC 62053-21:2003 can be used as well as the uncertainty limits given in this table. For active energy measurement classes 0,2 and 0,5 of this document, the uncertainty limits of classes 0,2S and 0,5S defined in Table 4 of IEC 62053-22:2003 can be used as well as the uncertainty limits given in this table.<br><sup>c</sup> In reference conditions, signals are sinusoidal, so in this case the power factor = $\cos \varphi$ . |                                             |                                 |                                                                                       |                                                          |      |

#### 4.8.2.4 Limits of variations due to influence quantities

The additional variations due to influence quantities with respect to reference conditions as given in 4.6.1, shall not exceed the limits for the relevant performance class given in Table 9:

Table 9 – Influence quantities for active power and active energy measurement (1 of 3)

| Influence type                                          | Influence quantities                                                               | Specified measuring range <sup>e</sup>                           |                                                                 | Power factor <sup>j</sup> | Temperature coefficient for PMD of function performance class C <sup>a b</sup> |                                | Unit           |
|---------------------------------------------------------|------------------------------------------------------------------------------------|------------------------------------------------------------------|-----------------------------------------------------------------|---------------------------|--------------------------------------------------------------------------------|--------------------------------|----------------|
|                                                         |                                                                                    | Value of current for direct connected PMD Dx <sup>†</sup>        | Value of current for sensor operated PMD Sx <sup>‡</sup>        |                           | for C < 1                                                                      | for C ≥ 1                      |                |
| Ambient temperature                                     | according to rated operating range of Table 5 and Table 6                          | 10 % $I_b \leq I \leq I_{max}$<br>20 % $I_b \leq I \leq I_{max}$ | 5 % $I_n \leq I \leq I_{max}$<br>10 % $I_n \leq I \leq I_{max}$ | 1<br>0,5 inductive        | 0,05 x C<br>0,1 x C                                                            | 0,05 x C<br>0,07 x C           | % / K<br>% / K |
|                                                         |                                                                                    |                                                                  |                                                                 |                           | Limits of variation for PMD of function performance class C <sup>a b</sup>     |                                |                |
|                                                         |                                                                                    |                                                                  |                                                                 |                           | for C < 1                                                                      | for C ≥ 1                      |                |
| Auxiliary power supply voltage <sup>l</sup>             | rated voltage ± 15 %                                                               | 10 % $I_b$                                                       | 10 % $I_n$                                                      | 1                         | 0,1 x C                                                                        | 0,1 x C                        | %              |
| Voltage                                                 | 80 % $U_n < U < 120$ % $U_n$                                                       | 5 % $I_b \leq I \leq I_{max}$<br>10 % $I_b \leq I \leq I_{max}$  | 2 % $I_n \leq I \leq I_{max}$<br>5 % $I_n \leq I \leq I_{max}$  | 1<br>0,5 inductive        | 0,3 x C + 0,04<br>0,6 x C + 0,08                                               | 0,3 x C + 0,4<br>0,5 x C + 0,5 | %              |
| Frequency                                               | rated frequency ± 2 %                                                              | 5 % $I_b \leq I \leq I_{max}$<br>10 % $I_b \leq I \leq I_{max}$  | 2 % $I_n \leq I \leq I_{max}$<br>5 % $I_n \leq I \leq I_{max}$  | 1<br>0,5 inductive        | 0,3 x C + 0,04<br>0,3 x C + 0,04                                               | 0,3 x C + 0,2<br>0,3 x C + 0,4 | %              |
| Reversed phase sequence                                 | ---                                                                                | 10 % $I_b$                                                       | 10 % $I_n$                                                      | 1                         | 0,15 x C + 0,02                                                                | 1,5                            | %              |
| Voltage unbalance                                       | 0 % to 10 %                                                                        | $I_b$                                                            | $I_n$                                                           | 1                         | 1,5 x C + 0,2                                                                  | 2,0 x C                        | %              |
| Phase missing <sup>f</sup>                              | one or two phases missing                                                          | $I_b$                                                            | $I_n$                                                           | 1                         | 2,0 x C                                                                        | 2,0 x C                        | %              |
| Harmonic components in the current and voltage circuits | voltage, 5 <sup>th</sup> harmonic: 10 %<br>current, 5 <sup>th</sup> harmonic: 40 % | 50 % $I_{max}$                                                   | 50 % $I_{max}$                                                  | 1                         | 0,4 x C + 0,3                                                                  | 0,2 x C + 0,6                  | %              |

Table 9 (2 of 3)

| Influence quantities                                                       |                                                                              | Specified measuring range <sup>e</sup>                                  |                                                                        | Power factor <sup>j</sup> | Limits of variation for PMD of function performance class C <sup>a b</sup> |               | Unit |
|----------------------------------------------------------------------------|------------------------------------------------------------------------------|-------------------------------------------------------------------------|------------------------------------------------------------------------|---------------------------|----------------------------------------------------------------------------|---------------|------|
| Influence type                                                             | Influence range                                                              | Value of current for direct connected PMD D <sub>x f</sub> <sup>f</sup> | Value of current for sensor operated PMD S <sub>x f</sub> <sup>f</sup> |                           |                                                                            |               |      |
| Odd harmonics in the AC current circuit                                    | see <sup>g</sup>                                                             | 50 % I <sub>b</sub>                                                     | 50 % I <sub>n</sub>                                                    | 1                         | 3,0 x C                                                                    | 3,0 x C       | %    |
| Sub-harmonics in the AC current circuit                                    | see <sup>g</sup>                                                             | 50 % I <sub>b</sub>                                                     | 50 % I <sub>n</sub>                                                    | 1                         | 3,0 x C                                                                    | 3,0 x C       | %    |
| Common mode voltage rejection on isolated current inputs <sup>k</sup>      | 0 to maximum voltage to earth (depending on measuring category) <sup>i</sup> | 10 % I <sub>b</sub>                                                     | 5 % I <sub>n</sub>                                                     | 1                         | 1,0 x C                                                                    | 0,5 x C       | %    |
| Permanent AC magnetic induction of external origin 0,5 mT <sup>c d h</sup> | see <sup>c</sup> and <sup>d</sup>                                            | I <sub>b</sub>                                                          | I <sub>n</sub>                                                         | 1                         | 2,0                                                                        | 1,0 x C + 1,0 | %    |
| Electromagnetic RF fields <sup>c d</sup>                                   | see <sup>c</sup> and <sup>d</sup>                                            | I <sub>b</sub>                                                          | I <sub>n</sub>                                                         | 1                         | 3,4 x C + 0,3                                                              | 1,0 x C + 1,0 | %    |
| Conducted disturbances, induced by radio frequency fields <sup>c d</sup>   | see <sup>c</sup> and <sup>d</sup>                                            | I <sub>b</sub>                                                          | I <sub>n</sub>                                                         | 1                         | 3,4 x C + 0,3                                                              | 1,0 x C + 1,0 | %    |

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Table 9 (3 of 3)

|                                                                                                                                                                                                                     |                                                                |                                                                                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                     |                                                                                    |                                                            |                                                         |                                                                                                                                                                                                                                                                                                                                                                                                                                 |                                                                                                          |                                                                                      |                                                                                                            |                        |                                                                                                                                                                                                                                                                                          |                                                                                                                      |                                                                                                                         |                                                                                                                      |                                                                                                                                                                                                                                                                                                                                       |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|------------------------------------------------------------|---------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p><del>a</del> <del>The permitted values for active energy function performance class C are: 0,1 0,2 0,5 1 2 2,5</del> <del>1 2, the permitted values for active power function performance class C are:</del></p> | <p>a Applicable performance classes are listed in Table 3.</p> | <p>b For active energy measurement classes 1 and 2 of this document, the variation limits of classes 1 and 2 defined in Table 8 of IEC 62053-21:2003 can be used as well as the uncertainty limits given in this table. For active energy measurement classes 0,2 and 0,5 of this document, the variation limits of class 0,2 S and 0,5 S defined in Table 6 of IEC 62053-22:2003 can be used as well as the uncertainty limits given in this table.</p> | <p>c EMC levels and test conditions are defined in IEC 61326-1 relating to industrial location.</p> | <p>d The EMC influence quantities are applicable only for energy measurements.</p> | <p>e Currents are balanced unless otherwise specified.</p> | <p><del>f Not applicable to self-powered PMD.</del></p> | <p>f Polyphase PMD with three measuring elements shall measure and register, within the limits of variation in percentage error shown in this table, if the following phases are interrupted:</p> <ul style="list-style-type: none"> <li>– in a three-phase, four-wire network one or two phases;</li> <li>– in a three-phase, three-wire network (if the PMD is designed for this service) one of the three phases.</li> </ul> | <p>This only covers phase interruptions and does not cover events such as transformer fuse failures.</p> | <p>In case of polyphase PMD with two measuring elements the test does not apply.</p> | <p>For PMD with auxiliary power supply, the auxiliary power supply is not interrupted during the test.</p> | <p>g See Clause 6.</p> | <p>h A magnetic induction of external origin of 0,5 mT produced by a current of the same frequency as that of the voltage applied to the PMD and under the most unfavourable conditions of phase and direction shall not cause a variation exceeding the values shown in this table.</p> | <p>i Measuring category is defined in IEC 61010-2-030, for instance 300 V common mode voltage for 300 V cat III.</p> | <p>j In reference conditions, signals are sinusoidal, so in this case the power factor = <math>\cos \varphi</math>.</p> | <p>k If current inputs are connected internally or externally to the ground, this requirement is not applicable.</p> | <p>l These limits are settled for a PMD powered by mains supply voltage. In the case of a larger range of the supply voltage AC or DC, tests shall be done at least at the lower input value and upper input value of this range. In any case, PMD shall comply with the requirement for all the specified supply voltage ranges.</p> |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|------------------------------------------------------------|---------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

#### 4.8.2.5 Starting and no-load condition

##### 4.8.2.5.1 Start-up of the PMD

See 4.7.

##### 4.8.2.5.2 No-load condition (only for energy measurement)

When the voltage is applied with no current flowing in the current circuit, the test output of the PMD shall not produce more than one pulse.

For this test, the current circuit shall be open-circuit and a voltage of 115 % of the rated voltage shall be applied to the voltage circuit.

**NOTE** In the case of an outside shunt, only the input circuit of the PMD shall be opened.

The minimum test period  $\Delta t$  shall be as described in Table 10:

**Table 10 – Minimum test period**

| PMD types | Minimum test period $\Delta t$ (min) for no-load condition                               |                                                                                          |
|-----------|------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
|           | for $C < 1$                                                                              | for $C \geq 1$                                                                           |
| PMD       | $\Delta t = \frac{((100 / C) + 400) \times 10^6}{k \times m \times U_n \times I_{\max}}$ | $\Delta t = \frac{((240 / C) + 360) \times 10^6}{k \times m \times U_n \times I_{\max}}$ |

where

$C$  is the function performance class;

$k$  is the number of pulses emitted by the output device of the PMD per kilowatt-hour (impulse/kWh);

$m$  is the number of measuring elements;

**NOTE** A measuring element is a part of the meter which produces an output proportional to the energy.

$U_n$  is the rated voltage in volts;

$I_{\max}$  is the maximum current in amperes.

For transformer-operated PMD with primary or half-primary registers, the constant  $k$  shall correspond to the secondary values (voltage and current).

##### 4.8.2.5.3 Starting current

The PMD shall start and continue to register at the starting current values (and in the case of three-phase meters, with balanced load) shown in Table 11.

When starting conditions are met (according to Table 11), intrinsic uncertainty shall be between –40 % and +90 % of measured values.

If the PMD is designed for the measurement of energy in both directions, then this test shall be applied with energy flowing in each direction.

**Table 11 – Starting current for active power and active energy measurement**

| PMD types | Power factor <sup>a</sup> | Starting current for PMD of function performance class C |                                     |
|-----------|---------------------------|----------------------------------------------------------|-------------------------------------|
|           |                           | for $C < 1$                                              | for $C \geq 1$                      |
| PMD Dx    | 1                         | $2 \times 10^{-3} \times I_b$                            | $(C + 3) \times 10^{-3} \times I_b$ |
| PMD Sx    | 1                         | $1 \times 10^{-3} \times I_n$                            | $(C + 1) \times 10^{-3} \times I_n$ |

<sup>a</sup> In reference conditions, signals are sinusoidal, so in this case the power factor =  $\cos \varphi$ .

### 4.8.3 Reactive power ( $Q_A$ , $Q_V$ ) and reactive energy ( $E_{rA}$ , $E_{rV}$ ) measurements

#### 4.8.3.1 Techniques

See Annex B.

~~Zero-blind~~ Gapless measurement is required.

#### 4.8.3.2 Rated range of operation

The intrinsic uncertainty requirements shall apply within the following rated range:

$$80 \% U_n < U < 120 \% U_n$$

#### 4.8.3.3 Intrinsic uncertainty table

The intrinsic uncertainty under reference conditions shall not exceed the limits given in Table 12:

**Table 12 – Intrinsic uncertainty table for reactive power and reactive energy measurement**

| Specified measuring range                                                                                                                                                                                                           |                                             | sin $\phi$ (inductive or capacitive) | Intrinsic uncertainty limits for PMD of function performance class C <sup>a b-e</sup> |                     | Unit |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|--------------------------------------|---------------------------------------------------------------------------------------|---------------------|------|
| value of current for direct connected PMD Dx                                                                                                                                                                                        | value of current for sensor operated PMD Sx |                                      | for $C < 3$                                                                           | for $C \geq 3$      |      |
| $5 \% I_b \leq I < 10 \% I_b$                                                                                                                                                                                                       | $2 \% I_n \leq I < 5 \% I_n$                | 1                                    | $\pm 1,25 \times C$                                                                   | $\pm 1,33 \times C$ | %    |
| $10 \% I_b \leq I \leq I_{\max}$                                                                                                                                                                                                    | $5 \% I_n \leq I \leq I_{\max}$             | 1                                    | $\pm 1,0 \times C$                                                                    | $\pm 1,0 \times C$  | %    |
| $10 \% I_b \leq I < 20 \% I_b$                                                                                                                                                                                                      | $5 \% I_n \leq I < 10 \% I_n$               | 0,5                                  | $\pm 1,25 \times C$                                                                   | $\pm 1,33 \times C$ | %    |
| $20 \% I_b \leq I \leq I_{\max}$                                                                                                                                                                                                    | $10 \% I_n \leq I \leq I_{\max}$            | 0,5                                  | $\pm 1,0 \times C$                                                                    | $\pm 1,0 \times C$  | %    |
| $20 \% I_b \leq I \leq I_{\max}$                                                                                                                                                                                                    | $10 \% I_n \leq I \leq I_{\max}$            | 0,25                                 | $\pm 1,25 \times C$                                                                   | $\pm 1,33 \times C$ | %    |
| <sup>a</sup> <del>The permitted values for reactive energy function performance class C are: 2 – 3; the permitted values for reactive power function performance class C are: 1 – 2 – 3.</del>                                      |                                             |                                      |                                                                                       |                     |      |
| <sup>b</sup> <del>The permitted values and formula to calculate the system performance class of a PMD with an external current sensor or voltage sensor are given in Annex D.</del>                                                 |                                             |                                      |                                                                                       |                     |      |
| <sup>a</sup> Applicable performance classes are listed in Table 3.                                                                                                                                                                  |                                             |                                      |                                                                                       |                     |      |
| <sup>b</sup> For reactive energy measurement classes 2 and 3 of this document, the uncertainty limits of classes 2 and 3 defined in Table 6 of IEC 62053-23:2003 can be used as well as the uncertainty limits given in this table. |                                             |                                      |                                                                                       |                     |      |

#### 4.8.3.4 Limits of variation due to influence quantities

The additional variations due to change of influence quantities with respect to reference conditions as given in 4.6.1, shall not exceed the limits for the relevant performance class given in Table 13:

Table 13 – Influence quantities for reactive power and reactive energy measurement

| Influence quantities                                                     |                                                           | Specified measuring range <sup>d</sup>                           |                                                                 | sin φ<br>(inductive or capacitive) | Temperature coefficient for PMD of function performance class C <sup>a e</sup> |                      | Unit           |
|--------------------------------------------------------------------------|-----------------------------------------------------------|------------------------------------------------------------------|-----------------------------------------------------------------|------------------------------------|--------------------------------------------------------------------------------|----------------------|----------------|
| Influence type                                                           | Influence range                                           | Value of current for direct connected PMD Dx                     | Value of current for sensor operated PMD Sx                     |                                    | for C < 3                                                                      | for C ≥ 3            |                |
| Ambient temperature                                                      | According to rated operating range of Table 5 and Table 6 | 10 % $I_b \leq I \leq I_{max}$<br>20 % $I_b \leq I \leq I_{max}$ | 5 % $I_n \leq I \leq I_{max}$<br>10 % $I_n \leq I \leq I_{max}$ | 1<br>0,5                           | 0,05 × C<br>0,075 × C                                                          | 0,05 × C<br>0,08 × C | % / K<br>% / K |
|                                                                          |                                                           |                                                                  |                                                                 |                                    | Limits of variation for PMD of function performance class C <sup>a b</sup>     |                      |                |
|                                                                          |                                                           |                                                                  |                                                                 |                                    | for C < 3                                                                      | for C ≥ 3            |                |
| Auxiliary power supply voltage <sup>f</sup>                              | Rated voltage ± 15 %                                      | 10 % $I_b$                                                       | 10 % $I_n$                                                      | 1                                  | 0,1 × C                                                                        | 0,1 × C              | %              |
| Voltage                                                                  | 80 % $U_n < U < 120$ % $U_n$                              | 5 % $I_b \leq I \leq I_{max}$<br>10 % $I_b \leq I \leq I_{max}$  | 2 % $I_n \leq I \leq I_{max}$<br>5 % $I_n \leq I \leq I_{max}$  | 1<br>0,5 inductive                 | 0,5 × C<br>0,75 × C                                                            | 0,66 × C<br>1,0 × C  | %<br>%         |
| Frequency                                                                | Rated frequency<br>± 2 %                                  | 5 % $I_b \leq I \leq I_{max}$<br>10 % $I_b \leq I \leq I_{max}$  | 2 % $I_n \leq I \leq I_{max}$<br>5 % $I_n \leq I \leq I_{max}$  | 1<br>0,5 inductive                 | 1,25 × C<br>1,25 × C                                                           | 2,5<br>2,5           | %              |
| Permanent AC magnetic induction of external origin 0,5 mT <sup>b c</sup> | see <sup>b</sup> and <sup>c</sup>                         | $I_b$                                                            | $I_n$                                                           | 1                                  | 1,5 × C                                                                        | 3,0                  | %              |
| Electromagnetic RF fields <sup>b c</sup>                                 | see <sup>b</sup> and <sup>c</sup>                         | $I_b$                                                            | $I_n$                                                           | 1                                  | 1,5 × C                                                                        | 3,0                  | %              |
| Conducted disturbances, induced by radio frequency fields <sup>b c</sup> | see <sup>b</sup> and <sup>c</sup>                         | $I_b$                                                            | $I_n$                                                           | 1                                  | 1,5 × C                                                                        | 3,0                  | %              |

<sup>a</sup> The permitted values for reactive energy function performance class C are: 2 – 3; the permitted values for reactive power function performance class C are: 1 – 2 – 3.

<sup>a</sup> Applicable performance classes are listed in Table 3.

<sup>b</sup> EMC levels and test conditions are defined in IEC 61326-1 relating to industrial location.

<sup>c</sup> The EMC influence quantities are applicable only for energy measurements.

<sup>d</sup> Currents are balanced unless otherwise specified.

<sup>e</sup> For reactive energy measurement classes 2 and 3 of this document, the variation limits of classes 2 and 3 defined in Table 8 of IEC 62053-23:2003 can be used as well as the uncertainty limits given in this table.

<sup>f</sup> These limits are settled for a PMD powered by mains supply voltage. In the case of a larger range of the supply voltage AC or DC, tests shall be done at least at the lower input value and upper input value of this range. In any case, the PMD shall comply with the requirement for all the specified supply voltage ranges.

### 4.8.3.5 Starting and no-load condition

#### 4.8.3.5.1 Start-up of the PMD

See 4.7.

#### 4.8.3.5.2 No-load condition

When the voltage is applied with no current flowing in the current circuit, the test output of the PMD shall not produce more than one pulse.

For this test, the current circuit shall be open-circuit and a voltage of 115 % of the rated voltage shall be applied to the voltage circuit.

**NOTE** In case of an outside shunt, only the input circuit shall be open circuited.

The minimum test period  $\Delta t$  shall be as described in Table 14:

**Table 14 – Minimum test period**

| PMD types | Minimum test period $\Delta t$ (min) for no-load condition                               |                                                                                            |
|-----------|------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|
|           | for $C < 3$                                                                              | for $C \geq 3$                                                                             |
| PMD       | $\Delta t = \frac{((240 / C) + 360) \times 10^6}{k \times m \times U_n \times I_{\max}}$ | $\Delta t = \frac{((1\,080 / C) - 60) \times 10^6}{k \times m \times U_n \times I_{\max}}$ |

where

$C$  is the function performance class;

$k$  is the number of pulses emitted by the output device of the PMD per kilovar-hour (impulse/kvarh);

$m$  is the number of measuring elements;

$U_n$  is the rated voltage in volts;

$I_{\max}$  is the maximum current in amperes.

For transformer-operated PMD with primary or half-primary registers, the constant  $k$  shall correspond to the secondary values (voltage and current).

#### 4.8.3.5.3 Starting current

The PMD shall start and continue to register at the starting current values (and in case of three-phase meters, with balanced load) shown in Table 15.

When starting conditions are met (according to Table 15) intrinsic uncertainty shall be between –40 % and +90 % of measured values.

If the PMD is designed for the measurement of energy in both directions, then this test shall be applied with energy flowing in each direction.

**Table 15 – Starting current for reactive energy measurement**

| PMD types | sin φ (inductive or capacitive) | Starting current for PMD of function performance class C |                                              |
|-----------|---------------------------------|----------------------------------------------------------|----------------------------------------------|
|           |                                 | for C < 3                                                | for C ≥ 3                                    |
| PMD Dx    | 1                               | $(C + 3) \times 10^{-3} \times I_b$                      | $(5 \times C - 5) \times 10^{-3} \times I_b$ |
| PMD Sx    | 1                               | $(C + 1) \times 10^{-3} \times I_n$                      | $(2 \times C - 1) \times 10^{-3} \times I_n$ |

#### 4.8.4 Apparent power ( $S_A$ , $S_V$ ) and apparent energy ( $E_{apA}$ , $E_{apV}$ ) measurements

##### 4.8.4.1 Techniques

See Annex B.

~~Zero-blind~~ Gapless measurement is required.

##### 4.8.4.2 Rated range of operation

The intrinsic uncertainty requirements shall apply within the following ~~rated~~ range:

$$80 \% U_n < U < 120 \% U_n$$

##### 4.8.4.3 Intrinsic uncertainty table

The intrinsic uncertainty under reference conditions shall not exceed the limits given in Table 16:

**Table 16 – Intrinsic uncertainty table for apparent power and apparent energy measurement**

| Specified measuring range                    |                                             | Intrinsic uncertainty limits for PMD of function performance class C <sup>a-b</sup> |                            | Unit |
|----------------------------------------------|---------------------------------------------|-------------------------------------------------------------------------------------|----------------------------|------|
| Value of current for direct connected PMD Dx | Value of current for sensor operated PMD Sx | for C < 1                                                                           | for C ≥ 1                  |      |
| $5 \% I_b < I \leq 10 \% I_b$                | $2 \% I_n < I \leq 5 \% I_n$                | $\pm 2,0 \times C$                                                                  | $\pm (1,0 \times C + 0,5)$ | %    |
| $10 \% I_b < I \leq I_{\max}$                | $5 \% I_n < I \leq I_{\max}$                | $\pm 1,0 \times C$                                                                  | $\pm 1,0 \times C$         | %    |

~~<sup>a</sup> The permitted values for function performance class C are: 0,2 – 0,5 – 1 – 2~~

~~<sup>b</sup> The permitted values and formula to calculate the system performance class of a PMD with an external current sensor or voltage sensor are given in Annex D.~~

<sup>a</sup> Applicable performance classes are listed in Table 3.

##### 4.8.4.4 Limits of variation due to influence quantities

The additional variations due to the change of influence quantities with respect to reference conditions as given in 4.6.1, shall not exceed the limits for the relevant performance class given in Table 17:

Table 17 – Influence quantities for apparent power and apparent energy measurement

| Influence quantities                                                     |                                                           | Specified measuring range <sup>d</sup>                            |                                                                  | Power factor <sup>e</sup> | Temperature coefficient for PMD of function performance class $C^a$ |                                              | Unit  |
|--------------------------------------------------------------------------|-----------------------------------------------------------|-------------------------------------------------------------------|------------------------------------------------------------------|---------------------------|---------------------------------------------------------------------|----------------------------------------------|-------|
| Influence type                                                           | Influence range                                           | Value of current for direct connected PMD Dx                      | Value of current for sensor operated PMD Sx                      |                           | for $C < 1$                                                         | for $C \geq 1$                               |       |
| Ambient temperature                                                      | According to rated operating range of Table 5 and Table 6 | $10\% I_b \leq I \leq I_{\max}$                                   | $5\% I_n \leq I \leq I_{\max}$                                   | 1                         | $0,05 \times C$                                                     | $0,05 \times C$                              | % / K |
|                                                                          |                                                           |                                                                   |                                                                  |                           | Limits of variation for PMD of function performance class $C^{a,b}$ |                                              |       |
|                                                                          |                                                           |                                                                   |                                                                  |                           | for $C < 1$                                                         | for $C \geq 1$                               |       |
| Auxiliary power supply voltage <sup>f</sup>                              | Rated voltage $\pm 15\%$                                  | $10\% I_b$                                                        | $10\% I_n$                                                       | 1                         | $0,1 \times C$                                                      | $0,1 \times C$                               | %     |
| Voltage                                                                  | $80\% U_n < U < 120\% U_n$                                | $5\% I_b \leq I \leq I_{\max}$<br>$10\% I_b \leq I \leq I_{\max}$ | $2\% I_n \leq I \leq I_{\max}$<br>$5\% I_n \leq I \leq I_{\max}$ | 1<br>0,5 inductive        | $0,3 \times C + 0,04$<br>$0,6 \times C + 0,08$                      | $0,3 \times C + 0,4$<br>$0,5 \times C + 0,5$ | %     |
| Continuous magnetic induction of external origin $0,5 \text{ mT}^{c,d}$  | see <sup>c</sup> and <sup>d</sup>                         | $I_b$                                                             | $I_n$                                                            | 1                         | 2,0                                                                 | $1,0 \times C + 1,0$                         | %     |
| Electromagnetic RF fields <sup>c,d</sup>                                 | see <sup>c</sup> and <sup>d</sup>                         | $I_b$                                                             | $I_n$                                                            | 1                         | $3,4 \times C + 0,3$                                                | $1,0 \times C + 1,0$                         | %     |
| Conducted disturbances, induced by radio frequency fields <sup>c,d</sup> | see <sup>c</sup> and <sup>d</sup>                         | $I_b$                                                             | $I_n$                                                            | 1                         | $3,4 \times C + 0,3$                                                | $1,0 \times C + 1,0$                         | %     |

~~a The permitted values for function performance class C are: 0,2 – 0,5 – 1 – 2.~~

a Applicable performance classes are listed in Table 3.

b EMC levels and test conditions are defined in IEC 61326-1 relating to industrial location.

c The EMC influence quantities are applicable only for energy measurements.

d Currents are balanced unless otherwise specified.

e In reference conditions, signals are sinusoidal, so in this case the power factor =  $\cos \varphi$ .

f These limits are settled for a PMD powered by mains supply voltage. In the case of a larger range of the supply voltage AC or DC, tests shall be done at least at the lower input value and upper input value of this range. In any case, PMD shall comply with the requirements for all the specified supply voltage ranges.

## 4.8.5 Frequency ( $f$ ) measurements

### 4.8.5.1 Techniques

~~Zero-blind~~ Gapless measurement is not required.

The measurement window for the frequency measurement may be longer than 3 s but cannot exceed 20 s at rated frequency.

### 4.8.5.2 Rated range of operation

The intrinsic uncertainty requirements shall apply within the following rated range:

- Voltage: 50 %  $U_n$  to  $U_{max}$ .

If the frequency measure is using the current the following range shall apply:

- Current: for PMD Dx: 20 %  $I_b$  to  $I_{max}$ , for PMD Sx: 10 %  $I_n$  to  $I_{max}$ .

NOTE Frequency is usually measured from the voltage function of the PMD; the current rated range of operation ~~has to be~~ is considered only if this function does not exist in the PMD.

### 4.8.5.3 Intrinsic uncertainty table

The intrinsic uncertainty under reference conditions shall not exceed the limits given in Table 18:

**Table 18 – Intrinsic uncertainty table for frequency measurement**

| Specified measuring range                                                                                                                                                                                                                                                                                                                              | Intrinsic uncertainty limits<br>for PMD of function performance class C <sup>a, b</sup> | Unit |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|------|
| 45 Hz to 55 Hz or 55 Hz to 65 Hz                                                                                                                                                                                                                                                                                                                       | $\pm 1,0 \times C$                                                                      | %    |
| <sup>a</sup> <del>The permitted values for function performance class C are: 0,02 – 0,05 – 0,1 – 0,2 – 0,5.</del><br><sup>b</sup> <del>The permitted values and formula to calculate the system performance class of a PMD with an external CS or VS are given in Annex D.</del><br><sup>a</sup> Applicable performance classes are listed in Table 3. |                                                                                         |      |

### 4.8.5.4 Limits of variation due to influence quantities

The additional variations due to the change of influence quantities with respect to reference conditions as given in 4.6.1, shall not exceed the limits for the relevant performance class given in Table 19:

**Table 19 – Influence quantities for frequency measurement**

| Influence quantities                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                    | Temperature coefficient for PMD of function performance class C <sup>a</sup>   | Unit  |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|-------|
| Influence type                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Influence range or influence level                                                                                                                                                                                                 |                                                                                |       |
| Ambient temperature                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | According to rated operating range of Table 5 and Table 6                                                                                                                                                                          | $0,1 \times C$                                                                 | % / K |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                    | <b>Limits of variation for PMD of function performance class C<sup>a</sup></b> |       |
| Voltage                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | 50 % $U_n$ to $U_{max}$                                                                                                                                                                                                            | $0,2 \times C$                                                                 | %     |
| Harmonics in the voltage circuits <sup>b</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                      | 3 <sup>rd</sup> harmonic 10 %<br>5 <sup>th</sup> harmonic 12 %<br>7 <sup>th</sup> harmonic 10 %<br>9 <sup>th</sup> harmonic 3 %<br>11 <sup>th</sup> harmonic 7 %<br>13 <sup>th</sup> harmonic 6 %<br>15 <sup>th</sup> harmonic 1 % | $0,2 \times C$                                                                 | %     |
| <sup>a</sup> <del>The permitted values for function performance class C are: 0,02 – 0,05 – 0,1 – 0,2 – 0,5</del><br><sup>b</sup> <del>All harmonics components have the same relative phase, but in opposite phase referred to the fundamental.</del><br><sup>a</sup> Applicable performance classes are listed in Table 3.<br><sup>b</sup> All harmonics components should have zero phase referred to the fundamental.<br>The resulting waveform and equation are shown in 6.2.9. |                                                                                                                                                                                                                                    |                                                                                |       |

#### 4.8.6 RMS phase current ( $I$ ) and neutral current ( $I_N$ , $I_{Nc}$ ) measurements

##### 4.8.6.1 Techniques

See Annex B.

~~Zero-blind~~ Gapless measurement is not required.

##### 4.8.6.2 Rated range of operation

###### 4.8.6.2.1 General

The intrinsic uncertainty requirements shall apply within the rated ranges given in Table 20 and Table 21:

###### 4.8.6.2.2 Rated range of operation for phase current

**Table 20 – Rated range of operation for phase current measurement**

| PMD types | Specified measuring range | Minimum bandwidth (harmonic)                                                     | Crest factor |
|-----------|---------------------------|----------------------------------------------------------------------------------|--------------|
| PMD Sx    | 10 % $I_n$ to 120 % $I_n$ | 45 Hz to 15 times rated frequency or<br>DC and 45 Hz to 15 times rated frequency | 2            |
| PMD Dx    | 20 % $I_b$ to $I_{max}$   | 45 Hz to 15 times rated frequency or<br>DC and 45 Hz to 15 times rated frequency | 2            |

#### 4.8.6.2.3 Rated range of operation for measured neutral current (with a sensor) and calculated neutral current (from phase currents)

**Table 21 – Rated range of operation for neutral current-measurement (calculated or measured)**

| PMD types | Specified measuring range <sup>a</sup> | Minimum bandwidth (harmonic)                                                     | Crest factor |
|-----------|----------------------------------------|----------------------------------------------------------------------------------|--------------|
| PMD Sx    | 10 % $I_n$ to 120 % $I_n$              | 45 Hz to 15 times rated frequency or<br>DC and 45 Hz to 15 times rated frequency | 2            |
| PMD Dx    | 20 % $I_b$ to $I_{max}$                | 45 Hz to 15 times rated frequency or<br>DC and 45 Hz to 15 times rated frequency | 2            |

**NOTE** <sup>a</sup> The nominal current of the neutral current sensor ~~may~~ can be different from the one for the phase current sensor.

#### 4.8.6.3 Intrinsic uncertainty table

##### 4.8.6.3.1 General

The intrinsic uncertainty under reference conditions shall not exceed the limits given in Table 22, Table 23 and Table 24.

##### 4.8.6.3.2 Intrinsic uncertainty table for phase current

**Table 22 – Intrinsic uncertainty table for phase current**

| Specified measuring range                    |                                             | Intrinsic uncertainty limits for PMD of function performance class C <sup>a-b</sup> | Unit |
|----------------------------------------------|---------------------------------------------|-------------------------------------------------------------------------------------|------|
| value of current for direct connected PMD Dx | value of current for sensor operated PMD Sx |                                                                                     |      |
| 20 % $I_b \leq I \leq I_{max}$               | 10 % $I_n \leq I \leq I_{max}$              | $\pm 1,0 \times C$                                                                  | %    |

~~<sup>a</sup> The permitted values for function performance class C are: 0,05 0,1 0,2 0,5 1 2.~~

~~<sup>b</sup> The permitted values and formula to calculate the system performance class of a PMD with an external current sensor are given in Annex D.~~

<sup>a</sup> Applicable performance classes are listed in Table 3.

##### 4.8.6.3.3 Intrinsic uncertainty table for measured neutral current (with a sensor)

**Table 23 – Intrinsic uncertainty table for neutral current measurement**

| Specified measuring range                    |                                             | Intrinsic uncertainty limits for PMD of function performance class C <sup>a-b</sup> | Unit |
|----------------------------------------------|---------------------------------------------|-------------------------------------------------------------------------------------|------|
| value of current for direct connected PMD Dx | value of current for sensor operated PMD Sx |                                                                                     |      |
| 20 % $I_b \leq I_N \leq I_{max}$             | 10 % $I_n \leq I_N \leq I_{max}$            | $\pm 1,0 \times C$                                                                  | %    |

~~<sup>a</sup> The permitted values for function performance class C are: 0,2 0,5 1 2.~~

~~<sup>b</sup> The permitted values and formula to calculate the system performance class of a PMD with an external current sensor are given in Annex D.~~

<sup>a</sup> Applicable performance classes are listed in Table 3.

#### 4.8.6.3.4 Intrinsic uncertainty table for calculated neutral current (from phase currents)

Table 24 – Intrinsic uncertainty table for neutral current calculation

| Specified measuring range                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |                                                | Intrinsic uncertainty limits<br>for PMD of function performance<br>class C <sup>a b c</sup> | Unit     |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|---------------------------------------------------------------------------------------------|----------|
| value of current for direct<br>connected PMD Dx                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | value of current for sensor<br>operated PMD Sx |                                                                                             |          |
| $20 \% I_b \leq I_p^c \leq I_{\max}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | $10 \% I_n \leq I_p^c \leq I_{\max}$           | $\pm 1,0 \times C$                                                                          | $\% I^b$ |
| <p><del>a The permitted values for function performance class C are: 0,1 – 0,2 – 0,5 – 1 – 2.</del></p> <p><del>b The permitted values and formula to calculate the system performance class of a PMD with an external current sensor are given in Annex D.</del></p> <p>a Applicable performance classes are listed in Table 3.</p> <p>b Uncertainty shall be expressed as a percentage of the phase current, whose current is the largest.</p> <p>c Performance class C refers to the phase current performance class.</p> |                                                |                                                                                             |          |

#### 4.8.6.4 Limits of variation due to influence quantities

The additional variations due to the change of influence quantities with respect to reference conditions as given in 4.6.1, shall not exceed the limits for the relevant performance class given in Table 25:

Table 25 – Influence quantities for phase current and neutral current measurement

| Influence quantities                        |                                                           | Specified measuring range <sup>b</sup> |                                    | Temperature coefficient for PMD of function performance class C <sup>a</sup> | Unit  |
|---------------------------------------------|-----------------------------------------------------------|----------------------------------------|------------------------------------|------------------------------------------------------------------------------|-------|
| Influence type                              | Influence range                                           | For current direct connected PMD Dx    | For current sensor operated PMD Sx |                                                                              |       |
| Ambient temperature                         | According to rated operating range of Table 5 and Table 6 | $20 \% I_b \leq I \leq I_{max}$        | $10 \% I_n \leq I \leq I_{max}$    | $0,05 \times C$                                                              | % / K |
|                                             |                                                           |                                        |                                    | Limits of variation for PMD of function performance class C <sup>a</sup>     |       |
| Auxiliary power supply voltage <sup>c</sup> | Rated voltage $\pm 15 \%$                                 | $20 \% I_b$                            | $10 \% I_n$                        | $0,1 \times C$                                                               | %     |

~~<sup>a</sup> The permitted values for function performance class C for measured neutral current are: 0,2 – 0,5 – 1 – 2. The permitted values for function performance class C for calculated neutral current are: 0,1 – 0,2 – 0,5 – 1 – 2.~~

<sup>a</sup> Applicable performance classes are listed in Table 3.

<sup>b</sup> Influence quantities for phase current are defined with balanced currents in the three-phase distribution system.

<sup>c</sup> These limits are settled for a PMD powered by a mains supply voltage. In the case of a larger range of the supply voltage AC or DC, tests shall be done at least at the lower input value and upper input value of this range. In any case, PMD shall comply with the requirements for all the specified supply voltage ranges.

## 4.8.7 RMS voltage ( $U$ ) measurements

### 4.8.7.1 Technique

See Annex B.

~~Zero-blind~~ Gapless measurement is not required.

### 4.8.7.2 Rated range of operation

The intrinsic uncertainty requirements shall apply within the rated ranges given in Table 26:

**Table 26 – Rated range of operation for RMS voltage measurement**

| PMD types | Specified measuring range                        | Minimum bandwidth (harmonic)                                                     | Crest factor <sup>a</sup> |
|-----------|--------------------------------------------------|----------------------------------------------------------------------------------|---------------------------|
| PMD xS    | 20 % $U_n$ to 120 % $U_n$<br><del>see NOTE</del> | 45 Hz to 15 times rated frequency or<br>DC and 45 Hz to 15 times rated frequency | 1,5                       |
| PMD xD    | As specified by manufacturer                     | 45 Hz to 15 times rated frequency or<br>DC and 45 Hz to 15 times rated frequency | 1,5                       |

**NOTE <sup>a</sup>** The PMD using frequency detection circuits not operating in all the rated range can measure voltage with the last consistent measured value of frequency between 20 % of  $U_n$  and 50 % of  $U_n$ .

### 4.8.7.3 Intrinsic uncertainty table

The intrinsic uncertainty under reference conditions shall not exceed the limits given in Table 27:

**Table 27 – Intrinsic uncertainty table for RMS voltage measurement**

| Specified measuring range                    |                                              | Intrinsic uncertainty limits for PMD of function performance class C <sup>a b</sup> | Unit |
|----------------------------------------------|----------------------------------------------|-------------------------------------------------------------------------------------|------|
| Value of voltage for direct connected PMD xD | Value of voltage for sensor operated PMD xS  |                                                                                     |      |
| $U_{\min} \leq U \leq U_{\max}$ <sup>b</sup> | $U_{\min} \leq U \leq U_{\max}$ <sup>b</sup> | $\pm 1,0 \times C$                                                                  | %    |

~~<sup>a</sup> The permitted values for function performance class C are: 0,05 0,1 0,2 0,5 1 2~~

~~<sup>b</sup> The permitted values and formula to calculate the system performance class of a PMD with an external CS or VS are given in Annex D.~~

<sup>a</sup> Applicable performance classes are listed in Table 3.

<sup>b</sup> The manufacturer can define  $U_{\max}$  and  $U_{\min}$ , taking into account the minimum measuring range of Table 26.

### 4.8.7.4 Limits of variation due to influence quantities

The additional variations due to the change of influence quantities with respect to reference conditions as given in 4.6.1, shall not exceed the limits for the relevant performance class given in Table 28:

Table 28 – Influence quantities for RMS voltage measurement

| Influence quantities                        |                                                           | Specified measuring range <sup>b</sup>       |                                             | Temperature coefficient for PMD of function performance class C <sup>a</sup> | Unit  |
|---------------------------------------------|-----------------------------------------------------------|----------------------------------------------|---------------------------------------------|------------------------------------------------------------------------------|-------|
| Influence type                              | Influence range                                           | value of voltage for direct connected PMD xD | value of voltage for sensor operated PMD xS |                                                                              |       |
| Ambient temperature                         | According to rated operating range of Table 5 and Table 6 | $U_{\min} \leq U \leq U_{\max}$              | $U_{\min} \leq U \leq U_{\max}$             | $0,05 \times C$                                                              | % / K |
|                                             |                                                           |                                              |                                             | Limits of variation for PMD of function performance class C <sup>a</sup>     |       |
| Auxiliary power supply voltage <sup>c</sup> | Rated voltage $\pm 15$ %                                  | $U_{\min} \leq U \leq U_{\max}$              | $U_{\min} \leq U \leq U_{\max}$             | $0,1 \times C$                                                               | %     |

~~a. The permitted values for function performance class C are: 0,1 0,2 0,5 1 2.~~

<sup>a</sup> Applicable performance classes are listed in Table 3.

<sup>b</sup> The manufacturer can define  $U_{\max}$  and  $U_{\min}$ , taking into account the specified measuring range of Table 26.

<sup>c</sup> These limits are settled for a PMD powered by a mains supply voltage. In the case of a large dynamic supply voltage AC or DC, tests shall be done at least at the lower input value and upper input value of this range. In any case, PMD shall comply with the requirements for all the specified supply voltage ranges.

## 4.8.8 Power factor ( $PF_A$ , $PF_V$ ) measurements

### 4.8.8.1 Techniques

See Annex B for methods and Annex C for conventions related to the sign of Power factor.

### 4.8.8.2 Rated range of operation

The intrinsic uncertainty requirements shall apply within the following rated ranges:

- voltage: 50 %  $U_n$  to  $U_{max}$ ; or
- current: for PMD Dx: 20 %  $I_b$  to  $I_{max}$   
for PMD Sx: 10 %  $I_n$  to  $I_{max}$

### 4.8.8.3 Intrinsic uncertainty table

The intrinsic uncertainty under reference conditions shall not exceed the limits given in Table 29:

**Table 29 – Intrinsic uncertainty table for power factor measurement**

| Specified measuring range                                                                                                                                                                                                                                                                                                                                                                                                                                   | Intrinsic uncertainty limits for PMD of function performance class C <sup>a b</sup> | Unit                                 |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|--------------------------------------|
| From 0,5 inductive to 0,8 capacitive                                                                                                                                                                                                                                                                                                                                                                                                                        | $\pm 0,1 \cdot 0,01 \times C$                                                       | <sup>e</sup><br>No unit <sup>b</sup> |
| <sup>a</sup> <del>The permitted values for function performance class C are: 0,5 1 2 5 10.</del><br><sup>b</sup> <del>The permitted values and formula to calculate the system performance class of a PMD with an external current sensor or voltage sensor are given in Annex D.</del><br><sup>c</sup> <del>No units.</del><br><sup>a</sup> Applicable performance classes are listed in Table 3.<br><sup>b</sup> No unit because power factor is a ratio. |                                                                                     |                                      |

### 4.8.8.4 Limits of variation due to influence quantities

The additional variations from intrinsic uncertainties shall be calculated according to Table 9 and Table 17 for power factor 1 and 0,5 inductive, within the rated ranges of operation, taking into account the worst case combination of uncertainties.

## 4.8.9 Short term flicker ( $P_{st}$ ) and long term flicker ( $P_{lt}$ ) measurements

### 4.8.9.1 Techniques

See IEC 61000-4-15.

### 4.8.9.2 Rated range of operation

The intrinsic uncertainty requirements shall apply within the following rated range:

- voltage: 80 %  $U_n$  to  $U_{max}$

### 4.8.9.3 Intrinsic uncertainty table

The intrinsic uncertainty under reference conditions shall not exceed the limits given in Table 30:

**Table 30 – Intrinsic uncertainty table for flicker measurement**

| Specified measuring range                                                                                | Intrinsic uncertainty limits for PMD of function performance class C <sup>a</sup> | Unit |
|----------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|------|
| From 0,4 to 2                                                                                            | $\pm 1,0 \times C$                                                                | %    |
| <del><sup>a</sup> The permitted values for function performance class C are: 0,5 – 1 – 2 – 5 – 10.</del> |                                                                                   |      |
| <sup>a</sup> Applicable performance classes are listed in Table 3.                                       |                                                                                   |      |

**4.8.10 Voltage dip ( $U_{\text{dip}}$ ) and voltage swell ( $U_{\text{swl}}$ ) measurements**~~**4.7.9.1 Techniques**~~~~See Annex A. Zero blind measurement is required.~~~~Requirements in 5.4 of IEC 61000-4-30 apply, with the following modifications:~~

- ~~— in this part, either a fixed reference voltage or a sliding reference voltage with a one-minute time constant first order filter are required as threshold value for voltage dips or voltage swells detection;~~
- ~~— in this part, a synchronisation on zero crossing of voltage fundamental is not required.~~

NOTE Requirements for voltage dip and voltage swell are equivalent to Class S in IEC 61000-4-30.

**4.8.10.1 Measurement method**

Gapless measurement is required.

The basic measurement  $U_{\text{rms}}$  of a voltage dip and swell shall be either the  $U_{\text{rms}(1/2)}$  on each measurement channel (see 3.3.15), or the  $U_{\text{rms}(1)}$  on each measurement channel (see 3.3.16). The manufacturer shall specify which measurement is used.

NOTE The  $U_{\text{rms}(1)}$  or  $U_{\text{rms}(1/2)}$  value includes, by definition, harmonics, interharmonics, mains signalling voltage, etc.

**4.8.10.2 Detection and evaluation of a voltage dip****4.8.10.2.1 Voltage dip detection**

The dip threshold is a percentage of either  $U_{\text{din}}$  or the sliding voltage reference  $U_{\text{sr}}$  (see 4.8.10.4).

NOTE The sliding voltage reference  $U_{\text{sr}}$  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  $U_{\text{rms}}$  voltage falls below the dip threshold, and ends when the  $U_{\text{rms}}$  voltage is equal to or above the dip threshold plus some hysteresis voltage.
- On polyphase systems, a dip begins when the  $U_{\text{rms}}$  voltage of one or more channels is below the dip threshold and ends when the  $U_{\text{rms}}$  voltage on all measured channels is equal to or above the dip threshold plus some hysteresis voltage.

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

**4.8.10.2.2 Voltage dip evaluation**

A voltage dip is characterized by a pair of data, either residual voltage ( $U_{\text{res}}$ ) 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 can be useful to also record the lowest  $U_{rms}$  on each channel, in addition to the residual voltage of the dip. The duration spent below the dip threshold on each channel can also be useful.

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

The start time of a dip shall be time stamped with the time of the start of the  $U_{rms}$  of the channel that initiated the event and the end time of the dip 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 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 of 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.

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

#### 4.8.10.3 Detection and evaluation of a voltage swell

##### 4.8.10.3.1 Voltage swell detection

The swell threshold is a percentage of either  $U_{din}$  or the sliding reference voltage  $U_{sr}$  (see 4.8.10.4). 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.

##### 4.8.10.3.2 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  $U_{\text{rms}}$  value measured on any channel during the swell;
- the start time of a swell shall be time stamped with the time of the start of the  $U_{\text{rms}}$  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  $U_{\text{rms}}$  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 It is possible that the voltage swell envelope is not 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  $U_{\text{din}}$ .

NOTE 4 Typically, the swell threshold is greater than 110 % of  $U_{\text{din}}$ .

NOTE 5 Phase shift can also occur during voltage swells.

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

#### 4.8.10.4 Calculation of a sliding reference voltage

The sliding reference voltage implementation is optional. 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.

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 not updated during a voltage dip or swell or interruption.

#### 4.8.10.5 Measurement uncertainty and measuring range

##### 4.8.10.5.1 Residual voltage and swell voltage magnitude measurement uncertainty

The measurement uncertainty shall not exceed  $\pm 1,0$  % of  $U_{\text{din}}$ .

NOTE If  $U_{\text{rms}(1)}$  is used, this uncertainty is only valid for rectangular dips or swell lasting at least 4 cycles.

##### 4.8.10.5.2 Duration measurement uncertainty

If  $U_{\text{rms}(\frac{1}{2})}$  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).

#### 4.8.10.6 Rated range of operation

The intrinsic uncertainty requirements shall apply within the rated ranges given in Table 31:

**Table 31 – Rated range of operation for voltage dips and swells measurement**

| PMD types | Minimum threshold range settable for voltage dip | Minimum threshold range settable for voltage swell |
|-----------|--------------------------------------------------|----------------------------------------------------|
| PMD xS    | from 5 % $U_n$ to 100 % $U_n$                    | from 100 % $U_n$ to 120 % $U_n$                    |
| PMD xD    | as specified by manufacturer                     | as specified by manufacturer                       |

Minimum detectable duration shall be equal at least to one period of the measured voltage.

#### 4.8.10.7 Intrinsic uncertainty table

The intrinsic uncertainty under reference conditions shall not exceed the limits given in Table 32:

**Table 32 – Intrinsic uncertainty table for voltage dips and swells measurement**

| Specified measuring range                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Intrinsic uncertainty limits for PMD of function performance class C <sup>a b c</sup> | Unit            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|-----------------|
| Dips, residual voltage and swells overvoltage                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | $\pm 1,0 \times C$                                                                    | % $U_n$         |
| Dips duration and swells duration                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | One period at the network frequency                                                   | ms <sup>c</sup> |
| <del>a – The permitted values for function performance class C are: 0,1 – 0,2 – 0,5 – 1 – 2.</del><br><del>b – The permitted values and formula to calculate the system performance class of a PMD with an external voltage sensor are given in Annex D.</del><br><sup>a</sup> Applicable performance classes are listed in Table 3.<br><sup>b</sup> 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).<br><sup>c</sup> This is a fixed uncertainty. |                                                                                       |                 |

#### 4.8.10.8 Limits of variation due to influence quantities

The additional variations due to the change of influence quantities with respect to reference conditions as given in 4.6.1, shall not exceed the limits for the relevant performance class given in Table 33:

Table 33 – Influence quantities for dips and swells measurement

| Influence quantities                        |  | Influence range                                           | Specified measuring range <sup>b</sup>       |                                             | Temperature coefficient for PMD of function performance class C <sup>a</sup> | Unit    |
|---------------------------------------------|--|-----------------------------------------------------------|----------------------------------------------|---------------------------------------------|------------------------------------------------------------------------------|---------|
| Influence type                              |  |                                                           | value of voltage for direct connected PMD xD | value of voltage for sensor operated PMD xS |                                                                              |         |
| Ambient temperature                         |  | according to rated operating range of Table 5 and Table 6 | $U_{\min} \leq U \leq U_{\max}$              | $U_{\min} \leq U \leq U_{\max}$             | $0,05 \times C$                                                              | % / K   |
|                                             |  |                                                           |                                              |                                             | Limits of variation for PMD of function performance class C <sup>a</sup>     |         |
| Auxiliary power supply voltage <sup>c</sup> |  | rated voltage $\pm 15$ %                                  | $U_{\min} \leq U \leq U_{\max}$              | $U_{\min} \leq U \leq U_{\max}$             | $0,1 \times C$                                                               | % $U_n$ |
| Frequency                                   |  | rated frequency $\pm 10$ %                                | $U_{\min} \leq U \leq U_{\max}$              | $U_{\min} \leq U \leq U_{\max}$             | $0,5 \times C$                                                               | % $U_n$ |

<sup>a</sup> ~~The permitted values for function performance class C are: 0,1 – 0,2 – 0,5 – 1 – 2.~~

<sup>a</sup> Applicable performance classes are listed in Table 3.

<sup>b</sup> The manufacturer can define  $U_{\max}$  and  $U_{\min}$ , taking into account the minimum measuring range of Table 31.

<sup>c</sup> These limits are settled for a PMD powered by a mains supply voltage. In the case of a larger range of the supply voltage AC or DC, tests shall be done at least at the lower input value and upper input value of this range. In any case, PMD shall comply with the requirements for all the specified supply voltage ranges.

#### 4.8.11 Voltage interruption ( $U_{\text{int}}$ ) measurements

##### ~~4.7.11.1 Techniques~~

~~See Annex A.~~

~~Zero blind measurement is required.~~

~~Subclause 5.4 of IEC 61000-4-30 applies excepted that, in this part, a synchronisation on zero crossing of voltage fundamental is not required.~~

~~NOTE This measurement is possible only if the neutral wire is connected to the PMD.~~

NOTE Requirements for voltage interruption are equivalent to Class S in IEC 61000-4-30.

##### 4.8.11.1 Measurement method

Gapless measurement is required.

The basic measurement of the voltage shall be as defined in 4.8.10.1.

##### 4.8.11.2 Evaluation of a voltage interruption

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

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

On polyphase systems, a voltage interruption begins when the  $U_{\text{rms}}$  voltages of all channels fall below the voltage interruption threshold, and ends when the  $U_{\text{rms}}$  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  $U_{\text{din}}$ .

The start time of a voltage interruption shall be the time stamped with the time of the start of the  $U_{\text{rms}}$  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  $U_{\text{rms}}$  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  $U_{\text{din}}$ .

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.

##### 4.8.11.3 Measurement uncertainty and measuring range

For duration measurement uncertainty, see 4.8.10.5.2.

#### 4.8.11.4 Rated range of operation

The manufacturer shall choose at least one value for the threshold of voltage interruption detection included in the range of 1 % to 5 % of  $U_n$ .

Minimum detectable duration shall be equal at least to one period of the measured voltage.

#### 4.8.11.5 Intrinsic uncertainty table

The intrinsic uncertainty under reference conditions shall not exceed the limits given in Table 34.

**Table 34 – Intrinsic uncertainty table for voltage interruption measurement**

| Specified measuring range                                                                                                                                                                                                                                                                                                                                                                           | Intrinsic uncertainty limits for PMD of function performance class C <sup>a-b</sup> | Unit            |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-----------------|
| Interruptions from 0 % to 5 % of $U_n$                                                                                                                                                                                                                                                                                                                                                              | $\pm 1,0 \times C$                                                                  | % $U_n$         |
| Interruption duration                                                                                                                                                                                                                                                                                                                                                                               | Less than two periods at the network frequency                                      | ms <sup>b</sup> |
| <sup>a</sup> <del>The permitted values for function performance class C are: 0,1 – 0,2 – 0,5 – 1 – 2.</del><br><sup>b</sup> <del>The permitted values and formula to calculate the system performance class of a PMD with an external voltage sensor are given in Annex D.</del><br><sup>a</sup> Applicable performance classes are listed in Table 3.<br><sup>b</sup> This is a fixed uncertainty. |                                                                                     |                 |

#### 4.8.12 Transient overvoltage ( $U_{tr}$ ) measurements

##### 4.8.12.1 Techniques

See Annex A of IEC 61000-4-30:2015.

~~Zero blind~~ Gapless measurement is required.

Reference waveform: 1,2/50  $\mu$ s as defined in IEC 61000-4-5.

##### 4.8.12.2 Rated range of operation

The intrinsic uncertainty requirements shall apply within the rated ranges given in Table 35.

##### 4.8.12.3 Intrinsic uncertainty table

The intrinsic uncertainty under reference conditions shall not exceed the limits given in Table 35:

**Table 35 – Intrinsic uncertainty table for transient overvoltage measurement**

| Specified measuring range for PMD of function performance class C                                                                                                                                                                                   | Intrinsic uncertainty limits for PMD | Resolution for duration measurement <sup>b</sup> |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|--------------------------------------------------|
| 0 to $U_{tr}$ <sup>a</sup>                                                                                                                                                                                                                          | $\pm 3,0 \% \times U_{tr}$           | 5 $\mu$ s                                        |
| <sup>a</sup> The recommended values for the specified measuring range are 6 kV – 4 kV – 2,5 kV – 1,5 kV – 0,8 kV.<br><sup>b</sup> Duration measurement is optional. If it is provided, it shall be made at 50 % of the peak value of the transient. |                                      |                                                  |

### 4.8.13 Voltage unbalance ( $U_{nb}$ , $U_{nba}$ ) measurements

#### 4.8.13.1 Techniques

~~Zero-blind~~ Gapless measurement is not required.

According to the manufacturer specification, one of the following functions shall be implemented:

- amplitude voltage unbalance ( $U_{nba}$ ,  $V_{nba}$ ): see Annex B
- amplitude and phase voltage unbalance ( $U_{nb}$ ,  $V_{nb}$ ): see IEC 61000-4-30

#### 4.8.13.2 Rated range of operation

The intrinsic uncertainty requirements shall apply within the following rated range:

- between 80 % and 120 % of  $U_n$

#### 4.8.13.3 Intrinsic uncertainty table

The intrinsic uncertainty under reference conditions shall not exceed the limits given in Table 36:

**Table 36 – Intrinsic uncertainty table for voltage unbalance measurement**

| Indicated range of $U_{nb}$ or $U_{nba}$ | Intrinsic uncertainty limits for PMD of function performance class C <sup>a</sup> | Resolution | Unit               |
|------------------------------------------|-----------------------------------------------------------------------------------|------------|--------------------|
| 0 % to 10 %                              | $\pm 1 \times C$ <sup>b</sup>                                                     | $\pm 0,1$  | <del>%</del> point |

~~<sup>a</sup> The permitted values for function performance class C are: 0,2 – 0,5 – 1.~~

<sup>a</sup> Applicable performance classes are listed in Table 3.

<sup>b</sup> The diagram below shows an example of uncertainty limits for class 0,5:

Intrinsic uncertainty limits for PMD of function performance class 0,5

The diagram illustrates the uncertainty limits for a true value of 5%. The uncertainty range is from 4,5% to 5,5%, which is  $\pm 0,5\%$  around the true value. The x-axis is marked from 0% to 10% in 1% increments.

### 4.8.14 Voltage harmonics ( $U_h$ ) and voltage THD ( $THD_u$ and $THD-R_u$ ) measurements

#### 4.8.14.1 Techniques

~~Manufacturer shall specify sampling frequency, number of ranks, windows and filtering methods, aggregation method.~~

~~NOTE 1 IEC 61000-4-7 compliance is not mandatory.~~

~~Zero-blind measurement is not required.~~

~~NOTE 2 When zero-blind measurement is not implemented, only stationary and quasi-stationary harmonics can be measured.~~

The manufacturer shall specify the standard with which the product complies or, alternatively, shall specify the number of ranks, and if applicable filtering methods and aggregation method.

Gapless measurement is not required.

NOTE  $THD_U$  and  $THD-R_U$  is a generic notation. This is also applied to  $THD_V$  and  $THD-R_V$ .

#### 4.8.14.2 Rated range of operation

The intrinsic uncertainty requirements shall apply within the rated range given in Table 37:

**Table 37 – Rated range of operation for voltage harmonics measurement**

| PMD types | Minimum bandwidth            | Fundamental frequency range |
|-----------|------------------------------|-----------------------------|
| PMD       | 15 times the rated frequency | 45 Hz to 65 Hz              |

#### 4.8.14.3 Intrinsic uncertainty table

The uncertainty indicated in Table 38 and Table 39 applies for a single tone stationary harmonic signal over the whole working conditions.

**Table 38 – Intrinsic uncertainty table for voltage harmonics measurement**

| Specified measuring range                                                                                                                                                                                                                                                                                                                | Intrinsic uncertainty limits for PMD of function performance class C <sup>a, b</sup> | Unit    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|---------|
| $U_h > 3 \times U_n \times C / 100$                                                                                                                                                                                                                                                                                                      | $\pm 5,0$                                                                            | % $U_h$ |
| $U_h \leq 3 \times U_n \times C / 100$                                                                                                                                                                                                                                                                                                   | $\pm 0,15 \times C$                                                                  | % $U_n$ |
| <sup>a</sup> <del>The permitted values for function performance class C are: 1 – 2 – 5.</del><br><sup>b</sup> <del>The permitted values and formula to calculate the system performance class of a PMD with an external voltage sensor are given in Annex D.</del><br><sup>a</sup> Applicable performance classes are listed in Table 3. |                                                                                      |         |

**Table 39 – Intrinsic uncertainty table for voltage  $THD_U$  or  $THD-R_U$  measurement**

| Specified measuring range for voltage THD                                                                                                                                                                                                                                                                                                                                                                                | Intrinsic uncertainty limits for PMD of function performance class C <sup>a, b</sup> | Unit               |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------|--------------------|
| 0 % to 20 %                                                                                                                                                                                                                                                                                                                                                                                                              | $\pm 0,3 \times C$ <sup>c</sup>                                                      | point <sup>c</sup> |
| <sup>a</sup> <del>The permitted values for function performance class C are: 1 – 2 – 5.</del><br><sup>b</sup> <del>The permitted values and formula to calculate the system performance class of a PMD with an external voltage sensor are given in Annex D.</del><br><sup>c</sup> <del>0,3 × C is a constant uncertainty. For example with 10 % of THD, if C = 1, the measured value may be between 9,7 and 10,3.</del> |                                                                                      |                    |
| Specified measuring range for voltage THD                                                                                                                                                                                                                                                                                                                                                                                | Intrinsic uncertainty limits for PMD of function performance class C <sup>a</sup>    | Unit               |
| $3 \times C \% < THD \leq 20 \%$                                                                                                                                                                                                                                                                                                                                                                                         | $\pm 5$                                                                              | %                  |
| $THD \leq 3 \times C \%$                                                                                                                                                                                                                                                                                                                                                                                                 | $\pm 0,15 \times C$                                                                  | point <sup>b</sup> |
| <sup>a</sup> Applicable performance classes are listed in Table 3.<br><sup>b</sup> 0,15 × C is a constant uncertainty. For example with 1 % of THD, if C = 1, the measured value may be between 0,85 % and 1,15 %.                                                                                                                                                                                                       |                                                                                      |                    |

#### 4.8.15 Current unbalance ( $I_{nb}$ , $I_{nba}$ ) measurements

##### 4.8.15.1 Techniques

Gapless measurement is not required.

According to the manufacturer specification, one of the following functions shall be implemented:

- amplitude current unbalance ( $I_{nba}$ ): see Annex B
- amplitude and phase current unbalance ( $I_{nb}$ ): see IEC 61000-4-30, only replacing voltage by current.

##### 4.8.15.2 Rated range of operation

The intrinsic uncertainty requirements shall apply within the following rated range:

- between 10 % and 120 % of  $I_n$
- between 20 % of  $I_b$  and  $I_{max}$

##### 4.8.15.3 Intrinsic uncertainty table

The intrinsic uncertainty under reference conditions shall not exceed the limits given in Table 40:

**Table 40 – Intrinsic uncertainty table for current unbalance measurement**

| Indicated range of $I_{nb}$ or $I_{nba}$ | Intrinsic uncertainty limits for PMD of function performance class C <sup>a</sup> | Resolution | Unit   |
|------------------------------------------|-----------------------------------------------------------------------------------|------------|--------|
| 0 % to 50 %                              | $\pm 1 \times C$ <sup>b</sup>                                                     | $\pm 0,1$  | Points |

<sup>a</sup> Applicable performance classes are listed in Table 3.

<sup>b</sup> The diagram below shows an example of uncertainty limits for class 0,5:

#### 4.8.16 Current harmonics ( $I_h$ ) and current THD ( $THD_i$ and $THD-R_i$ ) measurements

##### 4.8.16.1 Techniques

~~According to manufacturer specification: sampling frequency, number of ranks, windows and filtering methods, aggregation method.~~

The manufacturer shall specify the standard with which the product complies or, alternatively, shall specify the number of ranks, and if applicable filtering methods and aggregation method.

~~Zero blind~~ Gapless measurement is not required.

~~NOTE When zero blind measurement is not implemented, only stationary and quasi-stationary harmonics can be measured.~~

#### 4.8.16.2 Rated range of operation

The intrinsic uncertainty requirements shall apply within the rated range given in Table 41:

**Table 41 – Rated range of operation for current harmonics measurement**

| PMD types | Minimum bandwidth            | Fundamental frequency range |
|-----------|------------------------------|-----------------------------|
| PMD       | 15 times the rated frequency | 45 Hz to 65 Hz              |

#### 4.8.16.3 Intrinsic uncertainty table

The uncertainty indicated in Table 42 and Table 43 applies for a single tone stationary harmonic signal over the whole working condition.

**Table 42 – Intrinsic uncertainty table for current harmonics measurement**

| PMD types                                                                                                                                                                                                                                                                                                                                | Specified measuring range               | Intrinsic uncertainty limits for PMD of function performance class C <sup>a b</sup> | Unit    |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------|-------------------------------------------------------------------------------------|---------|
| PMD-Sx                                                                                                                                                                                                                                                                                                                                   | $I_h > 10 \times I_n \times C / 100$    | $\pm 5,0$                                                                           | % $I_h$ |
|                                                                                                                                                                                                                                                                                                                                          | $I_h \leq 10 \times I_n \times C / 100$ | $\pm 0,5 \times C$                                                                  | % $I_n$ |
| PMD-Dx                                                                                                                                                                                                                                                                                                                                   | $I_h > 10 \times I_b \times C / 100$    | $\pm 5,0$                                                                           | % $I_h$ |
|                                                                                                                                                                                                                                                                                                                                          | $I_h \leq 10 \times I_b \times C / 100$ | $\pm 0,5 \times C$                                                                  | % $I_b$ |
| <sup>a</sup> <del>The permitted values for function performance class C are: 1 – 2 – 5.</del><br><sup>b</sup> <del>The permitted values and formula to calculate the system performance class of a PMD with an external current sensor are given in Annex D.</del><br><sup>a</sup> Applicable performance classes are listed in Table 3. |                                         |                                                                                     |         |

**Table 43 – Intrinsic uncertainty table for current  $THD_i$  and  $THD-R_i$  measurement**

| Specified measuring range                                                                                                                                                                                                                                                                                                                                                                                                                                                     | Intrinsic uncertainty limits for PMD of function performance class C <sup>a-b</sup> | Unit               |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|--------------------|
| 0 % to 100 %                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | $\pm 0,3 \times C$ <sup>c</sup>                                                     | point <sup>c</sup> |
| 100 % to 200 %                                                                                                                                                                                                                                                                                                                                                                                                                                                                | $\pm 0,3 \times C \times THD / 100$ <sup>d</sup>                                    | point <sup>c</sup> |
| <sup>a</sup> The permitted values for function performance class C are: 1 – 2 – 5.<br><sup>b</sup> The permitted values and formula to calculate the system performance class of a PMD with an external current sensor are given in Annex D.<br><sup>c</sup> $0,3 \times C$ is an absolute uncertainty. For example with 10 % of THD, if $C = 1$ , the measured value may be between 9,7 and 10,3.<br><sup>d</sup> $THD$ is the measured value of current THD expressed in %. |                                                                                     |                    |

| PMD types                                                                                                                                                                                                                                                                                                                                                                       | Specified measuring range <sup>c d</sup>            | Intrinsic uncertainty limits for PMD of function performance class C <sup>a</sup> | Unit               |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------|-----------------------------------------------------------------------------------|--------------------|
| PMD Sx                                                                                                                                                                                                                                                                                                                                                                          | $200 \% \geq THD > 10 \times (I_n/I_1) \times C \%$ | $\pm 5,0$                                                                         | %                  |
|                                                                                                                                                                                                                                                                                                                                                                                 | $THD \leq 10 \times (I_n/I_1) \times C \%$          | $\pm 0,5 \times C \times (I_b/I_1)$                                               | Point <sup>b</sup> |
| PMD Dx                                                                                                                                                                                                                                                                                                                                                                          | $200 \% \geq THD > 10 \times (I_b/I_1) \times C \%$ | $\pm 5,0$                                                                         | %                  |
|                                                                                                                                                                                                                                                                                                                                                                                 | $THD \leq 10 \times (I_b/I_1) \times C \%$          | $\pm 0,5 \times C \times (I_b/I_1)$                                               | Point <sup>b</sup> |
| <sup>a</sup> Applicable performance classes are listed in Table 3.<br><sup>b</sup> $0,5 \times C$ is an absolute uncertainty. For example with 10 % of THD, if $C = 10$ , and $I_1 = I_n$ the measured value may be between 5 % and 15 %.<br><sup>c</sup> $THD$ is the measured value of current THD expressed in %.<br><sup>d</sup> $I_1$ is the fundamental (50 Hz or 60 Hz). |                                                     |                                                                                   |                    |

#### 4.8.17 Minimum, maximum, peak, three-phases average and demand measurements

##### 4.8.17.1 Rated range of operation

The manufacturer shall specify the rated range of operation.

##### 4.8.17.2 Intrinsic uncertainty table

The uncertainty on these values (minimum, maximum, ...) shall be the same as that from the corresponding measurements used to calculate these values.

For instance, a PMD claiming a class C performance on power measurement shall have to comply with the same performance class C for the power demand measurement if any.

Calculation methods are specified in Annex D.

#### ~~4.8 Requirements for PMD-A functions~~

~~Measuring uncertainties, measuring methods, measuring ranges, testing methods shall comply with IEC 61000-4-30 class A, and the complementary characteristics given in Table 41 below.~~

~~Depending on the purpose of the measurement, all or a subset of the functions listed in Table 41 shall be measured.~~

~~NOTE For contractual applications, all functions listed in Table 41 may be necessary.~~

~~Any "power quality assessment function" of a PMD-A shall comply with the measurement methods and measurement uncertainty defined for class A in IEC 61000-4-30.~~

~~Each function shall comply with IEC 61000-4-30 within operating conditions specified in 4.5.2 of this standard.~~

~~For PMD-A, the maximum variation caused by change of ambient temperature within the specified temperature operating range according to 4.5 shall not exceed 1,0 x measuring uncertainty as specified in IEC 61000-4-30. Manufacturers shall specify the variation as required in Note 2, subclause 4.1 of IEC 61000-4-30.~~

**Table 41 — Complementary characteristics of PMD-A**

| Function                                                                                                                                                             | Other complementary characteristics                                                                                                             |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| $f$                                                                                                                                                                  | Range of operation: 50 % $U_{din}$ to $U_{max}$ or 1 % $U_{din}$ to $U_{max}$ if dips and swells are in concern.<br>See Note.                   |
| $U$                                                                                                                                                                  | No complementary characteristics.                                                                                                               |
| $P_{St}, P_{It}$                                                                                                                                                     | No complementary characteristics.                                                                                                               |
| $U_{dip}$                                                                                                                                                            | Threshold settable from 50 % to 120 % of $U_{din}$ ;<br>Hysteresis: 2 % of $U_{din}$                                                            |
| $U_{swl}$                                                                                                                                                            | Threshold settable from 50 % to 120 % of $U_{din}$ ;<br>Hysteresis: 2 % of $U_{din}$                                                            |
| $U_{int}$                                                                                                                                                            | Threshold settable from 0,5 % to 10 % of $U_{din}$ ;<br>Duration measurement uncertainty < 2 cycles                                             |
| $U_{nb}$                                                                                                                                                             | Limit settable from 0 % to 5 %;<br>Resolution: 0,05 % minimum                                                                                   |
| $U_h$                                                                                                                                                                | Requirement is to measure up to 50 <sup>th</sup> rank, consequently minimum frequency bandwidth shall be at least 51 times the rated frequency. |
| $t_h$                                                                                                                                                                | No complementary characteristics.                                                                                                               |
| $Msv$                                                                                                                                                                | Threshold settable from 0,1 % to 10 % of $U_{din}$                                                                                              |
| NOTE Between 1% of $U_{din}$ and 50% of $U_{din}$ , PMD using frequency detection circuits can measure voltage with the last consistent measured value of frequency. |                                                                                                                                                 |

## 4.9 General mechanical requirements

### 4.9.1 Vibration requirements

~~Requirements for portable equipment are described in IEC 61557-1. For fixed installed equipment the requirement is as below:~~

In addition to the mechanical resistance test specified in IEC 61010-1, the PMD shall pass the following vibration test:

- amplitude: 0,35 mm for fixed equipment, 1 mm for portable equipment;
- frequency: 25 Hz;
- duration: 20 min in each 3 directions;
- PMD under test ~~must~~ shall be powered on.

The PMD functions shall remain in their specifications during the test.

### 4.9.2 IP requirements

The manufacturer shall document equipment IP according to IEC 60529. The minimum requirements are given in Table 44, which specifies minimum IP requirements for the different kind of housings of PMD:

**Table 44 – Minimum IP requirements for PMD**

| Type of PMD                                                                              | Front panel | Housing, except front panel |
|------------------------------------------------------------------------------------------|-------------|-----------------------------|
| Fixed installed PMD<br>→ panel mounted devices.                                          | IP 40       | IP 2X                       |
| Fixed installed PMD<br>→ modular devices snapped on DIN rails within distribution panel. | IP 40       | IP 2X                       |
| Fixed installed PMD<br>→ housing devices snapped on DIN rails within distribution panel. | IP 2X       | IP 2X                       |
| Portable PMD                                                                             | IP 40       | IP 40                       |

## 4.10 Safety requirements

### 4.10.1 Protection against electrical hazards

#### 4.10.1.1 General

PMD shall comply with the applicable safety requirements of IEC 61010-1 and IEC 61010-2-030 and with additional requirements specified hereafter.

~~NOTE 1 – Class II requirement as stated in IEC 61557-1 is not mandatory.~~

~~NOTE 2 – Protection classes are defined in IEC 61140.~~

#### 4.10.1.2 Clearances and creepage distances

Clearances and creepage distances shall be selected at least in accordance with:

- pollution degree 2;
- measurement category III for measuring input circuits;
- overvoltage category III for mains circuits.

~~NOTE~~ For portable equipment, overvoltage category II is acceptable only for mains circuits powered from socket outlets.

For plug-in PMD for socket outlets, overvoltage category II and measurement category II are acceptable.

NOTE Measurement category is defined in IEC 61010-2-030.

#### 4.10.1.3 Connection of a fixed installed PMD with a current transformer

When a hazardous situation can be the result of an unintended disconnection of a current transformer from its PMD, connections of the current inputs shall be designed in such a way to prevent open circuit condition. This condition may be achieved either by removable auto short-circuiting connectors, screwable connectors, fixed connections, external protective devices, or protective devices integrated in the current transformer.

#### 4.10.1.4 Connection of a PMD with a sensor in high voltage ~~sensor~~ networks

The connection of a PMD xS or a PMD xD with external high voltage sensors (e.g. for systems with rated voltages higher than 1 000 V AC and 1 500 V DC) is allowed, provided that design features of such sensors prevent any hazards.

NOTE IEC 61010-1 gives guidance for system safety aspects including the sensors used with the PMD.

#### 4.10.1.5 Accessible parts

Requirements for accessible parts as defined in IEC 61010-1 apply.

Circuits intended to be connected to an external accessible circuit shall be considered as accessible conductive parts, for example communication circuits.

A communication port that may be connected to a data system shall also be considered as an accessible conductive part.

These accessible conductive parts require protection against single fault condition.

NOTE Basic insulation is not a sufficient protection against single fault condition. An example of relevant insulation is double insulation or reinforced insulation, etc., see IEC 61010-1.

#### 4.10.1.6 Hazardous live parts

In a distribution system, a neutral conductor shall be considered as a hazardous live part.

#### 4.10.2 Protection against mechanical hazards

The requirements of IEC 61010-1 apply.

#### 4.10.3 Protection against other hazards

PMDs shall be assessed against potential hazards specified in IEC 61010-1. If any hazard is deemed to be relevant, then it shall be covered by the corresponding IEC 61010-1 requirements.

Special attention will be paid to devices embedding batteries.

#### 4.11 EMC requirements

##### 4.11.1 Immunity

For immunity, Table 2 of IEC 61326-1:2012 shall apply. For testing, see 6.2.16.

##### 4.11.2 Emission

For emissions either class A or class B limits as defined in IEC 61326-1 shall apply.

#### 4.12 Inputs and/or outputs

##### 4.12.1 General

The manufacturer shall specify the characteristics and the performance of the inputs and outputs of the PMD.

NOTE Digital and analog inputs/outputs are defined in IEC 61131-2.

##### 4.12.2 Analog outputs

###### 4.12.2.1 General requirements

The global uncertainty of each analog output representing a measured parameter shall be in the uncertainty limits specified for the measurement of that parameter in Clause 4 unless otherwise specified.

**NOTE 1** For testing of analog outputs, see 6.2.14. For a PMD fitted with analog outputs the requirements specified in 4.12.2.5 ~~shall~~ apply.

**NOTE 2** The current analog output signal ~~should be~~ is 4 mA to 20 mA, but 0 mA to 20 mA is also possible.

**NOTE 3** The preferred voltage output signal is 0 V to 10 V. Voltages 0 V to  $\pm 1$  V and 0 V to -10 V are also possible.

#### 4.12.2.2 Compliance voltage

Current output signals shall have a compliance voltage of at least 10 V. The actual compliance voltage shall be specified in the accompanying documentation (see 5.3).

When tested in accordance with the compliance voltage tests of 6.2.14.2 the uncertainty of the analog output shall not exceed  $(2 \times C)$  % of full scale for a PMD with an analog output of performance class C.

#### 4.12.2.3 Analog output ripple content

When tested in accordance with 6.2.14.3 the maximum ripple content in the output signal for an output of performance class C shall not exceed  $(2 \times C)$  % of full scale of the maximum specified output signal.

#### 4.12.2.4 Analog output response time

The response time of the analog output, in accordance with 6.2.14.4, for both increasing and decreasing inputs if different, shall be specified in the accompanying documentation (see 5.3).

#### 4.12.2.5 Limiting value of the analog output signal

The output signal shall be limited to a maximum of twice the rated maximum output signal. For bipolar outputs, this shall apply in both directions.

When tested in accordance with 6.2.14.5 and when the measurement is not between the lower and upper values represented by the maximum and minimum output signals, the ~~meter~~ PMD shall not, under any conditions of operation except loss of auxiliary power, produce an output having a value between its maximum and minimum output signals.

#### 4.12.3 Pulse outputs

For these outputs, 4.1 of IEC 62053-31:1998 (functional requirements) shall apply.

However for some specific applications, deviations are possible and the level of these outputs has to be declared and compliance to IEC 62053-31 cannot be declared.

#### 4.12.4 Control outputs

When such output is available, the level shall be declared in the documentation.

#### 4.12.5 Analog inputs

The current analog input should be 4 mA to 20 mA, but 0 mA to 20 mA is also possible.

For testing of analog inputs, the product should be able to measure signals transmitted by analog output as specified in 4.12.2.

#### 4.12.6 Pulse and control inputs

For these inputs, PMD shall accept signals as defined in IEC 62053-31.

However for some specific applications, deviations are possible and the level of these outputs has to be declared and compliance to IEC 62053-31 cannot be declared.

## 5 Marking and operating instructions

### 5.1 General

Marking and operating instructions shall comply with IEC 61010-1 and ~~IEC 61557-1~~ IEC 61010-2-030, unless otherwise specified in Clause 5.

### 5.2 Marking

~~Marking requirements as defined in IEC 61010 shall apply. In addition, but not in contradiction, the following markings shall be clearly readable and indelible:~~

- ~~— wiring diagrams or Symbol 14 according to IEC 61010-1;~~
- ~~— if necessary, also inside the device, serial number, year of manufacturing or type designation.~~

Marking requirements as defined in IEC 61010-1 and IEC 61010-2-030 shall apply. In addition the equipment shall be marked with:

- a) wiring diagrams or symbol 14 according to IEC 61010-1;
- b) serial number.

It is recommended to provide also the year of manufacturing.

### 5.3 Operating, installation and maintenance instructions

#### 5.3.1 General

Operating instructions, including maintenance aspects, defined in IEC 61010-1 and IEC 61010-2-030 shall apply. In addition, ~~but not in contradiction~~, the following requirements apply:

#### 5.3.2 General characteristics

The following characteristics shall be documented:

- a) calibration period, if a periodic calibration is necessary;
- b) the rated voltage in one of the following forms:
  - 1) the number of active conductors of the connecting system if more than one, and the applicable voltage at the PMD terminals of the voltage circuit(s);
  - 2) the nominal voltage of the system or the secondary voltage of the instrument transformer to which the PMD is intended to be connected;
- c) for direct connected PMD, the basic current ( $I_b$ ) and the maximum current ( $I_{max}$ ) ~~expressed~~. For example: 10 A to 40 A or 10(40) A for a PMD having a basic current of 10 A and a maximum current of 40 A;
- d) for current transformer-operated PMD, the rated secondary current ( $I_n$ ) of the transformer(s) and the maximum secondary current ( $I_{max}$ ) of the transformer which the PMD should be connected to. For example: ~~15(6,5)~~ 5(6) A;
- e) for sensor-operated PMD, the main characteristics of the corresponding PMD input. For example: 1 V / 1 000 A;
- f) the rated frequency or frequency range in Hz;
- g) for energy measurement, the meter constant if any;

- h) start-up time, if it is longer than 15 s;
- i) for PMD with pulse inputs and/or outputs, the class A or class B classification;
- j) for PMD with control outputs, the maximum level of the outputs. For example: 1 A / 230 V AC;
- k) overcurrent protection specification.

### 5.3.3 Essential characteristics

#### 5.3.3.1 Characteristics of PMD

The characteristics of the PMD shall be specified in a table as specified in Table 45 with the following items:

- a) power quality assessment function (if any);
- b) classification of PMD according to 4.3 and to 4.4;
- c) temperature according to 4.6.2.2 and 4.6.2.3;
- d) humidity and altitude conditions according to 4.6.2.4;
- e) active power or active energy function (if existing) performance class according to 4.8.2.

The sequence of function symbols shall be the following:

**Table 45 – PMD specification form**

| Type of characteristic                                                           | Examples of possible characteristic value | Other complementary characteristics |
|----------------------------------------------------------------------------------|-------------------------------------------|-------------------------------------|
| <del>Power quality assessment function (if any)</del>                            | <del>A or blank</del>                     |                                     |
| Classification of PMD according to 4.3                                           | PMD-I or PMD-II or PMD-III or PMD-x       |                                     |
| Classification of PMD according to 4.4                                           | SD or DS or DD or SS                      |                                     |
| Temperature                                                                      | K40 or K55 or K70 or Kx                   |                                     |
| Humidity + altitude                                                              | Blank or extended values                  |                                     |
| Active power or active energy function (if function available) performance class | 0,1 or 0,2 or 0,5 or 1 or 2               |                                     |

**NOTE** It is strongly recommended that all items be listed, and only existing ones be specified.

#### 5.3.3.2 Characteristics of functions

The characteristics of functions of the PMD shall be specified in a table as specified in Table 46 with the following items:

- a) function symbols as defined in Table 46;
- b) function performance class according to this document;
- c) measuring range for the specified performance class;
- d) other complementary characteristics.

The sequence of function symbols shall be the following:

**Table 46 – Characteristics specification template**

| Function symbols           | Function performance class according to IEC 61557-12 | Measuring range | Other complementary characteristics |
|----------------------------|------------------------------------------------------|-----------------|-------------------------------------|
| $P$                        |                                                      |                 |                                     |
| $Q_A$ or/and $Q_V$         |                                                      |                 |                                     |
| $S_A$ or/and $S_V$         |                                                      |                 |                                     |
| $E_a$                      |                                                      |                 |                                     |
| $E_{rA}$ or/and $E_{rV}$   |                                                      |                 |                                     |
| $E_{apA}$ or/and $E_{apV}$ |                                                      |                 |                                     |
| $f$                        |                                                      |                 |                                     |
| $I$                        |                                                      |                 |                                     |
| $I_N$ or/and $I_{Nc}$      |                                                      |                 |                                     |
| $U$ or/and $V$             |                                                      |                 |                                     |
| $PF_A$ or/and $PF_V$       |                                                      |                 |                                     |
| $U_{dip}$ or/and $V_{dip}$ |                                                      |                 |                                     |
| $U_{swl}$ or/and $V_{swl}$ |                                                      |                 |                                     |
| $U_{tr}$ or/and $V_{tr}$   |                                                      |                 |                                     |
| $U_{int}$ or/and $V_{int}$ |                                                      |                 |                                     |
| $U_{nba}$ or/and $V_{nba}$ |                                                      |                 |                                     |
| $U_{nb}$ or/and $V_{nb}$   |                                                      |                 |                                     |
| $U_h$ or/and $V_h$         |                                                      |                 |                                     |
| $THD_U$ or/and $THD_V$     |                                                      |                 |                                     |
| $THD-R_U$ or/and $THD-R_V$ |                                                      |                 |                                     |
| $I_h$                      |                                                      |                 |                                     |
| $THD_i$                    |                                                      |                 |                                     |
| $THD-R_i$                  |                                                      |                 |                                     |
| <b><math>Msv</math></b>    |                                                      |                 |                                     |
| $P_{st}$                   |                                                      |                 |                                     |
| $P_{fl}$                   |                                                      |                 |                                     |

**NOTE** It is strongly recommended that all functions be listed, and only existing ones be specified.

### **5.2.2.3 — Characteristics of "Power quality assessment functions"**

Characteristics of the "power quality assessment functions" of the PMD shall be specified in a table as specified in Table 45 with the following items:

- a) function symbols as defined in Table 45;
- b) function performance class according to this standard;
- c) measuring range for the specified performance class;
- d) other complementary characteristics;

~~e) measurement method class according to IEC 61000-4-30.~~

~~The sequence of function symbols shall be the following:~~

~~Table 45 — Characteristics specification template~~

| <del>function symbols</del>              | <del>Function performance class according to IEC 61557-12</del> | <del>Measuring range</del> | <del>Other complementary characteristics</del> | <del>Class acc. to IEC 61000-4-30 if any</del> |
|------------------------------------------|-----------------------------------------------------------------|----------------------------|------------------------------------------------|------------------------------------------------|
| <del><math>f</math></del>                |                                                                 |                            |                                                |                                                |
| <del><math>I</math></del>                |                                                                 |                            |                                                |                                                |
| <del><math>I_{N_r}, I_{N_g}</math></del> |                                                                 |                            |                                                |                                                |
| <del><math>U</math></del>                |                                                                 |                            |                                                |                                                |
| <del><math>P_{St}, P_{It}</math></del>   |                                                                 |                            |                                                |                                                |
| <del><math>U_{dip}</math></del>          |                                                                 |                            |                                                |                                                |
| <del><math>U_{swl}</math></del>          |                                                                 |                            |                                                |                                                |
| <del><math>U_{int}</math></del>          |                                                                 |                            |                                                |                                                |
| <del><math>U_{nba}</math></del>          |                                                                 |                            |                                                |                                                |
| <del><math>U_{nb}</math></del>           |                                                                 |                            |                                                |                                                |
| <del><math>U_h</math></del>              |                                                                 |                            |                                                |                                                |
| <del><math>I_h</math></del>              |                                                                 |                            |                                                |                                                |
| <del><math>Msv</math></del>              |                                                                 |                            |                                                |                                                |

~~NOTE — It is strongly recommended that all functions be listed, and only existing ones be specified.~~

### ~~5.2.3 — Safety characteristics~~

#### ~~5.2.3.1 — Insulation between circuits~~

~~For safety reasons, accessible parts shall be defined and documented.~~

~~Manufacturer shall state the type of insulation according to IEC 61010 used between each independent circuit (e.g. basic insulation, double or reinforced insulation, etc.)~~

## 6 Tests

### 6.1 General

~~Measuring equipment shall be tested in accordance with IEC 61557-1 unless otherwise specified.~~

All tests shall be carried out under reference conditions unless otherwise specified. The reference conditions are stated in 4.6.1.

### 6.2 Type tests of PMD

#### 6.2.1 General

Type tests shall be executed to check the compliance with the requirements of ~~4.7, 4.6 and 4.5~~ Clauses 4 and 5. ~~For some of them, tests of the influence quantities on several functions can be combined if applicable (e.g. test of influence of temperature done on active power measurement can be done at the same time as those of voltage and current).~~

## 6.2.2 Tests of intrinsic uncertainty

### 6.2.2.1 General requirements

As a general principle, each line of the intrinsic uncertainty tables in Clause 4 shall be associated to a test.

### 6.2.2.2 Minimum test points

The intrinsic uncertainty shall be verified at least at the limits of the measuring range specified in the intrinsic uncertainty tables in Clause 4.

### 6.2.2.3 Acceptance criterion

For each test, the absolute value of the measurement uncertainty shall be less than the specified intrinsic uncertainty limit.

NOTE See G.3.2 and G.4.1 for more information.

## 6.2.3 Tests of variation of uncertainty with influence quantities

### 6.2.3.1 General requirements

As a general principle, each line of the uncertainty with influence quantities tables in Clause 4 shall be associated to a test.

Tests of the influence quantities on several functions can be combined if applicable (e.g. the test of influence of temperature done on active power measurement can be done at the same time as those of voltage and current).

### 6.2.3.2 Minimum test points

The variation of uncertainty with influence quantities shall be verified at least at the limits of the specified influence range and measuring range.

### 6.2.3.3 Acceptance criterion

For each test, the absolute value of the variation of the measurement uncertainty shall be less than the limits of variation specified in the influence quantities tables in Clause 4.

NOTE See G.3.2 and G.4.1 for more information.

## 6.2.4 Test of temperature influence

The temperature coefficient shall be determined for the whole operating range. The operating temperature range shall be divided into 20 K wide ranges. The temperature coefficient shall then be determined for each of these ranges, by taking measurements 10 K above and 10 K below the middle of the range. During the test, the temperature shall be in no case outside the specified operating temperature range.

The indicated temperature coefficient shall be the greatest one.

## 6.2.5 Active power

### 6.2.5.1 Influence of harmonics in current and voltage circuits

Test conditions shall be:

- fundamental frequency current:  $I_1 = 50\%$  of  $I_{\max}$ ;
- fundamental frequency voltage:  $U_1 = U_n$ ;

- fundamental frequency power factor: 1;
- content of 5<sup>th</sup> harmonic voltage:  $U_5 = 10\%$  of  $U_n$ ;
- content of 5<sup>th</sup> harmonic current:  $I_5 = 40\%$  of  $I_1$ ;
- harmonic power factor: 1;
- fundamental and harmonic voltages in phase, at positive zero crossing;
- total active power:  $1,04 \times P_1 = 1,04 \times U_1 \times I_1$ .

#### 6.2.5.2 Influence of odd harmonics in the current circuit

The peak value of the test waveform shall be equal to  $\sqrt{2} \times I_b$  or to  $\sqrt{2} \times I_n$ .

The current test waveform shall be generated according to Figure 4 and Figure 5.

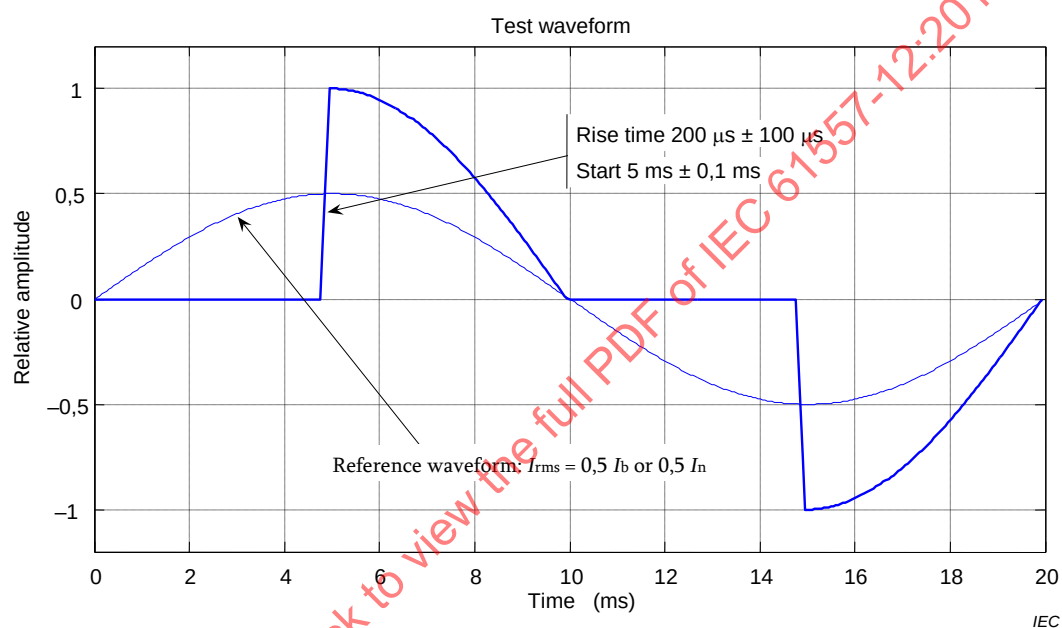


Figure 4 – Waveform for odd harmonics influence test on active power measurement

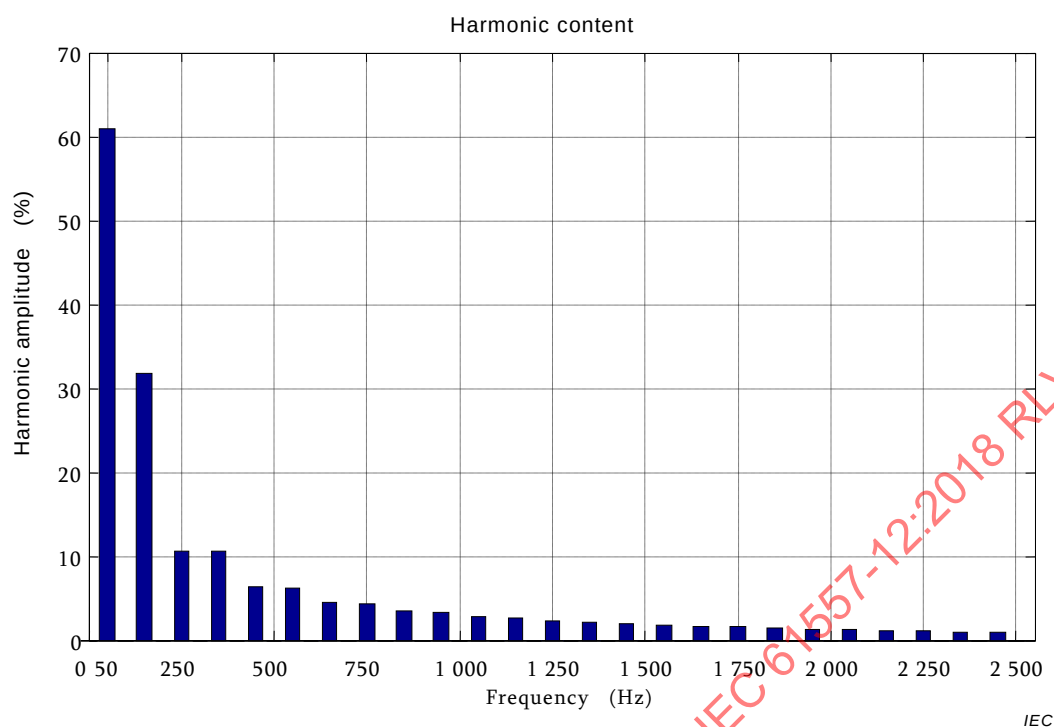


**Figure 5 – Spectral content for odd harmonics influence test on active power measurement**

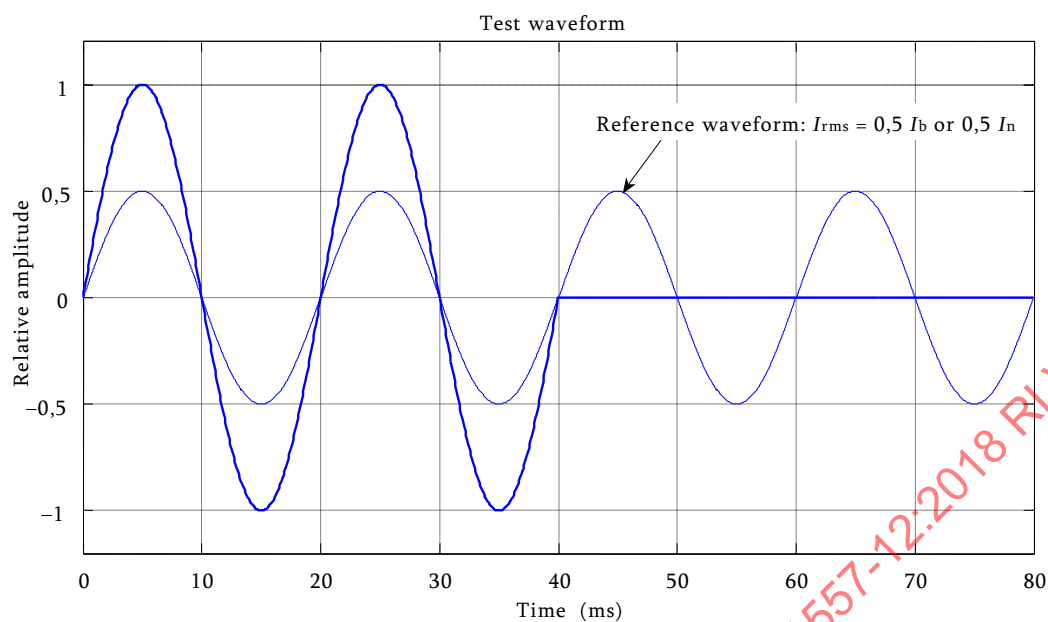
**NOTE 1** The reference waveform and the distorted waveform result in approximately the same active power or active energy, but some variation is expected due to the variation in rise time and start time shown in Figure 4. It is recommended to use a reference meter to verify test results.

**NOTE 2** The curve, diagram and values are given at 50 Hz. For other frequencies, they ~~must~~ shall be adapted accordingly.

### 6.2.5.3 Influence of sub-harmonics

The peak value shall be equal to  $\sqrt{2} \times I_b$  or to  $\sqrt{2} \times I_n$ . The cycle of the signal is made of two full waves followed by two non-signal periods.

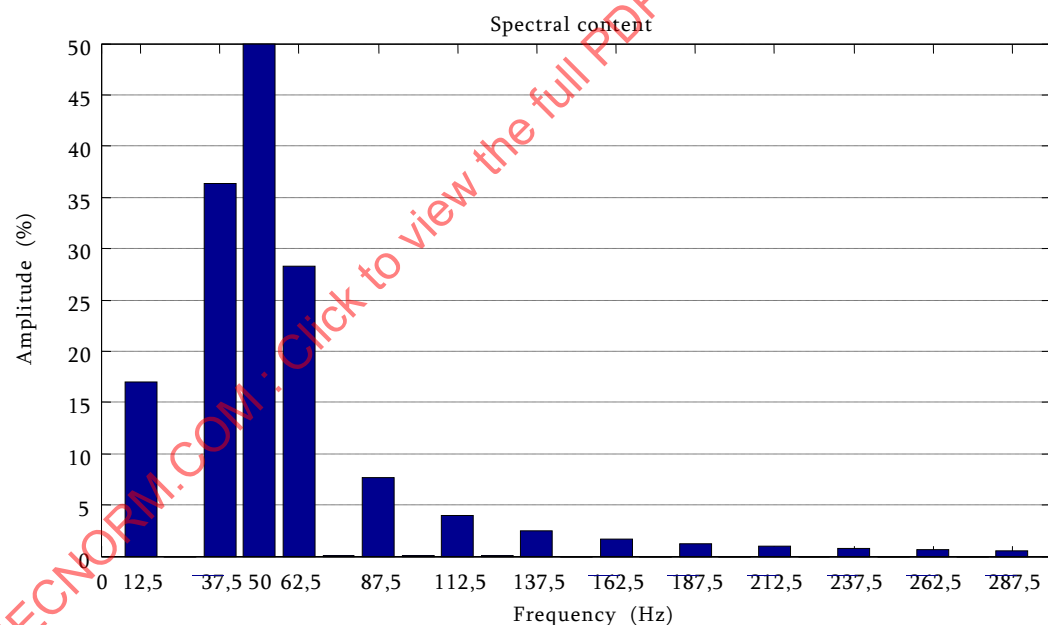
The test waveform shall be generated according to Figure 6 and Figure 7.



NOTE The reference results in the same active power or active energy.

IEC

**Figure 6 – Waveform for sub-harmonics influence test on active power measurement**



IEC

**Figure 7 – Spectral content for sub-harmonics influence test on active power measurement**

~~NOTE 1 The reference results in the same active power or active energy.~~

~~NOTE 2~~ The curve, diagram and values are given at 50 Hz. For other frequencies, they ~~must~~ shall be adapted accordingly.

## 6.2.6 Apparent power

The test on the apparent power is not mandatory if at least two of the following functions are tested:

- active power;
- reactive power;
- power factor.

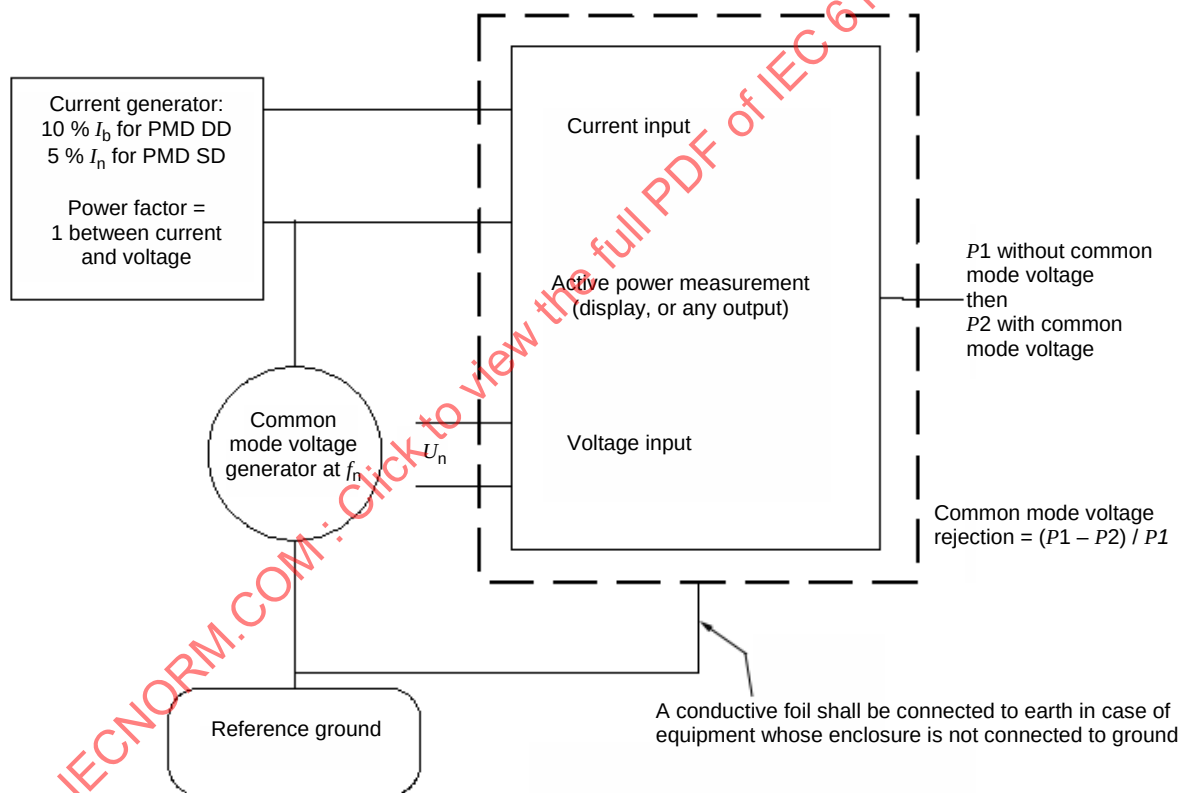
### 6.2.7 Power factor

The test on the power factor is not mandatory if at least two of the following functions are tested:

- active power;
- reactive power;
- apparent power.

### 6.2.8 Common mode voltage rejection test

For each isolated current input, the following test (as described in Figure 8) shall be made. It consists in calculating the difference between two measurements,  $P1$  without common mode voltage and  $P2$  with a common mode voltage applied between the current inputs and the reference ground.

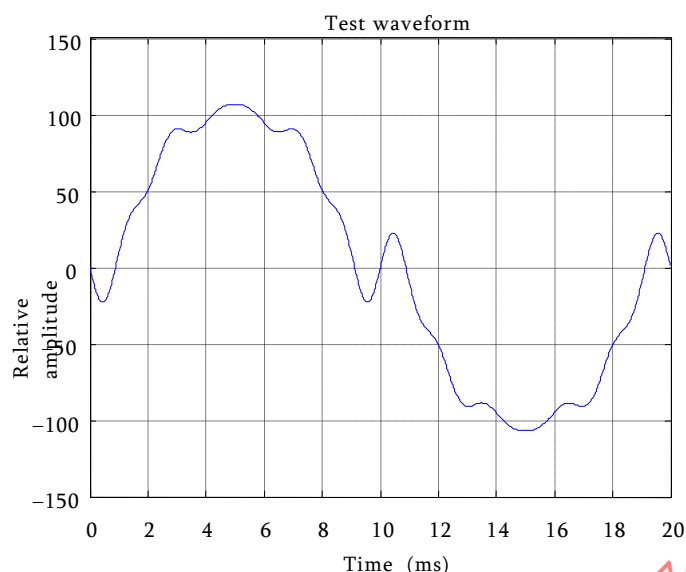


IEC

Figure 8 – Common mode voltage influence testing

### 6.2.9 Frequency

With the set-up of Table 19, the waveform in Figure 9 is generated:



**NOTE** The relative amplitude is expressed in percent of fundamental peak value.

**NOTE** The curve is given at 50 Hz. For other frequencies, it ~~must~~ shall be adapted accordingly.

The curve has the following expression:

$$x(t) = 100 \sin(\omega t) - \sum_{k=1}^7 a_{2k+1} \sin((2k+1)\omega t)$$

with  $a_3 = 10$ ,  $a_5 = 12$ ,  $a_7 = 10$ ,  $a_9 = 3$ ,  $a_{11} = 7$ ,  $a_{13} = 6$ ,  $a_{15} = 1$

**Figure 9 – Waveform for harmonics influence test on frequency measurement**

## 6.2.10 Measurement of voltage harmonics and $THD_u$

### 6.2.10.1 General

The following tests shall be performed at rated voltage  $U_n$  at 45 Hz, 50 Hz and 55 Hz for 50 Hz rated frequency, and at 55 Hz, 60 Hz and 65 Hz for 60 Hz rated frequency.

### 6.2.10.2 Test with a sinusoidal waveform

The test shall be performed with a pure sinusoidal voltage waveform, with frequencies taken from 6.2.10. The PMD shall not measure any voltage harmonics component and  $THD_u$  with amplitude above  $0,001 5 \times C \times U_n$  ( $C$  is the function performance class).

### 6.2.10.3 Test with a ~~square~~ distorted waveform

~~Test shall be performed with a square voltage waveform with frequencies taken from 6.1.7. PMD shall measure the voltage harmonics components within the uncertainty limits defined in Table 36.~~

~~The spectral content of the square waveform shall include at least the upper limit of the bandwidth specified in 4.7.13 without alteration.~~

The test shall be performed with at least one distorted waveform with fundamental frequencies taken from 6.2.10. All the specified harmonics and  $THD_i$  shall be tested with respect to the uncertainty limits defined in Table 38 and Table 39 respectively.

## 6.2.11 Measurement of current harmonics and $THD_i$

### 6.2.11.1 General

The following tests shall be performed at rated current  $I_n$  or  $I_b$  and at 45 Hz, 50 Hz and 55 Hz for 50 Hz rated frequency, and at 55 Hz, 60 Hz and 65 Hz for 60 Hz rated frequency.

### 6.2.11.2 Test with a sinusoidal waveform

The test shall be performed with a pure sinusoidal current waveform, with frequencies taken from 6.2.11. The PMD shall not measure any current harmonics component and  $THD_i$  with amplitude above  $0,005 \times C \times I_n$  (or  $I_b$ ). ( $C$  is the function performance class).

### 6.2.11.3 Test with a ~~square~~ distorted waveform

~~Test shall be performed with a square current waveform with frequencies taken from 6.1.8. PMD shall measure the current harmonics components within the uncertainty limits defined in Table 39.~~

~~The spectral content of the square waveform shall include at least the upper limit of the bandwidth specified in 4.7.14 without alteration.~~

The test shall be performed with at least one distorted waveform with fundamental frequencies taken from 6.2.11. All the specified harmonics and  $THD$  shall be tested with respect to the uncertainty limits defined in Table 42 and Table 43 respectively.

## 6.2.12 Dips and swells

The tests shall at least be done with rectangular dip or swell modulation and with a dip or swell duration of one full cycle.

The test of the influence quantities can be omitted if this test has been done during the voltage RMS measurements.

## 6.2.13 Voltage interruptions

The tests shall at least be done for a voltage interruption of one full cycle.

## 6.2.14 Outputs tests

### 6.2.14.1 General

PMD shall be tested under reference conditions.

### 6.2.14.2 Test of compliance voltage and effect of variation of load.

This test shall only be carried out on a PMD with analog outputs that are a current signal.

Testing shall be carried out at the minimum and maximum (low and high) values of the analog output. At each point the output load resistance shall be set at 10 % and 90 % of its specified maximum value:

- the supply voltage for the analog output, if supplied from a source external to the PMD, shall be set to its minimum and maximum specified values;

- the supply of the PMD shall be set to its specified minimum and maximum values or in accordance with the rated voltage  $\pm 15\%$ .

The worst case maximum and minimum readings at the low and high outputs shall be noted. The percentage uncertainty  $E$  shall be determined using the following formula:

$$E = \frac{N - W}{U} \times 100$$

where  $N$  is the rated signal,  $W$  is the worst case signal and  $U$  is the output span.

#### 6.2.14.3 Test of ripple content

The ripple content of the analog output shall be tested at rated minimum and maximum values of the output. The ripple content shall be measured as a peak-to-peak value.

#### 6.2.14.4 Tests of analog output response time

The response time for an increasing input shall be determined for an input step intended to produce a change in output signal from 0 % to 100 % of the output range as the time for the output to reach 90 % of the output range.

The response time for a decreasing input shall be determined for an input step intended to produce a change in output signal from 100 % to 0 % of the output range as the time for the output to reach 10 % of the output range.

#### 6.2.14.5 Test of limit value of analog output

The limiting value of the analog output shall be tested by varying the input parameter between minimum and maximum values. Any programmable features of the output, such as input offset or full-scale value, shall be set so as to provide the maximum overloads.

### 6.2.15 Climatic tests

#### 6.2.15.1 General

After an appropriate recovering time after each climatic test, the PMD shall show no damage or change of the information and shall operate within its specifications.

#### 6.2.15.2 Dry heat test

The test shall be carried out according to IEC 60068-2-2, under the following conditions:

- PMD in non-operating condition;
- temperature:  $+70\text{ °C} \pm 2\text{ °C}$  for K40 PMD and K55 PMD;  
 $+85\text{ °C} \pm 2\text{ °C}$  for K70 PMD;
- duration of test: 16 h.

#### 6.2.15.3 Cold test

The test shall be carried out according to IEC 60068-2-1, under the following conditions:

- PMD in non-operating condition;
- temperature:  $-25\text{ °C} \pm 3\text{ °C}$  for K40 PMD and K55 PMD;  
 $-40\text{ °C} \pm 3\text{ °C}$  for K70 PMD;
- duration of test: 16 h.

#### 6.2.15.4 Damp heat cyclic test

The test shall be carried out according to IEC 60068-2-30, under the following conditions:

- voltage and auxiliary circuits energised with rated voltage;
- without any current in the current circuits;
- variant 1;
- upper temperature:
  - +40 °C ± 2 °C for K40 PMD;
  - +55 °C ± 2 °C for K55 PMD;
  - +70 °C ± 2 °C for K70 PMD;
- no special precautions shall be taken regarding the removal of surface moisture;
- duration of the test: 6 cycles.

The damp heat test also serves as a corrosion test. The result is judged visually. No trace of corrosion likely to affect the functional properties of the PMD shall be apparent.

#### 6.2.16 EMC tests

~~The PMD shall be tested in accordance with IEC 61326-1 Table 2 (industrial location).~~

For EM RF fields and conducted RF the following requirements apply:

- the auxiliary circuits of the PMD shall be energised with the rated voltage,
- the PMD shall be tested in its operating conditions,

with basic current  $I_b$ , respectively rated current  $I_n$ , rated voltage, power factor equal to 1 (or equal to 0 for reactive power) whichever is applicable.

Variations due to the EM influence quantities as defined in ~~the previous tables~~ Table 9, Table 13 and Table 17 (limits of variation due to influence quantities) apply.

#### 6.2.17 Start-up tests

The starting time of PMD without communication or local user interface shall be tested with the following procedure:

- configure PMD scales to maximum possible values without causing calculation overflows;
- set up the kWh/pulse value to the minimum possible value;
- set up the optical pick up probe or other pulse pick-up device; a solid state relay or a mechanical relay may be used as the energy pulse output device;
- power down the PMD;
- apply  $U_{max}$  and  $I_{max}$ ,  $PF = 1,0$  on all voltage and current measurement inputs;
- power up the PMD and measure the time from the application of power until the first energy pulse registered by the probe.

#### 6.2.18 Gapless measurement test

The gapless nature of the measurement process shall be tested using:

- a) voltage waveform as in reference conditions
- b) current varying between two levels:
  - 1)  $I_b$  or  $I_n$  over periods of 1 s
  - 2) 50 %  $I_b$  or 50 %  $I_n$  over periods of 0,2 s

The measurement uncertainty of the following quantities shall be checked against the intrinsic uncertainty limits after a test period of at least 1 min: active energy, reactive energy, apparent energy according to Table 8, Table 12, Table 16.

It is recommended to use a reference meter to perform the test.

#### **6.2.19 ~~Type tests of PMD-A~~ Safety tests**

~~Tests shall be done according to Clause 6 of IEC 61000-4-30 and if necessary according to this standard.~~

Tests shall be conducted according to IEC 61010-1 and IEC 61010-2-030 test requirements.

### **6.3 Routine tests**

#### **6.3.1 Protective bonding test**

The PMD shall be tested in accordance with Annex F of IEC 61010-1:2010.

#### **6.3.2 Dielectric strength test**

The PMD shall be tested in accordance with Annex F of IEC 61010-1:2010.

#### **6.3.3 Uncertainty test**

~~Every basic measurement function (e.g. current, voltage, power, etc.), which is accessible to the user, shall be submitted to a routine test.~~

~~NOTE – it is strongly recommended that the results of this test should be recorded.~~

The intrinsic uncertainty of each main function (e.g. voltage, current or power measurement) which is accessible to the user shall be verified throughout the measuring range.

For each test, it is recommended to verify the intrinsic uncertainty at a minimum of three test points spanning the measurement range.

The operating uncertainty can be evaluated according to Annex G on a statistical basis.

It is recommended to record the test results of the routine test.

## Annex A (informative)

### Metering, measuring and monitoring applications

#### A.1 Applications on demand side and supply side

Measurement applications can be roughly summarized according to Figure A.1.

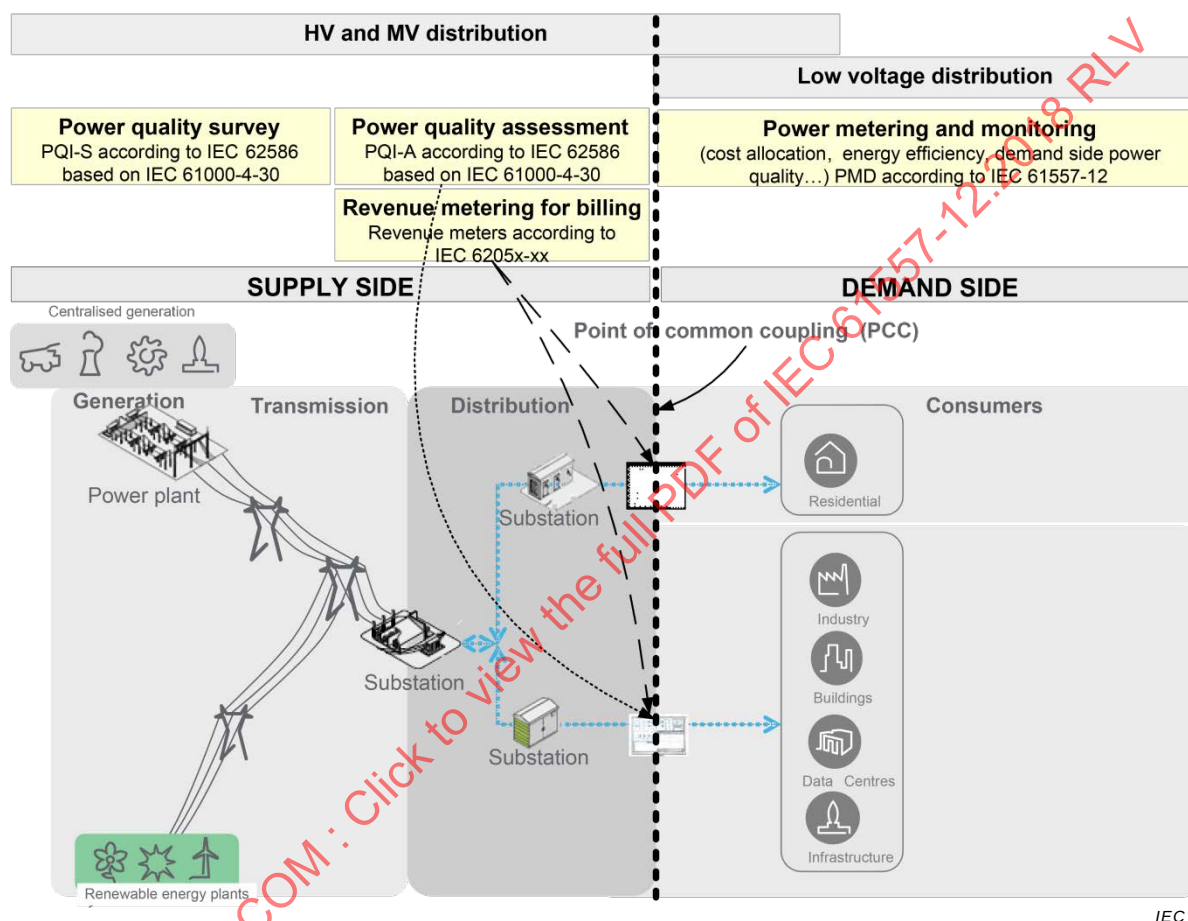


Figure A.1 – Simplified overview of measurement applications on supply side and demand side

#### A.2 Link between applications, devices and standards

Table A.1 shows the relevant device and associated standards related to the main measurement applications.

**Table A.1 – Main measurement applications**

| Measurement Application                                                                                                                                                                                                                                    | Relevant IEC product standards             | Device name according to standards             | Usual device name                                                                                                                                                    | Complementary explanations                                                                                                                                 |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Billing                                                                                                                                                                                                                                                    | IEC 62052-11 and IEC 62053-2x <sup>a</sup> | Electricity metering equipment                 | Revenue meter<br>Electricity meter for billing<br>Utility meter<br>Billing meter                                                                                     | Energy metering for billing applications (e.g. utility billing a landlord or a mall owner).<br><br>Transmission grid-level metering.<br><br>Shadow-billing |
| Energy usage analysis                                                                                                                                                                                                                                      | IEC 61557-12 <sup>b</sup>                  | Power metering and monitoring device (PMD-I)   | Power meter<br>Energy meter                                                                                                                                          | Energy cost and usage analysis (for cost allocation within a company or for energy efficiency purposes)                                                    |
| Basic power monitoring                                                                                                                                                                                                                                     | IEC 61557-12                               | Power metering and monitoring device (PMD-II)  | Power meter<br>Power monitor<br>Power monitor device<br>Power energy monitoring device<br>Power analyser<br>Multifunction meter<br>Measuring multifunction equipment | Basic demand side quality analysis + energy cost and usage analysis                                                                                        |
| Advanced power monitoring                                                                                                                                                                                                                                  | IEC 61557-12                               | Power metering and monitoring device (PMD-III) | Power meter<br>Power monitor<br>Power monitor device<br>Power energy monitoring device<br>Power analyser<br>Multifunction meter<br>Measuring multifunction equipment | Advanced demand side quality analysis + energy cost and usage analysis                                                                                     |
| Power quality analysis                                                                                                                                                                                                                                     | IEC 62586-1                                | Power quality instrument (PQI)                 | Power quality instrument<br>Power quality analyser<br>Power analyser<br>Network analyser                                                                             | Power quality analysis according to IEC 61000-4-30 for power quality survey (e.g. according to EN 50160)                                                   |
| <sup>a</sup> Regional regulations or standards may apply, for example MID, ANSI,... as well as utility specifications.<br><sup>b</sup> Energy meters complying with IEC 62052-11 and IEC 62053-2x can also be used for energy usage analysis applications. |                                            |                                                |                                                                                                                                                                      |                                                                                                                                                            |

## Annex B (informative)

### Definitions of electrical parameters

This informative annex gives the preferred definition and method for calculating quantities. Manufacturers using other methods will have to specify their own method in technical documentation.

This informative annex cannot be considered as a requirement for PMD-A. See definitions for PMD-A in this standard which refer only to IEC 61000-4-30 concerning measuring aspects.

Table A.1 gives the list of symbols used in this annex. Table A.2 specifies how to calculate parameters.

**Table A.1 – Symbols definition**

| Symbol                                                           | Definition                                                                                                   |
|------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------|
| $U_{\text{resid}}$                                               | Residual voltage                                                                                             |
| $N$                                                              | Total number of samples by period (period 20 ms for instance)                                                |
| $k$                                                              | Number of sample in the period ( $0 \leq k < N$ )                                                            |
| $p$                                                              | Number of phase ( $p = 1, 2$ or $3$ ; or $p = a, b, c$ ; or $p = r, s, t$ ; or $p = R, Y, B$ ). <sup>a</sup> |
| $g$                                                              | Number of phase ( $g = 1, 2$ or $3$ ; or $g = a, b, c$ ; or $g = r, s, t$ ; or $g = R, Y, B$ ). <sup>a</sup> |
| $i_{pk}$                                                         | Phase $p$ current sampling number $k$                                                                        |
| $v_{pNk}$                                                        | Phase $p$ to Neutral voltage sampling number $k$                                                             |
| $v_{gNk}$                                                        | Phase $g$ to Neutral voltage sampling number $k$                                                             |
| $\varphi_p$                                                      | Phase angle between current and voltage for phase $p$ , see Figure A.2                                       |
| $h_i$                                                            | Harmonic component of rank $i$                                                                               |
| <sup>a</sup> $p$ and $g$ are variable meaning a number of phase. |                                                                                                              |

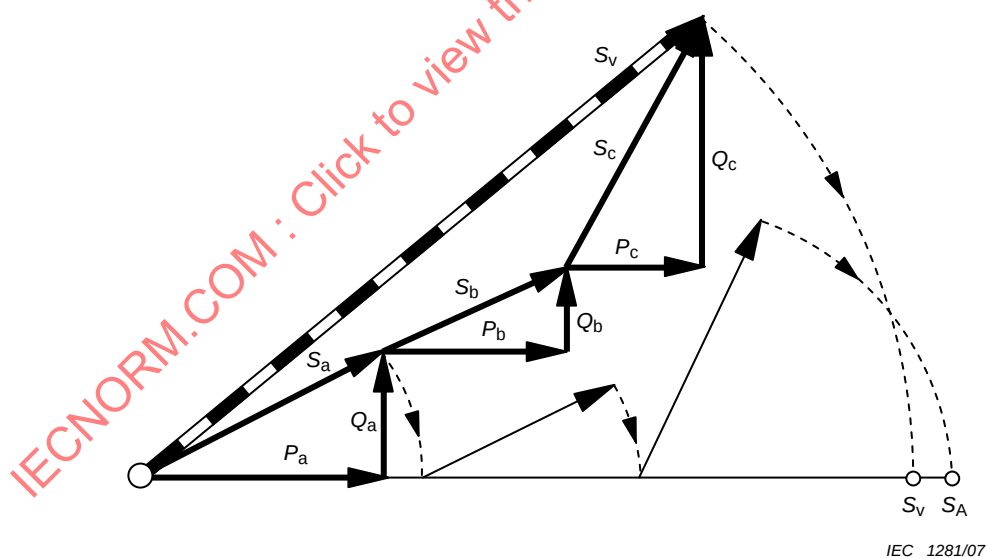
**Table A.2 — Calculation definitions of electrical parameters,  
for 3 phase unbalanced system with neutral**

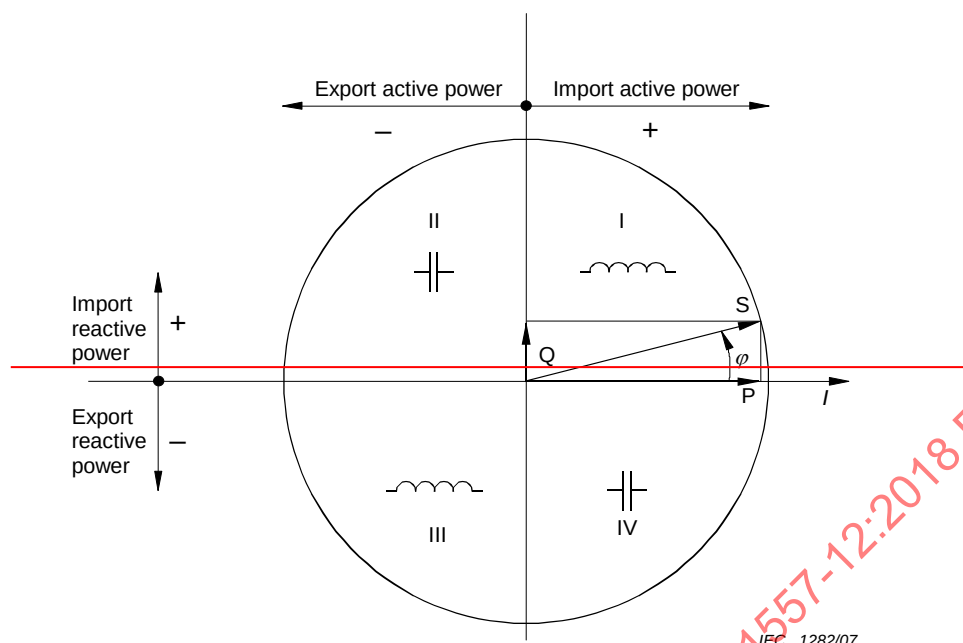
These methods are derived from IEEE Std 1459-2000:

| Item                                 | Definition                                                                                                                                                                               | Not relevant method                                                                      |
|--------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
| R.m.s current for phase $p$          | $I_p = \sqrt{\frac{\sum_{k=0}^{N-1} i_{pk}^2}{N}}$                                                                                                                                       |                                                                                          |
| R.m.s neutral current                | $I_N = \sqrt{\frac{\sum_{k=0}^{N-1} (i_{1k} + i_{2k} + i_{3k})^2}{N}}$                                                                                                                   | Vectorial sum of phase currents.                                                         |
| $L_p-N$ r.m.s. voltage               | $V_{pN} = \sqrt{\frac{\sum_{k=0}^{N-1} v_{pNk}^2}{N}}$                                                                                                                                   |                                                                                          |
| $L_p-L_g$ r.m.s. voltage             | $U_{pg} = \sqrt{\frac{\sum_{k=0}^{N-1} (v_{gNk} - v_{pNk})^2}{N}}$                                                                                                                       | Vectorial difference of line $L$ voltage and neutral voltage: $U_{pg} = V_{pN} - V_{gN}$ |
| Active power for phase $p$           | $P_p = \frac{1}{N} \cdot \sum_{k=0}^{N-1} (v_{pNk} \times i_{pk})$                                                                                                                       |                                                                                          |
| Apparent power for phase $p$         | $S_p = V_{pN} \times I_p$                                                                                                                                                                |                                                                                          |
| Sign of reactive power (SignQ)       | $\text{SignQ}(\varphi_p) = +1 \text{ if } \varphi_p \in [0^\circ - 180^\circ] \text{ —a}$<br>$\text{SignQ}(\varphi_p) = -1 \text{ if } \varphi_p \in [180^\circ - 360^\circ] \text{ —a}$ |                                                                                          |
| Reactive power for phase $p$         | $Q_p = \text{SignQ}(\varphi_p) \times \sqrt{S_p^2 - P_p^2}$                                                                                                                              |                                                                                          |
| Total active power                   | $P = P_1 + P_2 + P_3$                                                                                                                                                                    |                                                                                          |
| Total reactive power (vector)        | $Q_V = Q_1 + Q_2 + Q_3$                                                                                                                                                                  |                                                                                          |
| Total apparent power (vector)        | $S_V = \sqrt{P^2 + Q_V^2}$                                                                                                                                                               |                                                                                          |
| Total apparent power (arithmetic)    | $S_A = S_1 + S_2 + S_3$                                                                                                                                                                  |                                                                                          |
| Total reactive power (arithmetic) —b | $Q_A = \sqrt{S_A^2 - P^2} \text{ —b}$                                                                                                                                                    |                                                                                          |
| Power factor (vector)                | $PF_V = \frac{P}{S_V}$                                                                                                                                                                   |                                                                                          |
| Power factor (arithmetic)            | $PF_A = \frac{P}{S_A}$                                                                                                                                                                   |                                                                                          |

**Table A.2 (continued)**

| Item                                                                                                       | Definition                                                                                                                                                                                       | Not relevant method |
|------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------|
| Voltage dips                                                                                               | $U_{\text{dip}}(\%) = \frac{U_n - U_{\text{resid}}}{U_n}$                                                                                                                                        |                     |
| Voltage swells                                                                                             | $U_{\text{swl}}(\%) = \frac{U_{\text{resid}} - U_n}{U_n}$                                                                                                                                        |                     |
| Amplitude voltage unbalance                                                                                | $U_{\text{nba}} = \frac{\max\{ U_{12} - U_{\text{avg}} ,  U_{23} - U_{\text{avg}} ,  U_{31} - U_{\text{avg}} \}}{U_{\text{avg}}}$ where<br>$U_{\text{avg}} = \frac{U_{12} + U_{23} + U_{31}}{3}$ |                     |
| Total Harmonic Distortion referring to r.m.s. value<br>( $THD-R_u$ for voltage and $THD-R_i$ for current). | $THD-R(\%) = \frac{\sqrt{\sum_{i=2} h_i^2}}{\text{rms value}}$<br>r.m.s. value = $U_{\text{rms}}$ for $THD-R_u$ , $I_{\text{rms}}$ for $THD-R_i$                                                 |                     |
| total harmonic distortion referring to fundamental<br>( $THD_u$ for voltage and $THD_i$ for current).      | $THD(\%) = \frac{\sqrt{\sum_{i=2} h_i^2}}{h_1}$                                                                                                                                                  |                     |
| <sup>a</sup> See Figure A.2.<br><sup>b</sup> This power is unsigned.                                       |                                                                                                                                                                                                  |                     |

**Figure A.1 — Arithmetic and vector apparent powers in sinusoidal situation**



NOTE 1 — Diagram in accordance with clauses 12 and 14 of IEC 60375.

NOTE 2 — Reference of this diagram is the current vector (fixed on right hand line).

NOTE 3 — The voltage vector  $V$  varies its direction according to the phase angle  $\varphi$ .

NOTE 4 — The phase angle  $\varphi$  between voltage  $V$  and current  $I$  is taken to be positive in the mathematical sense (counter clockwise).

**Figure A.2 — Geometric representation of active and reactive power**

## B.1 General

Annex B gives the common definitions and methods for measuring electrical quantities. Some of these definitions can be found in IEEE 1459. Manufacturers using other methods should specify their own methods in the technical documentation.

## B.2 Definitions in the presence of a neutral

Table B.1 gives the list of symbols used in Annex B. Table B.2 specifies how to calculate the parameters.

**Table B.1 – Definition of symbols**

| Symbol                | Definition                                                                                                                                                                                                    |
|-----------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $N$                   | Number of samples in one fundamental period                                                                                                                                                                   |
| $M$                   | Number of samples used for measurement (length of measurement window)                                                                                                                                         |
| $\Delta t$            | Duration of the measurement window in seconds                                                                                                                                                                 |
| $k$                   | Index of a sample within the measurement window ( $0 \leq k \leq M-1$ )                                                                                                                                       |
| $p$                   | Index of a phase ( $p = 1, 2$ or $3$ ; or $p = a, b, c$ ; or $p = r, s, t$ ; or $p = R, Y, B$ )                                                                                                               |
| $g$                   | Index of a phase ( $g = 1, 2$ or $3$ ; or $g = a, b, c$ ; or $g = r, s, t$ ; or $g = R, Y, B$ )                                                                                                               |
| $N_{ph}$              | Number of phases excluding neutral (generally 1 or 3)                                                                                                                                                         |
| $i_{pk}$              | Phase $p$ current sample number $k$                                                                                                                                                                           |
| $i_{Nk}$              | Measured neutral current sample number $k$                                                                                                                                                                    |
| $v_{pk}$              | Phase $p$ to neutral voltage sample number $k$                                                                                                                                                                |
| $v_{gk}$              | Phase $g$ to neutral voltage sample number $k$                                                                                                                                                                |
| $u_{pgk}$             | Phase $p$ to phase $g$ voltage sample number $k$ : $u_{pgk} = v_{pk} - v_{gk}$                                                                                                                                |
| $\varphi_p$           | Phase angle between the fundamental current and the fundamental voltage for phase $p$                                                                                                                         |
|                       |                                                                                                                                                                                                               |
| $h_{max}$             | Maximum harmonic rank used for harmonic measurements                                                                                                                                                          |
| $I_{i,p}$             | Harmonic current of rank $i$ in phase $p$ (RMS value)                                                                                                                                                         |
| $I_{N,i}$             | Harmonic current of rank $i$ in the neutral (RMS value)                                                                                                                                                       |
| $V_{i,p}$             | Harmonic phase $p$ to neutral voltage of rank $i$ (RMS value)                                                                                                                                                 |
| $\varphi_{i,p}$       | Phase angle between harmonic current and harmonic voltage at rank $i$ on phase $p$                                                                                                                            |
| $U_{i,pg}$            | Harmonic phase $p$ to phase $g$ voltage of rank $i$ (RMS value)                                                                                                                                               |
| $I_{1,p,maxdem}$      | Maximum 15 min or 30 min demand value of fundamental current for phase $p$                                                                                                                                    |
|                       |                                                                                                                                                                                                               |
| $X$                   | Generic symbol of an electrical quantity within a formula, to be replaced by $I$ , $I_p$ or $I_N$ for current, by $V$ or $V_p$ for phase to neutral voltage, or by $U$ or $U_{pg}$ for phase to phase voltage |
| $X_{neg}$             | Negative-sequence component of electrical quantity $X$ considering its decomposition into symmetrical components                                                                                              |
| $X_{pos}$             | Positive-sequence component of electrical quantity $X$ considering its decomposition into symmetrical components                                                                                              |
| $X_{zero}$            | Zero-sequence component of electrical quantity $X$ considering its decomposition into symmetrical components                                                                                                  |
|                       |                                                                                                                                                                                                               |
| $X_{1cy} (X_{1/2cy})$ | RMS value of electrical quantity $X$ (current or voltage) measured over 1(1/2) fundamental cycle and refreshed each cycle                                                                                     |
| $X_{ref}$             | Reference r.m.s value used to detect and characterize dips and swells, may be a fixed value or a time-varying value                                                                                           |
| $X_{res}$             | Lowest $X_{1cy}$ or $X_{1/2cy}$ value measured during a dip event                                                                                                                                             |
| $X_{swell}$           | Highest $X_{1cy}$ value measured during a swell event                                                                                                                                                         |

The calculation methods in Table B.2 are reference algorithms for computing electrical quantities in the general case.

Depending on the characteristics of a PMD, different implementations are possible. Manufacturers of PMD not using these formulas should document the calculation methods used in the product.

**Table B.2 – Calculation definitions for electrical parameters**

| Item                                                                                                  | Symbol and definition                                                                                                                                                                                                                                                                                                       |
|-------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>RMS values</b>                                                                                     |                                                                                                                                                                                                                                                                                                                             |
| RMS current in phase $p$                                                                              | $I_p = \sqrt{\frac{\sum_{k=0}^{M-1} ip_k^2}{M}}$                                                                                                                                                                                                                                                                            |
| Phase $p$ to neutral RMS voltage                                                                      | $V_p = \sqrt{\frac{\sum_{k=0}^{M-1} vp_k^2}{M}}$                                                                                                                                                                                                                                                                            |
| Phase $p$ to phase $g$ RMS voltage                                                                    | $U_{pg} = \sqrt{\frac{\sum_{k=0}^{M-1} (upg_k)^2}{M}}$                                                                                                                                                                                                                                                                      |
| Total (or average) RMS current or voltage                                                             | $X = \frac{\sum_{p=1}^{N_{ph}} X_p}{N_{ph}}$                                                                                                                                                                                                                                                                                |
| Calculated RMS neutral current                                                                        | $I_N = \sqrt{\frac{\sum_{k=0}^{M-1} (i1_k + i2_k + i3_k)^2}{M}}$                                                                                                                                                                                                                                                            |
| <b>Phase powers</b>                                                                                   |                                                                                                                                                                                                                                                                                                                             |
| Active power for phase $p$                                                                            | $P_p = \frac{1}{M} \cdot \sum_{k=0}^{M-1} (vp_k \times ip_k)$                                                                                                                                                                                                                                                               |
| Apparent power for phase $p$                                                                          | $S_p = V_p \times I_p$                                                                                                                                                                                                                                                                                                      |
| Reactive power for phase $p$ , power triangle formula (also known as Fryze's definition) <sup>a</sup> | $Q_p = Q_{p_{\text{trian}}} = \text{Sign}Q(\phi_p) \times \sqrt{S_p^2 - P_p^2}$ <p>with</p> $\text{Sign}Q(\phi_p) = +1 \text{ if } \phi_p \in [0^\circ - 180^\circ]$ $\text{Sign}Q(\phi_p) = -1 \text{ if } \phi_p \in [180^\circ - 360^\circ]$ <p>NOTE This quantity is sometimes referred to as the non-active power.</p> |
| Reactive power for phase $p$ , quadrature phase shift formula <sup>a,c</sup>                          | $Q_p = Q_{p_{\text{quad}}} = \frac{1}{M} \cdot \sum_{k=0}^{M-1} (vp_{k-N/4} \times ip_k)$                                                                                                                                                                                                                                   |
| Reactive power for phase $p$ , Budeanu's harmonic definition <sup>a,c</sup>                           | $Q_p = Q_{p_{\text{harm}}} = \sum_{i=1}^{h_{\max}} I_{i,p} \cdot V_{i,p} \cdot \sin(\phi_{i,p})$                                                                                                                                                                                                                            |
| Distortion power                                                                                      | $D_p = \sqrt{S^2 - P^2 - Q^2}$                                                                                                                                                                                                                                                                                              |
| <b>Phase energies</b>                                                                                 |                                                                                                                                                                                                                                                                                                                             |
| Active energy for phase $p$                                                                           | $E_p = P_p \cdot \Delta t$                                                                                                                                                                                                                                                                                                  |
| Reactive energy for phase $p$                                                                         | $E_{rp} = Q_p \cdot \Delta t$                                                                                                                                                                                                                                                                                               |
| Apparent energy for phase $p$                                                                         | $E_{ap} = S_p \cdot \Delta t$                                                                                                                                                                                                                                                                                               |

| Item                                                                                                            | Symbol and definition                                                                                               |
|-----------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------|
| <b>Total powers</b>                                                                                             |                                                                                                                     |
| Total active power                                                                                              | $P = \sum_{p=1}^{N_{ph}} P_p$                                                                                       |
| Total reactive power (vector)                                                                                   | $Q_V = \sum_{p=1}^{N_{ph}} Q_p$                                                                                     |
| Total apparent power (vector)                                                                                   | $S_V = \sqrt{P^2 + Q_V^2}$                                                                                          |
| Total apparent power (arithmetic)                                                                               | $S_A = \sum_{p=1}^{N_{ph}} S_p$                                                                                     |
| Total reactive power (arithmetic) <sup>b</sup>                                                                  | $Q_A = \sqrt{S_A^2 - P^2}$                                                                                          |
| <b>Power factors</b>                                                                                            |                                                                                                                     |
| Power factor for phase $p$                                                                                      | $PF_p = \frac{P_p}{S_p}$<br><br>NOTE The power factor is sometimes defined with an absolute value on the numerator. |
| Displacement power factor for phase $p$                                                                         | $DPF_p = \cos(\varphi_p)$                                                                                           |
| Total power factor (vector)                                                                                     | $PF_V = \frac{P}{S_V}$                                                                                              |
| Total power factor (arithmetic)                                                                                 | $PF_A = \frac{P}{S_A}$                                                                                              |
| <b>Fundamental powers</b>                                                                                       |                                                                                                                     |
| Fundamental active power on phase $p$                                                                           | $P_{1,p} = I_{1,p} \cdot V_{1,p} \cdot \cos(\varphi_p)$                                                             |
| Fundamental reactive power on phase $p$                                                                         | $Q_{1,p} = I_{1,p} \cdot V_{1,p} \cdot \sin(\varphi_p)$                                                             |
| Fundamental apparent power on phase $p$                                                                         | $S_{1,p} = I_{1,p} \cdot V_{1,p}$                                                                                   |
| <b>Distortion indicators</b>                                                                                    |                                                                                                                     |
| Harmonic distortion of electrical quantity $X$ ( $I_p$ , $V_p$ , or $U_{pg}$ ) – Phase quantity                 | $THDX_p = \frac{\sqrt{\sum_{i=2}^{h_{max}} X_{i,p}^2}}{X_{1,p}}$                                                    |
| Harmonic distortion referred to RMS of electrical quantity $X$ ( $I_p$ , $V_p$ , or $U_{pg}$ ) – Phase quantity | $THD_{RX_p} = \frac{\sqrt{\sum_{i=2}^{h_{max}} X_{i,p}^2}}{X_p}$                                                    |
| Total harmonic distortion of electrical quantity $X$ ( $I$ , $V$ , or $U$ )                                     | $THDX = \frac{\sum_{p=1}^{N_{ph}} THDX_p}{N_{ph}}$                                                                  |
| Total harmonic distortion referred to RMS of electrical quantity $X$ ( $I$ , $V$ , or $U$ )                     | $THD_{RX} = \frac{\sum_{p=1}^{N_{ph}} THD_{RX_p}}{N_{ph}}$                                                          |

| Item                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Symbol and definition                                                                                                                                                     |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Total distortion ratio of electrical quantity $X$ ( $I$ , $V$ , or $U$ ) – Phase quantity                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | $TDRX_p = \frac{\sqrt{X_p^2 - X_{1,p}^2}}{X_{1,p}}$ <p>NOTE Unlike the <math>THD</math>, this distortion ratio contains the contribution of interharmonic components.</p> |
| Total distortion ratio of electrical quantity $X$ ( $I$ , $V$ , or $U$ )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | $TDRX = \frac{\sum_{p=1}^{N_{ph}} TDRX_p}{N_{ph}}$                                                                                                                        |
| Distortion active power on phase $p$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | $PD_p = P_p - P_{1,p}$                                                                                                                                                    |
| Total distortion active power                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       | $PD = \sum_{p=1}^{N_{ph}} PD_p$                                                                                                                                           |
| Total demand distortion (current) on phase $p$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | $TDD_p = \frac{\sqrt{\sum_{i=2}^{h_{max}} I_{i,p}^2}}{I_{1,p,maxdem}}$                                                                                                    |
| <b>Unbalance indicators</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |                                                                                                                                                                           |
| Amplitude unbalance for electrical quantity $X$ ( $I_p$ , $V_p$ , or $U_{pg}$ ) – Phase quantity, in percent                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | $X_{nba,p} = 100 \cdot \frac{X_p - X_{avg}}{X_{avg}} \quad \text{where} \quad X_{avg} = \frac{\sum_{p=1}^{N_{ph}} X_p}{N_{ph}}$                                           |
| Total amplitude unbalance for electrical quantity $X$ ( $I$ , $V$ , or $U$ ), in percent                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            | $X_{nba} = \max \left\{ \left  X_{nba,p} \right  \right\}_{p=1..N_{ph}}$                                                                                                  |
| Amplitude and angle unbalance for electrical quantity $X$ ( $I$ , $V$ , or $U$ )                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    | $X_{nb} = 100 \cdot \frac{X_{neg}}{X_{pos}}$ <p>NOTE There is no phase quantity for this type of unbalance.</p>                                                           |
| <b>Internal power quality indicators</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                                                                                                                                           |
| 1-cycle RMS value of electrical quantity $X$ (generally voltage) on phase $p$ .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | $X_{p1cy} = \sqrt{\frac{\sum_{k=0}^{N-1} x_{p_k}^2}{N}}$                                                                                                                  |
| Dip depth for electrical quantity $X$ (generally voltage)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | $X_{dip}(\%) = 100 \cdot \frac{X_{ref} - X_{resid}}{X_{ref}}$                                                                                                             |
| Swell depth for electrical quantity $X$ (generally voltage)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | $X_{swl}(\%) = 100 \cdot \frac{X_{swell} - X_{ref}}{X_{ref}}$                                                                                                             |
| <p><sup>a</sup> See Figure B.1. Reactive power is a controversial notion, there is no “true” definition in non-sinusoidal conditions. This table only gives the most common definitions. Different standards or measurement products may use different definitions for the reactive power, or consider only the fundamental reactive power. Under sinusoidal voltage and current these definitions are equivalent.</p> <p><sup>b</sup> This power is unsigned.</p> <p><sup>c</sup> Under sinusoidal voltage, these definitions are equivalent even with non-sinusoidal current.</p> |                                                                                                                                                                           |

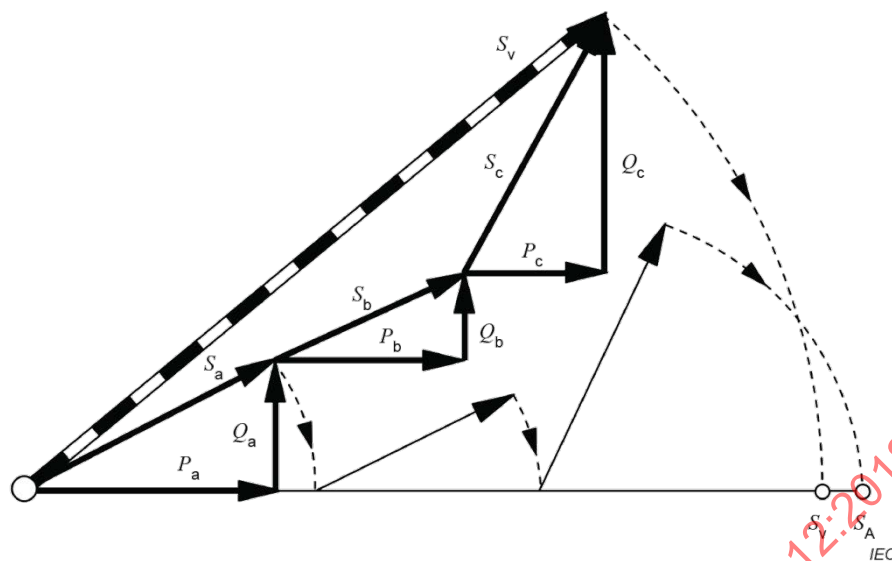


Figure B.1 – Arithmetic and vector apparent powers in sinusoidal situation

### B.3 Power measurement in three-phase three-wire systems using the two-wattmeter method

#### B.3.1 General

If no neutral is present, the three-phase techniques in Clause B.2 may still be used to compute the total powers provided a virtual neutral is used in the measurement process. Otherwise, for three-phase systems without neutral the two-wattmeter method can be used.

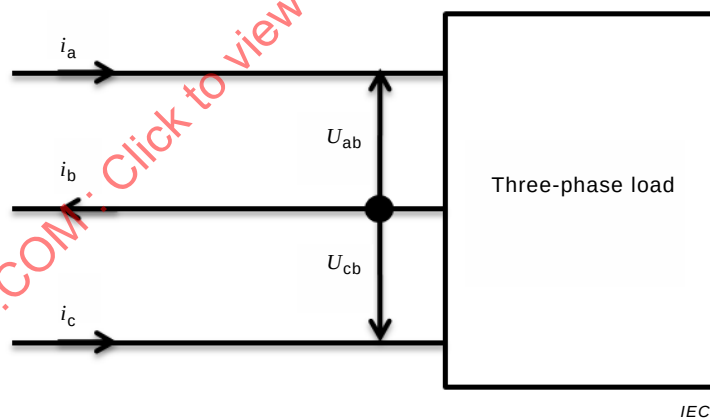


Figure B.2 – Three-phase circuit without neutral

Considering the circuit in Figure B.2, the measurement device can measure the current in all three phases ( $i_a$ ,  $i_b$  and  $i_c$ ) but, since no neutral is present, can only measure line to line voltages. Taking phase b as a reference, let's consider the measured voltages are  $U_{ab}$  and  $U_{cb}$ .

If a neutral were present, these line to line voltages would write:

$$u_{ab} = v_a - v_b \quad \text{and} \quad u_{cb} = v_c - v_b$$

Furthermore, since there is no neutral, the following property is always true:

$$i_a + i_b + i_c = 0$$

The purpose is to use the available quantities and these properties to obtain an accurate measurement of the total powers consumed by the load.

### B.3.2 Total active power

Suppose the measuring instrument measures two-phase active powers using the available line to line voltages:

$$P_1 = \mu(i_a \cdot u_{ab}) \quad \text{and} \quad P_2 = \mu(i_c \cdot u_{cb})$$

where the  $\mu$  operator stands for the averaging over the measurement window of  $M$  samples.

These phase active powers are physically meaningless in the sense that they are not individually related to the total active power drawn by the load.

However, using the properties in B.3.1, it can be shown that:

$$P_1 + P_2 = \mu(i_a \cdot v_a) + \mu(i_b \cdot v_b) + \mu(i_c \cdot v_c) = P_a + P_b + P_c = P$$

The total active power drawn by the load can be determined as the algebraic sum of the phase active powers measured using the two currents and the two line to line voltages.

### B.3.3 Total vector reactive power using quadrature phase shift definition

If the phase reactive powers are measured using the quadrature formula, the total vector reactive power can be determined from the phase reactive powers:

$$Q_{1,\text{quad}} = \mu(i'_a \cdot u_{ab}) \quad \text{and} \quad Q_{2,\text{quad}} = \mu(i'_c \cdot u_{cb})$$

where  $i'_a$  and  $i'_c$  stand for the phase a current in quadrature and the phase c current in quadrature. Using the properties in B.3.1, it can be shown that:

$$Q_{1,\text{quad}} + Q_{2,\text{quad}} = \mu(i'_a \cdot v_a) + \mu(i'_b \cdot v_b) + \mu(i'_c \cdot v_c) = Q_{a,\text{quad}} + Q_{b,\text{quad}} + Q_{c,\text{quad}} = Q_v$$

### B.3.4 Total vector reactive power using Budeanu's definition

If the phase reactive powers are measured using Budeanu's formula, the total vector reactive power can be determined from the phase reactive powers:

$$Q_{1,\text{harm}} = \sum_{i=1}^{h_{\max}} I_{i,a} \cdot U_{i,ab} \cdot \sin(\varphi_{i,ab}) \quad \text{and} \quad Q_{2,\text{harm}} = \sum_{i=1}^{h_{\max}} I_{i,c} \cdot U_{i,cb} \cdot \sin(\varphi_{i,cb})$$

It can be shown that the total reactive power using Budeanu's definition is the sum of both measured phase reactive powers:

$$Q_{1,\text{harm}} + Q_{2,\text{harm}} = Q_{a,\text{harm}} + Q_{b,\text{harm}} + Q_{c,\text{harm}} = Q_v$$

NOTE There is no simple formula for the total vector reactive power in the general case if the phase reactive powers are measured using the triangle formula definition.

#### B.4 Additional relationships in case of sinusoidal voltage

If the voltage can be considered sinusoidal, the power comes from the fundamental current and the fundamental voltage only.

The following additional relationships between the electrical quantities hold, even if the current is not sinusoidal and/or in the presence of current and/or voltage unbalance:

$$P_p = P_{1p}$$

$$Q_{p_{\text{harm}}} = Q_{p_{\text{quad}}} = Q_{1p}$$

$$V_a = \frac{\sqrt{2}}{3} \cdot \sqrt{U_{ab}^2 + U_{ac}^2 - \frac{U_{bc}^2}{2}}$$

$$V_b = \frac{\sqrt{2}}{3} \cdot \sqrt{U_{ab}^2 + U_{bc}^2 - \frac{U_{ac}^2}{2}}$$

$$V_c = \frac{\sqrt{2}}{3} \cdot \sqrt{U_{ac}^2 + U_{bc}^2 - \frac{U_{ab}^2}{2}}$$

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## Annex C (informative)

### Convention about the sign of the power factor

#### C.1 General

The formatting of the power factor is just a question of convention. Manufacturers need to define the convention used on their devices, or need to let customers know the conventions selectable on their devices.

Table C.1 shows the conventions IEC-C and IEEE-C available with a consumer perspective, according to a scheme given in Figure C.1.

Table C.2 shows the conventions IEC-P available with a producer perspective, according to a scheme given in Figure C.2.

#### C.2 Convention for power factor (consumer perspective)

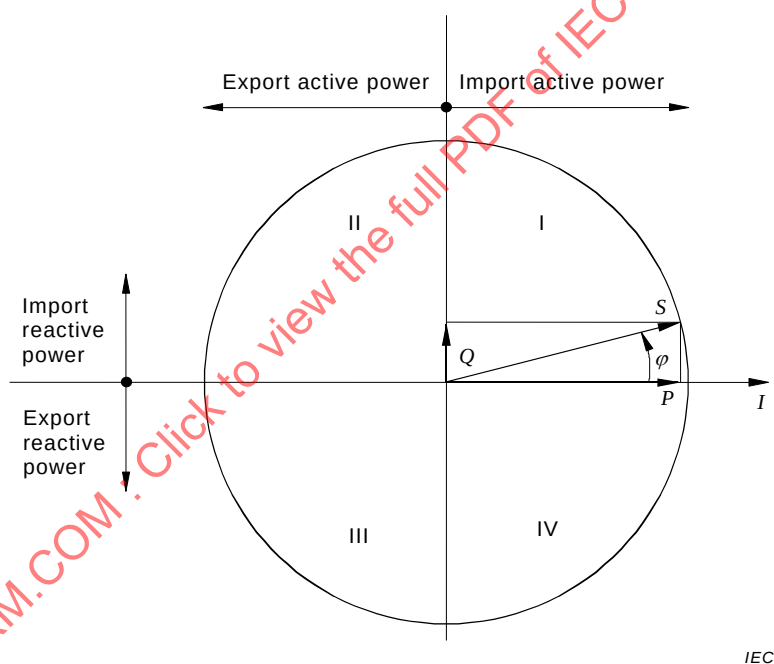


Figure C.1 – Formatting of power factor with a consumer perspective

**Table C.1 – Conventions for the sign of Power factor with a Consumer perspective**

| Quadrant     | Meaning with a consumer perspective | IEC consumer convention for sign (IEC-C convention) | IEEE consumer convention for sign (IEEE-C convention) |
|--------------|-------------------------------------|-----------------------------------------------------|-------------------------------------------------------|
| Quadrant I   | Import $P$ ; Import $Q$             | +(Inductive)                                        | -(Lagging)                                            |
| Quadrant II  | Export $P$ ; Import $Q$             | -(Capacitive)                                       | +(Leading)                                            |
| Quadrant III | Export $P$ ; Export $Q$             | -(Inductive)                                        | -(Lagging)                                            |
| Quadrant IV  | Import $P$ ; Export $Q$             | +(Capacitive)                                       | +(Leading)                                            |

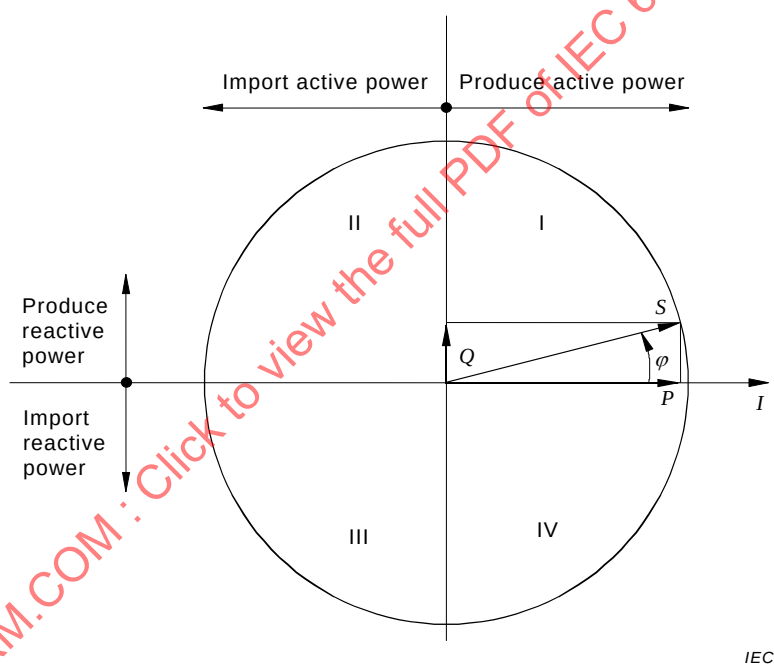
**C.3 Convention for power factor (producer reference frame)****Figure C.2 – Convention for power factor with a producer perspective**

**Table C.2 – Conventions for the sign of power factor  
with a producer perspective**

| Quadrant     | Meaning with a producer perspective | IEC producer convention for sign<br>(IEC-P convention) |
|--------------|-------------------------------------|--------------------------------------------------------|
| Quadrant I   | Produce $P$ ; Produce $Q$           | +<br>(Overexcited)                                     |
| Quadrant II  | Import $P$ ; Produce $Q$            | -<br>(Overexcited)                                     |
| Quadrant III | Import $P$ ; Import $Q$             | -<br>(Under excited)                                   |
| Quadrant IV  | Produce $P$ ; Import $Q$            | +<br>(Under excited)                                   |

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## Annex D (normative)

### Definitions of minimum, maximum, peak and demand values

#### D.1 Demand quantities

##### D.1.1 General

A demand is the average value of a quantity over a specified period of time.

##### D.1.2 Power demand

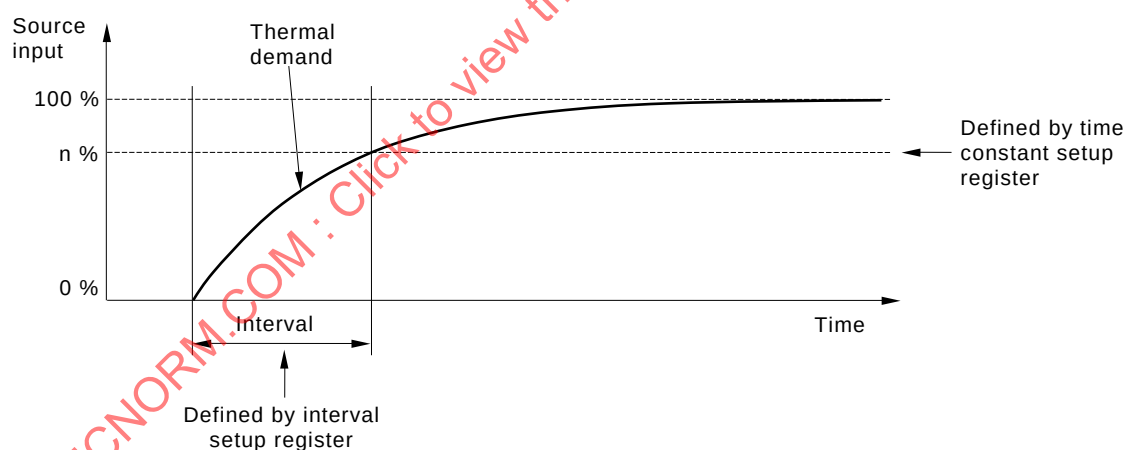
Power demand is calculated using arithmetical integration of power values during a period of time divided by the length of the period. The result is equivalent to the energy accumulated during the period of time divided by the length of the period.

##### D.1.3 Current demand

Current demand is calculated using arithmetical integration of the current RMS values during a period of time, divided by the length of the period.

##### D.1.4 Thermal current demand (or bi-metal current demand)

Thermal current demand calculates the demand based on a thermal response, which mimics the analog thermal demand meters as described in Figure D.1.



IEC

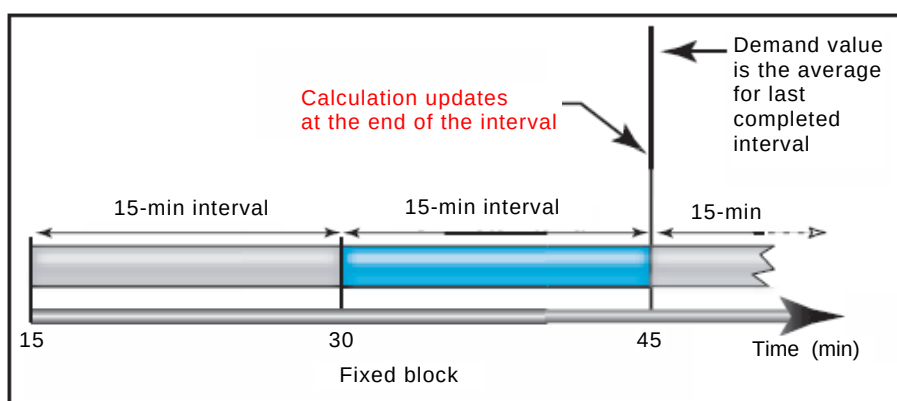
NOTE The value of  $n$  is usually 90 %; the time interval is usually 15 min.

**Figure D.1 – Thermal current demand**

##### D.1.5 Specified intervals for demand calculation

The PMD handle the duration of intervals to calculate the demand. PMD can implement several methods:

- fixed block interval: the intervals are consecutive; the PMD calculates and updates the demand at the end of each interval as described in Figure D.2;

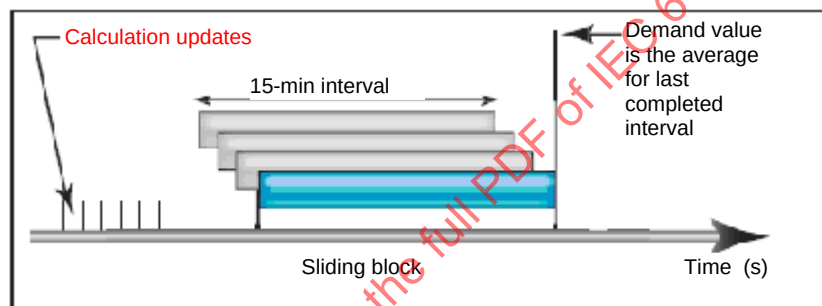


IEC

NOTE 15 min is only an example.

**Figure D.2 – Fixed block interval**

- sliding block interval: the intervals are sliding; the PMD calculates and updates the demand at the sliding speed as described in Figure D.3.



IEC

NOTE 15 min is only an example.

**Figure D.3 – Sliding block interval**

## D.2 Peak demand quantities

Peak demand is the highest demand value (positive or negative) since the beginning of the measurement or the last reset.

## D.3 Three-phase average quantities

In a three- or four-wire system, the average value of a quantity is the arithmetical average of each phase value.

EXAMPLE: Three-phase average line to neutral voltage =  $(V1 \text{ RMS voltage} + V2 \text{ RMS voltage} + V3 \text{ RMS voltage}) / 3$

## D.4 Maximum and minimum quantities

The maximum value of a quantity is the highest value measured or calculated since the beginning of the measurement or the last reset.

The minimum value of a quantity is the lowest value measured or calculated since the beginning of the measurement or the last reset.

## **Annex E** **(normative)**

### **Requirements applicable to PMD and to PMD-A**

Table E.1 gives a summary of all applicable requirements for each kind of PMD.

**Table E.1 — Requirements applicable to PMD and to PMD-A**

|                                                                              | Requirements applicable to PMD including PMD-A                                                     | Requirements applicable to PMD except PMD-A | Requirements applicable to PMD-A only |
|------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------|---------------------------------------------|---------------------------------------|
| Scope                                                                        | Clause 1                                                                                           |                                             |                                       |
| Normative references                                                         | Clause 2                                                                                           |                                             |                                       |
| Definitions                                                                  | Clause 3                                                                                           |                                             |                                       |
| General requirements                                                         | Subclause 4.1<br>Subclause 4.2<br>Subclause 4.3<br>Subclause 4.4<br>Subclause 4.5<br>Subclause 4.6 |                                             |                                       |
| Performance requirements                                                     |                                                                                                    | Subclause 4.7                               | Subclause 4.8                         |
| Mechanical requirements                                                      | Subclause 4.9                                                                                      |                                             |                                       |
| Safety requirements                                                          | Subclause 4.10                                                                                     |                                             |                                       |
| Analog outputs                                                               | Subclause 4.11                                                                                     |                                             |                                       |
| Marking and operating instruction                                            | Clause 5                                                                                           |                                             |                                       |
| Type test                                                                    | Subclause 6.1.14                                                                                   | Subclause 6.1                               | Subclause 6.2                         |
| Climatic tests                                                               | Subclause 6.1.12                                                                                   |                                             |                                       |
| EMC tests                                                                    | Subclause 6.1.13                                                                                   |                                             |                                       |
| Routine Test                                                                 | Subclause 6.3                                                                                      |                                             |                                       |
| Definitions of electrical parameters                                         |                                                                                                    | Annex A                                     |                                       |
| Definitions of minimum, maximum, peak and demand measurements                |                                                                                                    | Annex B                                     |                                       |
| Intrinsic uncertainty, operating uncertainty, and overall system uncertainty | Annex C                                                                                            |                                             |                                       |
| Recommended sensors classes for the different kind of PMD                    | Annex D                                                                                            |                                             |                                       |

## Annex E (informative)

### Intrinsic uncertainty and operating uncertainty<sub>T</sub> ~~and overall system uncertainty~~

#### E.1 General

The operating uncertainty of a monitoring instrument is defined by a specification of:

- uncertainty limits over a measuring range;
- maximum deviations in the presence of influencing quantities (power system parameters or external conditions).

Annex E provides guidance on the calculation of operating uncertainty and does not address the additional concept of a measurement performance class. An operating uncertainty is a quality indicator, not comparable with a measurement performance class, because they are different in nature and are not used for the same purposes.

Figure E.1 below describes different kinds of uncertainties:

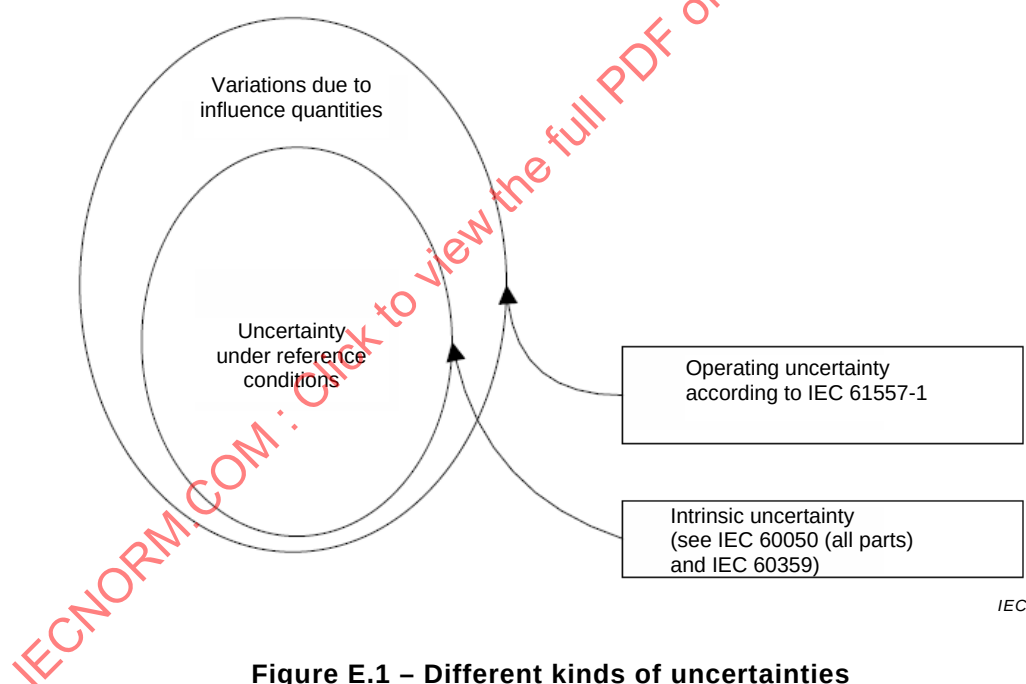


Figure E.1 – Different kinds of uncertainties

#### E.2 Operating uncertainty calculation

Operating uncertainty ~~shall~~ includes intrinsic uncertainty (under reference conditions) and variation due to influence quantities.

$$\text{Operating uncertainty} = \sqrt{(\text{PMD intrinsic uncertainty})^2 + \frac{4}{3} \sum_{i=1}^{NIQ} (\text{variation due to influence quantity})^2}$$

NOTE 1 NIQ = number of influence quantities.

NOTE 2 This formula is derived from ISO/IEC Guide 98-3:2008, 6.2, taking into account a coverage probability of 95 %.

In this formula the PMD intrinsic measurement uncertainty is determined at two standard deviations as described in G.3.2. In order to take into account a coverage factor of 95,45 % in the formula, the variation of the uncertainty due to the influence quantity shall be determined at one standard deviation. The process of determining the operating uncertainty is shown in Figure E.2. The correction factors to be applied to the calculated standard deviations are tabulated in Table G.1.

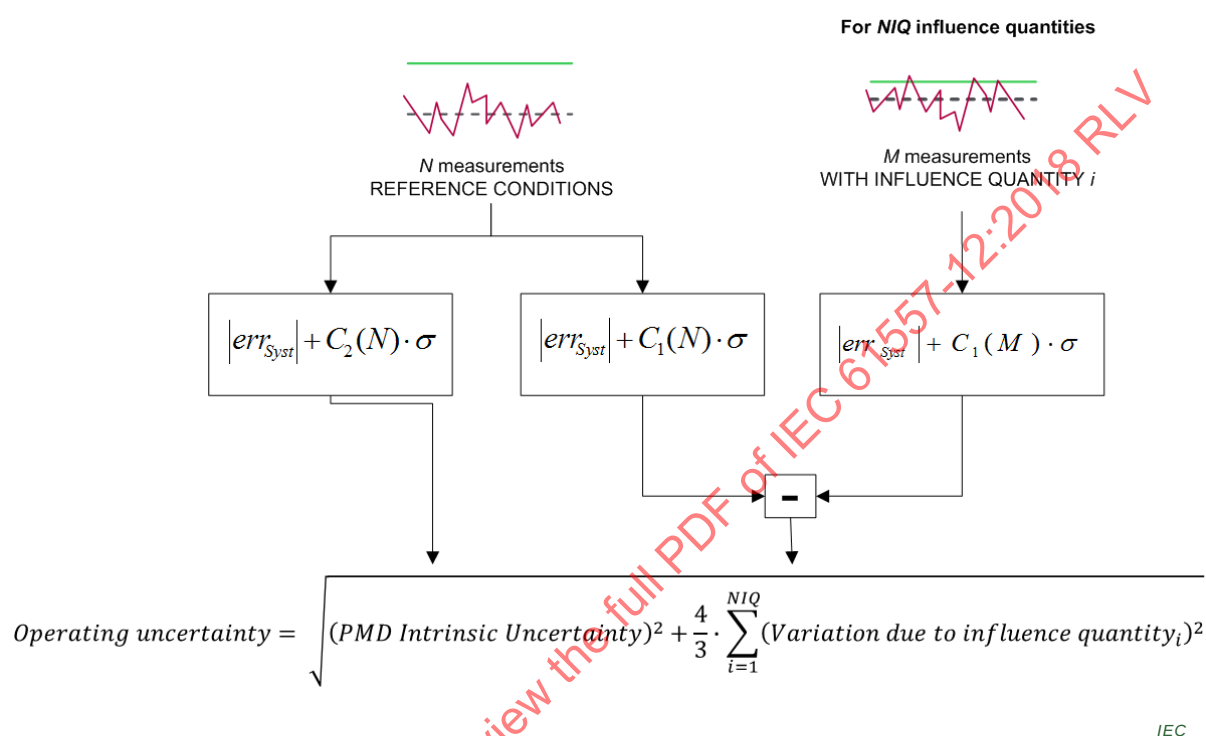


Figure E.2 – Flowchart for the determination of the operating uncertainty

## C.2 Overall system uncertainty

Overall system uncertainty shall include operating uncertainty, uncertainty due to impedance of wires and uncertainty due to sensors.

For PMD DD: Overall system uncertainty = operating uncertainty

For PMD xS and PMD Sx: The formula given below is a simplified approach, and applies only to voltage, current, active power and active energy measurements:

$$\text{Overall system uncertainty} = 115 \times \sqrt{(\text{PMD operating uncertainty})^2 + \sum_{i=1}^N (\text{sensor uncertainty} + \text{wirings uncertainty})^2}$$

with  $N$  = number of kind of external sensors (voltage or current).

NOTE  $N = 1$  when only a current (or voltage) sensor is used,  $N = 2$  when a current sensor and a voltage sensor are used.

## Annex F (informative)

### Recommended sensor classes for the different kinds of PMD

#### D.1 General considerations

The association of a PMD Sx, PMD xS or PMD SS with external current and/or voltage sensors builds a complete system. The system performance class depends on the sensor class and the PMD performance class (See Clauses D.2 and D.3 for evaluation of the system performance class).

However, this system performance class is only applicable for the range where the sensor intrinsic uncertainty is within the limit of its performance class, and is not equivalent to the performance class of a PMD DD. Current sensors that comply with IEC 60044-1 for example, have only a limited specified range compared to a PMD DD of the same performance class.

Special considerations must be taken for power and energy measurements, because phase error of the sensor affects the measurements for non unity power factor: a phase error of 20 min adds 1 % error for active power measurement at PF = 0,5.

For this reason, if improved performance class is required, it is strongly recommended to use class 0,2S or class 0,5S sensors for power or energy measurement.

#### D.2 PMD with external current sensor or voltage sensor

Table D.1 gives some recommendations when associating a PMD with an external sensor.

**Table D.1 PMD SD associated to current sensor or PMD DS  
associated to voltage sensor**

| Performance class of the PMD without external sensors                                                                                                                                                            | Recommended sensor class to associate to the PMD <sup>b,c</sup> | Expected performance class for PMD Sx or PMD xS including their external sensors | maximum possible sensor class to associate to the PMD <sup>a</sup> |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------|----------------------------------------------------------------------------------|--------------------------------------------------------------------|
| 0,1                                                                                                                                                                                                              | 0,1 or below                                                    | 0,2                                                                              | 0,2                                                                |
| 0,2                                                                                                                                                                                                              | 0,2 or below                                                    | 0,5                                                                              | 0,5                                                                |
| 0,5                                                                                                                                                                                                              | 0,5 or below                                                    | 1                                                                                | 1                                                                  |
| 1                                                                                                                                                                                                                | 1 or below                                                      | 2                                                                                | 2                                                                  |
| 2                                                                                                                                                                                                                | 2 or below                                                      | 5                                                                                | 5                                                                  |
| 5                                                                                                                                                                                                                | 5 or below                                                      | 10                                                                               |                                                                    |
| <sup>a</sup> —This induces an acceptable loss of performance of the system.                                                                                                                                      |                                                                 |                                                                                  |                                                                    |
| <sup>b</sup> —For power and energy measurements 0,2 S and 0,5 S class sensors are usually required.                                                                                                              |                                                                 |                                                                                  |                                                                    |
| <sup>c</sup> —Class sensor refers to classes defined in IEC 60044-1, IEC 60044-2, IEC 60044-7 and IEC 60044-8. When transducers replace sensors, class sensor refers to intrinsic uncertainty of the transducer. |                                                                 |                                                                                  |                                                                    |

Overall system performance class =

$$1,15 \times \sqrt{\text{Class}(\text{sensor})^2 + \text{Performance class}(\text{PMD SS})^2}$$

NOTE In a three phase system, the class of the three sensors is equal to the class of one sensor provided that the three sensors have the same class.

The overall system performance class is rounded up to the closest standard default value (see Table D.4).

For example, a class 1 PMD and a class 1 CS will give an overall system performance class equivalent to class 2.

### D.3 PMD with external current sensor and voltage sensor

Table D.2 gives some recommendations when associating a PMD with an external current sensor and an external voltage sensor.

**Table D.2 – PMD SS with current sensor and voltage sensor association**

| Performance class of the PMD without external sensors | Recommended sensor class to associate to the PMD <sup>b,c</sup> | Expected performance class for PMD SS including their external sensors | maximum possible sensor class to associate to the PMD <sup>a</sup> |
|-------------------------------------------------------|-----------------------------------------------------------------|------------------------------------------------------------------------|--------------------------------------------------------------------|
| 0,1                                                   | 0,1 or below                                                    | 0,2                                                                    | 0,2                                                                |
| 0,2                                                   | 0,2 or below                                                    | 0,5                                                                    | 0,5                                                                |
| 0,5                                                   | 0,5 or below                                                    | 1                                                                      | 1                                                                  |
| 1                                                     | 1 or below                                                      | 2                                                                      | 2                                                                  |
| 2                                                     | 2 or below                                                      | 5                                                                      | 5                                                                  |
| 5                                                     | 5 or below                                                      | 10                                                                     |                                                                    |

<sup>a</sup> This induces an acceptable loss of performance of the system.

<sup>b</sup> For power and energy measurements, 0,2 S and 0,5 S class sensors are usually required.

<sup>c</sup> Class sensor refers to classes defined in IEC 60044-1, IEC 60044-2, IEC 60044-7 and IEC 60044-8. When transducers replace sensors, class sensor refers to intrinsic uncertainty of the transducer.

Overall system performance class =

$$115 \times \sqrt{\text{Class}(\text{current\_sensor})^2 + \text{Class}(\text{voltage\_sensor})^2 + \text{Performance class}(\text{PMD SS})^2}$$

NOTE In a three phase system, the class of the three sensors is equal to the class of one sensor provided that the three sensors have the same class.

The system performance class is rounded up to the closest standard default value (see Table D.4).

For example, a class 1 PMD with a class 0,5 CS and a class 0,5 VS will give a system performance class equivalent to class 2.

### D.4 Range of applicable performance classes

Each applicable performance class for each specific function of PMD is given in Clause 0 of this standard.

Table D.3 gives a summary of all applicable performance classes.

**Table D.3 – Range of applicable performance classes for PMD without its associated external sensors**

|      |      |     |     |     |   |   |     |   |   |    |    |
|------|------|-----|-----|-----|---|---|-----|---|---|----|----|
| 0,02 | 0,05 | 0,1 | 0,2 | 0,5 | 1 | 2 | 2,5 | 3 | 5 | 10 | 20 |
|------|------|-----|-----|-----|---|---|-----|---|---|----|----|

~~Table D.4 gives the list of applicable performance classes resulting from the calculations given in Clauses D.2 and D.3.~~

~~**Table D.4 – Range of applicable performance classes when calculating performance class of PMD with its associated external sensors**~~

|                |                |                |                 |              |                |              |                |              |              |                |               |               |               |
|----------------|----------------|----------------|-----------------|--------------|----------------|--------------|----------------|--------------|--------------|----------------|---------------|---------------|---------------|
| <del>0,2</del> | <del>0,3</del> | <del>0,5</del> | <del>0,75</del> | <del>1</del> | <del>1,5</del> | <del>2</del> | <del>2,5</del> | <del>3</del> | <del>5</del> | <del>7,5</del> | <del>10</del> | <del>15</del> | <del>20</del> |
|----------------|----------------|----------------|-----------------|--------------|----------------|--------------|----------------|--------------|--------------|----------------|---------------|---------------|---------------|

## F.1 General considerations

The association of a PMD Sx, PMD xS and PMD SS with external current and/or voltage sensors builds a system. The performance of that system depends on the measurement itself (active energy, frequency, harmonic voltage ...), the sensor class and the PMD performance class.

Overall uncertainty of the measurement chain formed by this association includes uncertainty due to the PMD and uncertainty due to the sensors under reference conditions.

For PMD DD: overall uncertainty = intrinsic uncertainty

For PMD xS, PMD Sx and PMD SS, typical overall uncertainty values for relevant combinations are shown in Table F.1.

## F.2 Specific case of an active power and energy measurement, achieved by a PMD associated with an external current sensor or/and a voltage sensor

Table F.1 provides information about associating a PMD with external sensors.

**Table F.1 – PMD SD associated with current sensor or PMD DS associated with voltage sensor or PMD SS associated with voltage and current sensors**

| Performance class of the PMD<br>(for active power and energy<br>measurement) without external sensors<br>(PMD-Sx or PMD-xS or PMD SS)                                                                           | Recommended sensor class to<br>associate to the PMD <sup>a b c</sup> | Typical overall uncertainty<br>(for active power and energy<br>measurement) |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|-----------------------------------------------------------------------------|
| 0,1                                                                                                                                                                                                             | 0,1 or better                                                        | 0,2 %                                                                       |
| 0,2                                                                                                                                                                                                             | 0,2 or better                                                        | 0,5 %                                                                       |
| 0,5                                                                                                                                                                                                             | 0,5 or better                                                        | 1 %                                                                         |
| 1                                                                                                                                                                                                               | 1 or better                                                          | 2 %                                                                         |
| 2                                                                                                                                                                                                               | 2 or better                                                          | 5 %                                                                         |
| For other combinations, manufacturers should provide information or recommended sensors for association.                                                                                                        |                                                                      |                                                                             |
| <sup>a</sup> This induces an acceptable loss of performance of the system.                                                                                                                                      |                                                                      |                                                                             |
| <sup>b</sup> For power and energy measurements 0,2 S and 0,5 S class sensors are usually required.                                                                                                              |                                                                      |                                                                             |
| <sup>c</sup> Class sensor refers to classes defined in IEC 61869-2, IEC 61869-3, IEC 60044-7 and IEC 60044-8. When transducers replace sensors, class sensor refers to intrinsic uncertainty of the transducer. |                                                                      |                                                                             |

## F.3 List of functions affected by uncertainty of external sensors

Table F.2 defines the influence of each kind of sensor on each function of a PMD.

**Table F.2 – List of functions affected by uncertainty of external sensors**

| Symbol                                                                           | Function                                                                                             | Current sensor | Voltage sensor |
|----------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------|----------------|----------------|
| $P_a$                                                                            | Total active power                                                                                   | x              | x              |
| $Q_A, Q_V$                                                                       | Total reactive power (arithmetic or vector)                                                          | x              | x              |
| $S_A, S_V$                                                                       | Total apparent power (arithmetic or vector)                                                          | x              | x              |
| $E_a$                                                                            | Total active energy                                                                                  | x              | x              |
| $E_{rA}, E_{rV}$                                                                 | Total reactive energy (arithmetic or vector)                                                         | x              | x              |
| $E_{apA}, E_{apV}$                                                               | Total apparent energy (arithmetic or vector)                                                         | x              | x              |
| $f$                                                                              | Frequency                                                                                            | -              | -              |
| $I$                                                                              | Phase current                                                                                        | x              | -              |
| $I_N, I_{Nc}$                                                                    | Neutral current (measured, calculated)                                                               | x              | -              |
| $U$ or $V$                                                                       | Voltage ( $L_p-L_g$ or $L_p-N$ )                                                                     | -              | x              |
| $PF_A, PF_V$                                                                     | Power factor (arithmetic, vector)                                                                    | x              | x              |
| $P_{st}, P_{lt}$                                                                 | Flicker (short term, long term)                                                                      | -              | -              |
| $U_{dip}$ or $V_{dip}$                                                           | Voltage dips ( $L_p-L_g$ or $L_p-N$ )                                                                | -              | x              |
| $U_{swl}$ or $V_{swl}$                                                           | Voltage swells ( $L_p-L_g$ or $L_p-N$ )                                                              | -              | x              |
| $U_{int}$ or $V_{int}$                                                           | Voltage interruption ( $L_p-L_g$ or $L_p-N$ )                                                        | -              | x              |
| $U_{nba}$                                                                        | <del>Voltage Unbalance amplitude (<math>L_p-N</math>)</del>                                          | -              | *              |
| $U_{nb}$                                                                         | <del>Voltage Unbalance phase and amplitude (<math>L_p-L_g</math> or <math>L_p-N</math>)</del>        | -              | *              |
| $U_{nba}$ or $V_{nba}$                                                           | Amplitude voltage unbalance ( $L_p-L_g$ or $L_p-N$ )                                                 | -              | x              |
| $U_{nb}$ or $V_{nb}$                                                             | Amplitude and phase voltage unbalance ( $L_p-L_g$ or $L_p-N$ )                                       | -              | x              |
| $U_h$ or $V_h$                                                                   | Voltage harmonics                                                                                    | -              | x              |
| $THD_u, THD-R_u$<br>or $THD_v, THD-R_v$                                          | Voltage $THD$ (referred to fundamental, referred to RMS value)                                       | -              | x              |
| $I_h$                                                                            | Current harmonics                                                                                    | x              | -              |
| $THD_i, THD-R_i$                                                                 | Current $THD$ ( $THD$ referred to the fundamental, $THD-R_i$ referred to the RMS value respectively) | x              | -              |
| <b>Msv</b>                                                                       | <del>Mains signalling voltage</del>                                                                  | -              | *              |
| NOTE "x" means "affects the function", "-" means "does not affect the function". |                                                                                                      |                |                |

## Annex G (informative)

### Notion of measurement uncertainty

#### G.1 General considerations

Annex G is intended to become normative for the next edition of this document.

For this document, the level of confidence is 95,45 %, meaning that 95,45 % of the measurements are expected to lie within the interval defined by the average of the measurements plus or minus the calculated expanded uncertainty. This corresponds to two times the standard deviation.

Annex G provides information about how a number  $N$  of values measured on one PMD can be used to determinate the measurement uncertainty of that device. Using measurements to derive the uncertainty is generally referred to as “Type A” method of evaluation of uncertainty. Qualifying a product typically requires applying this procedure on several product samples.

The uncertainty of a measurement under certain operating conditions is a value that characterizes the dispersion of the values that could reasonably be attributed to the measurand. It is a measure of the bounds within which a value may be reasonably (with a certain level of confidence) presumed to lie.

The measurement uncertainty is not the measurement error, which characterizes the difference between a measured value and the conventional true value.

In the calculations below, it is assumed that the distribution of the measurements around their mean reasonably follows a normal distribution. If this is not the case, the estimated standard deviation shall be corrected appropriately (e.g. by dividing by  $\sqrt{3}$  if the actual distribution is uniform).

#### G.2 Computing the expanded uncertainty

##### G.2.1 General

The expanded uncertainty is an estimate of the uncertainty taking into account important parameters such as:

- the number  $N$  of measured values available from the test
- the level of confidence desired for the uncertainty results

##### G.2.2 Estimated standard deviation

The sample standard deviation of the set of  $N$  measurements  $\{x_i\}_{i=1..N}$  is computed as follows:

$$\sigma = \sqrt{\frac{\sum_{i=1}^N (x_i - \bar{x})^2}{N - 1}} \quad \text{with} \quad \bar{x} = \frac{1}{N} \cdot \sum_{i=1}^N x_i$$

### G.2.3 Expanded uncertainty

The expanded uncertainty takes into account both the number  $N$  of measurements and the desired level of confidence in the final uncertainty. The level of confidence indicates how many of the measurements are likely to be within the calculated uncertainty limits.

The correction factor  $C(N)$  to be applied to the estimated standard deviation for the number of measurements  $N$  is the Student t-factor. It compensates for the underestimation of the standard deviation when calculated on a reduced set of measurements. It is specified in Table G.1. Values not tabulated can be recalculated or interpolated from the tabulated values.

**Table G.1 – Correction factor  $C(N)$  for sample size  $N$**

| Number of measurements $N$ | Correction factor $C_1(N)$ for one standard deviation | Correction factor $C_2(N)$ for two standard deviations |
|----------------------------|-------------------------------------------------------|--------------------------------------------------------|
| 3                          | 1,321                                                 | 4,527                                                  |
| 4                          | 1,197                                                 | 3,307                                                  |
| 5                          | 1,142                                                 | 2,869                                                  |
| 6                          | 1,111                                                 | 2,649                                                  |
| 7                          | 1,091                                                 | 2,517                                                  |
| 8                          | 1,077                                                 | 2,429                                                  |
| 9                          | 1,067                                                 | 2,366                                                  |
| 10                         | 1,059                                                 | 2,320                                                  |
| 11                         | 1,053                                                 | 2,284                                                  |
| 12                         | 1,048                                                 | 2,255                                                  |
| 13                         | 1,043                                                 | 2,231                                                  |
| 14                         | 1,040                                                 | 2,212                                                  |
| 15                         | 1,037                                                 | 2,195                                                  |
| 16                         | 1,034                                                 | 2,181                                                  |
| 17                         | 1,032                                                 | 2,169                                                  |
| 18                         | 1,030                                                 | 2,158                                                  |
| 19                         | 1,029                                                 | 2,149                                                  |
| 20                         | 1,027                                                 | 2,140                                                  |
| 30                         | 1,018                                                 | 2,090                                                  |
| 40                         | 1,013                                                 | 2,066                                                  |
| 50                         | 1,010                                                 | 2,052                                                  |
| 100                        | 1,005                                                 | 2,026                                                  |

The expanded uncertainty is calculated as:

$$unc_{Exp} = C_2(N) \cdot \sigma$$

The estimated standard deviation and the expanded uncertainty are measures of the dispersion of the measurements (taken in identical conditions) around their average value. It characterizes the random error, sometimes called the precision of the measurement.

### G.3 Determining the measurement uncertainty

#### G.3.1 Systematic error

The systematic error is the difference between the conventional true value and the average of the measured values. It can be determined as:

$$err_{Syst} = x_{true} - \bar{x}$$

It can be positive or negative. It can be expressed in physical units or as a percentage of the true value. In statistics, the systematic error is also called a bias.

The conventional true value is typically estimated using a reference power meter. The accuracy of the reference meter should typically be better than the expected accuracy of the PMD under test, by at least a factor 10.

The systematic error is a measure of the accuracy of the measurement. Values of the systematic error significantly different from zero typically result from imperfect or invalid calibration in the operating conditions of the test, or from considering too small a number of measurements.

#### G.3.2 Measurement uncertainty

The difference between the measurements and the true value of the measurand is characterized by both the systematic error and the random error. A good measurement is a measurement that is both true and precise.

Both indicators can be combined to provide an estimate of the overall uncertainty, which will be considered as the measurement uncertainty. The measurement uncertainty in absolute value can be computed as:

$$unc_{Meas} = |err_{Syst}| + unc_{Exp}$$

This concept is shown in Figure G.1.

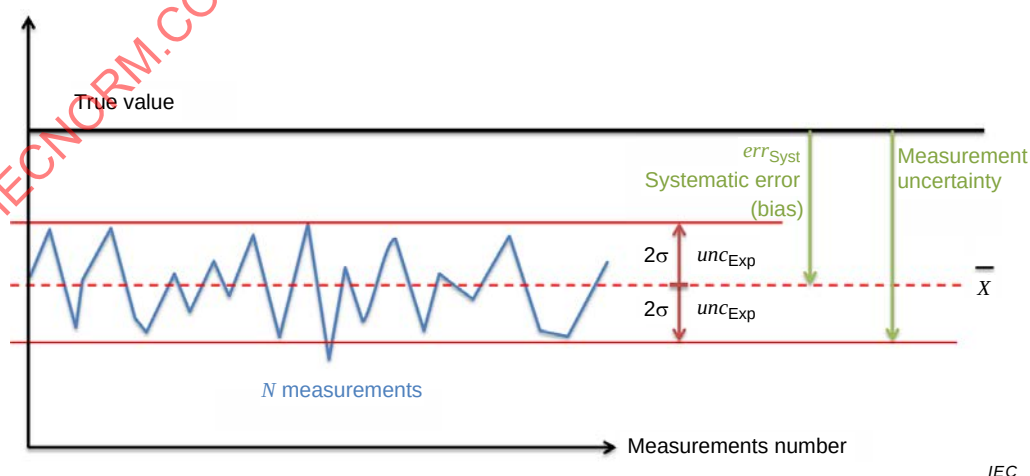


Figure G.1 – Illustration of the notion of measurement uncertainty

The value of the measurement uncertainty depends on:

- the systematic error, reflecting the quality of the calibration of the product in the operating conditions of the test,
- the random error, reflecting the quality of the measurement process and the level of noise in the operating conditions of the test,
- the number  $N$  of measurements made during the test,
- the resolution of the measurement

and therefore provides a good indicator of the overall quality of the measurement.

NOTE Other sources of uncertainty are normally taken into account but are disregarded in this edition:

- uncertainty of the reference meter,
- uncertainty on the estimated mean  $\bar{x}$  due to a limited number of measurements.

## **G.4 Using the measurement uncertainty as a pass/fail criterion**

### **G.4.1 Intrinsic uncertainty tests**

The measurement uncertainty calculated for each intrinsic uncertainty test conducted needs to be compared to the uncertainty limit specified in the intrinsic uncertainty table, in order to assess the class of the measurement.

- If the measurement uncertainty is smaller than the specified uncertainty limit of class  $C$  for all the intrinsic uncertainty tests, then compliance to class  $C$  for intrinsic uncertainty is granted.
- Otherwise, i.e. if the measurement uncertainty is greater than the specified uncertainty limit for at least one of the intrinsic uncertainty tests, compliance to class  $C$  is not granted and a larger class should be considered.

### **G.4.2 Tests with influence quantities**

The measurement uncertainty calculated for a test with influence quantities can be compared to the intrinsic measurement uncertainty.

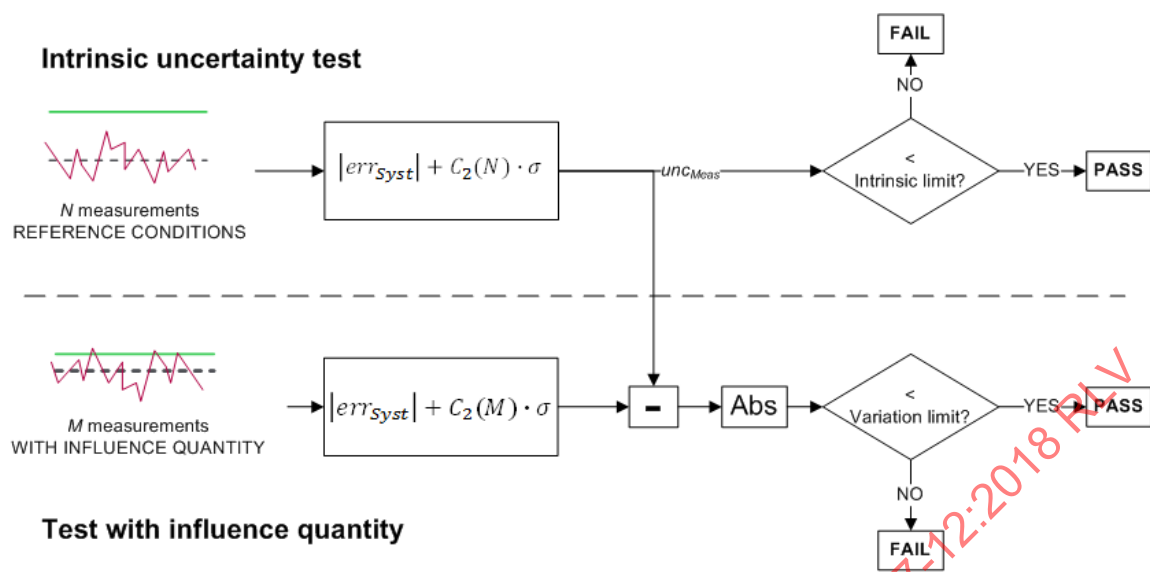
- If the variation of measurement uncertainty is smaller than the specified limit of variation of class  $C$  for all the tests with influence quantity, then compliance to class  $C$  is granted for the uncertainty under influence quantities.
- Otherwise, compliance to class  $C$  is not granted and a larger class should be considered.

### **G.4.3 Overall pass/fail criterion**

Compliance to a class requires that the product meet the performance requirements in terms of both intrinsic uncertainty and variation of uncertainty under influence quantities. Therefore:

- If compliance to class  $C$  is granted as described above for both the intrinsic uncertainty tests and the tests with influence quantities, then compliance to class  $C$  is granted.
- Otherwise, compliance to class  $C$  is not granted, a larger class shall be considered.

This process is illustrated in Figure G.2.



IEC

Figure G.2 – Overview of the uncertainty test procedure

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# INTERNATIONAL STANDARD

## NORME INTERNATIONALE



**Electrical safety in low voltage distribution systems up to 1 000 V AC and 1 500 V DC. – Equipment for testing, measuring or monitoring of protective measures –**

**Part 12: Power metering and monitoring devices (PMD)**

**Sécurité électrique dans les réseaux de distribution basse tension jusqu'à 1 000 V c.a. et 1 500 V c.c. – Dispositifs de contrôle, de mesure ou de surveillance de mesures de protection –**

**Partie 12: Dispositifs de comptage et de surveillance du réseau électrique (PMD)**

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## INTERNATIONAL ELECTROTECHNICAL COMMISSION

**ELECTRICAL SAFETY IN LOW VOLTAGE DISTRIBUTION  
SYSTEMS UP TO 1 000 V AC AND 1 500 V DC. –  
EQUIPMENT FOR TESTING, MEASURING OR  
MONITORING OF PROTECTIVE MEASURES –****Part 12: Power metering and monitoring devices (PMD)**

## FOREWORD

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International Standard IEC 61557-12 has been prepared by IEC technical committee 85: Measuring equipment for electrical and electromagnetic quantities.

This second edition cancels and replaces the first edition published in 2007. This edition constitutes a technical revision.

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

- a) PMD-A has been withdrawn due the fact these devices are now mainly covered by the IEC 62586 series of standards.
- b) Three categories of PMD have been created with a list of minimum required functions for each category.

- c) Added a new Annex A explaining the different applications linked to the relevant standards and devices, and another new Annex C about the power factor conventions.

The text of this International Standard is based on the following documents:

|             |                  |
|-------------|------------------|
| FDIS        | Report on voting |
| 85/644/FDIS | 85/649/RVD       |

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

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

A list of all parts in the IEC 61557 series, published under the general title *Electrical safety in low voltage distribution systems up to 1 000 V AC and 1 500 V DC – Equipment for testing, measuring or monitoring of protective measures*, can be found on the IEC website.

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

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

**IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.**

## INTRODUCTION

Energy distribution systems need to guarantee energy efficiency, availability and network performances in order to address the following challenges:

- sustainable development requirements where energy measurement, for instance, is recognised as an essential element of energy management, part of the overall drive to reduce carbon emissions and to improve the commercial efficiency of manufacturing, commercial organizations and public services;
- technological evolutions (electronic loads, electronic measuring methods, etc.);
- end-users needs (cost saving, compliance with aspects of building regulations, etc.) regarding electrical energy management as well as other energies, or fluids. Other functionalities involving several non electrical parameters are often needed in parallel;
- safety and continuity of service;
- evolution of installation standards, for instance over-current detection is now a new requirement for the neutral conductor due to harmonic content.

Monitoring electrical quantities in internal networks allows to address these challenges.

The devices on the current market have different characteristics, which need a common system of references. Therefore there is a need for this document in order to facilitate the choices of the end-users in terms of performance, safety, interpretation of the indications, etc. This document provides a basis by which such devices can be specified and described, and their performance evaluated.

In order to fulfil the requirements of the energy efficiency project, many PMD measuring electrical parameters can also collect data (water, air, gas, temperature...) coming from other sensors or meters inside building or plant areas. In order to be able to transmit all these data to a supervision software it will be relevant to equip the PMD with a communication bus. The supervision software will then manage all the collected data in order to monitor them and produce useful reports for energy usage and consumption analysis.

# **ELECTRICAL SAFETY IN LOW VOLTAGE DISTRIBUTION SYSTEMS UP TO 1 000 V AC AND 1 500 V DC. – EQUIPMENT FOR TESTING, MEASURING OR MONITORING OF PROTECTIVE MEASURES –**

## **Part 12: Power metering and monitoring devices (PMD)**

### **1 Scope**

This part of IEC 61557 specifies requirements for power metering and monitoring devices (PMD) that measure and monitor the electrical quantities within electrical distribution systems, and optionally other external signals. These requirements also define the performance in single- and three-phase AC or DC systems having rated voltages up to 1 000 V AC or up to 1 500 V DC.

These devices are fixed or portable. They are intended to be used indoors and/or outdoors.

Power metering and monitoring devices (PMD), as defined in this document, give additional safety information, which aids the verification of the installation and enhances the performance of the distribution systems.

The power metering and monitoring devices (PMD) for electrical parameters described in this document are used for general industrial and commercial applications.

This document does not address functional safety and cyber security aspects.

This document is not applicable for:

- electricity metering equipment that complies with IEC 62053-21, IEC 62053-22, IEC 62053-23 and IEC 62053-24. Nevertheless, uncertainties defined in this document for active and reactive energy measurement are derived from those defined in IEC 62053 (all parts);
- the measurement and monitoring of electrical parameters defined in IEC 61557-2 to IEC 61557-9 and IEC 61557-13 or in IEC 62020;
- power quality instrument (PQI) according IEC 62586 (all parts);
- devices covered by IEC 60051 (all parts) (direct acting analogue electrical measuring instrument).

NOTE 1 Generally such types of devices are used in the following applications or for the following general needs:

- energy management inside the installation, such as facilitating the implementation of documents such as ISO 50001 and IEC 60364-8-1;
- monitoring and/or measurement of electrical parameters;
- measurement and/or monitoring of the quality of energy inside commercial/industrial installations.

NOTE 2 A measuring and monitoring device of electrical parameters usually consists of several functional modules. All or some of the functional modules are combined in one device. Examples of functional modules are:

- measurement and monitoring of several electrical parameters simultaneously;
- energy measurement and/or monitoring, as well as sometimes compliance with aspects of building regulations;
- alarms functions;
- demand side quality (current and voltage harmonics, over/under voltages, voltage dips and swells, etc.).

NOTE 3 PMD are historically called power meter, power monitor, power monitor device, power energy monitoring device, power analyser, multifunction meter, measuring multifunction equipment, energy meters.

NOTE 4 Metering, measuring and monitoring applications are explained in Annex A.

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 60068-2-1, *Environmental testing – Part 2-1: Tests – Test A: Cold*

IEC 60068-2-2, *Environmental testing – Part 2: Tests – Tests B: Dry heat*

IEC 60068-2-30, *Environmental testing – Part 2-30 – Tests – Test Db: Damp heat, cyclic (12 h + 12 h cycle)*

IEC 60529, *Degrees of protection provided by enclosures (IP Code)*

IEC 61000-4-30:2015, *Electromagnetic compatibility (EMC) – Part 4-30: Testing and measurement techniques – Power quality measurement methods*

IEC 61010-1:2010, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 1: General requirements*

IEC 61010-1:2010/AMD1:2016

IEC 61010-2-030:2017, *Safety requirements for electrical equipment for measurement, control, and laboratory use – Part 2-030: Particular requirements for testing and measuring circuits*

IEC 61326-1:2012, *Electrical equipment for measurement, control and laboratory use – EMC requirements – Part 1: General requirements*

IEC 62053-31:1998, *Electricity metering equipment (a.c.) – Particular requirements – Part 31: Pulse output devices for electromechanical and electronic meters (two wires only)*

## 3 Terms, definitions and notations

For the purposes of this document, the following terms, definitions and notations apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

### 3.1 General definitions

#### 3.1.1

##### **power metering and monitoring device**

##### **PMD**

combination in one or more devices of several functional modules dedicated to metering and monitoring electrical parameters in energy distribution systems or electrical installations, used for applications such as energy efficiency, power monitoring and network performance

Note 1 to entry: Under the generic term “monitoring” are also included functions of recording, alarm management, etc.

Note 2 to entry: These devices may include demand side quality functions for monitoring inside commercial/industrial installations.

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

### 3.1.2

#### **power quality assessment function**

power quality functions whose measurement methods are defined in IEC 61000-4-30

### 3.1.3

#### **supply side**

part of the grid where electric energy is generated, transmitted and distributed to end-use customers through the public supply network

Note 1 to entry: This definition encompasses micro-grids, decentralised generators or renewable energy generators.

### 3.1.4

#### **demand side**

part of the grid where electric energy is consumed by end-use customers within their electric distribution system

### 3.1.5

#### **point of common coupling**

##### **PCC**

point of a power supply network, electrically nearest to a particular load, at which other loads are, or may be, connected

Note 1 to entry: These loads can be either devices, equipment or systems, or distinct customer's installations.

Note 2 to entry: In some applications, the term "point of common coupling" is restricted to public networks.

[SOURCE: IEC 60050-161:1990, 161-07-15]

### 3.1.6

#### **power quality**

characteristics of the electric current, voltage and frequencies at a given point in an electric power 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 in an electric power system and the loads connected to that electric power system

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

### 3.1.7

#### **dedicated external sensor**

proprietary external sensor able to operate only with a range of PMD specified by the manufacturer

### 3.1.8

#### **current sensor**

##### **CS**

electrical, magnetic, optical or other device intended to transmit a signal corresponding to the current flowing through the primary circuit of this device

Note 1 to entry: A current transformer (CT) is in general a magnetic current sensor.

Note 2 to entry: This note applies to the French language only.

**3.1.9****compliance voltage**

value of the voltage that can be developed at the current analog output while conforming to the requirement of the uncertainty specification for that output

Note 1 to entry: This definition applies to current analog output signals.

**3.1.10****voltage sensor****VS**

electrical, magnetic, optical or other device intended to transmit a signal corresponding to the voltage across the primary terminals of this device

Note 1 to entry: A voltage transformer (VT) is in general a magnetic voltage sensor.

Note 2 to entry: This note applies to the French language only.

**3.1.11****self-powered PMD**

equipment where measuring terminals are also used for power supply

**3.1.12****auxiliary power supply**

external power supply, either AC or DC, that powers the PMD through dedicated terminals separated from the measurement inputs of the PMD

**3.1.13****transformer operated PMD**

PMD intended to be connected to the circuit(s) being measured via external instrument transformer(s)

Note 1 to entry: Transformer operated PMD corresponds to PMD Sx or PMD xS in this document.

**3.1.14****primary register**

register of an instrument transformer-operated meter which takes into account the ratios of all the transformers (voltage and current transformers) to which the meter is connected

Note 1 to entry: The value of the energy on the primary side of the transformers is obtainable from the direct reading of the register.

[SOURCE IEC 62053-52:2005, 3.4]

**3.1.15****half-primary register**

register of an instrument transformer-operated meter which takes into account either the ratio(s) of the current transformer(s) or the ratio(s) of the voltage transformer(s), but not both

Note 1 to entry: The value of the energy on the primary side of the transformer(s) is obtainable from the reading of the register multiplied by an appropriate factor.

[SOURCE IEC 62053-52:2005, 3.5]

**3.2 Definitions related to uncertainty and performance****3.2.1****reference conditions**

appropriate set of specified values and/or ranges of values of influence quantities under which the smallest permissible uncertainties of a measuring instrument are specified

Note 1 to entry: The ranges specified for the reference conditions, called reference ranges, are not wider, and are usually narrower, than the ranges specified for the rated operating conditions.

[SOURCE: IEC 60359:2001, 3.3.10]

### 3.2.2

#### **measurand**

quantity subjected to measurement, evaluated in the state assumed by the measured system during the measurement itself

[SOURCE: IEC 60359:2001, 3.1.1, modified – the notes have been removed.]

### 3.2.3

#### **uncertainty**

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

Note 1 to entry: In this document, measurement uncertainty includes components arising from systematic effects and from random effects

### 3.2.4

#### **intrinsic uncertainty**

uncertainty of a measuring instrument when used under reference conditions

Note 1 to entry: In this document, it is a percentage of the measured value defined in its rated range and with the influence quantities under reference conditions, unless otherwise stated.

[SOURCE: IEC 60359:2001, 3.2.10, modified – a note has been added.]

### 3.2.5

#### **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

Note 1 to entry: Influence quantities can originate from the measured system, the measuring equipment or the environment [IEV].

Note 2 to entry: As the calibration diagram depends on the influence quantities, in order to assign the result of a measurement it is necessary to know whether the relevant influence quantities lie within the specified range [IEV].

[SOURCE: IEC 60359:2001, 3.1.14, modified – note 3 has been removed.]

### 3.2.6

#### **variation**

<under single influence quantity> difference between the value measured under reference conditions and any value measured within the influence range

Note 1 to entry: The other performance characteristics and the other influence quantities should stay within the ranges specified for the reference conditions.

### 3.2.7

#### **rated operating conditions**

set of conditions that must be fulfilled during the measurement in order that a calibration diagram may be valid

Note 1 to entry: Beside the specified measuring range and rated operating ranges for the influence quantities, the conditions may include specified ranges for other performance characteristics and other indications that cannot be expressed as ranges of quantities.

[SOURCE: IEC 60359:2001, 3.3.13]

**3.2.8****operating uncertainty**

calculated uncertainty taking into account the intrinsic uncertainty and the additional uncertainties due to the defined influence quantities

Note 1 to entry: The operating uncertainty, like the intrinsic one, is not evaluated by the user of the instrument, but is stated by its manufacturer or calibrator. The statement may be expressed by means of an algebraic relation involving the intrinsic uncertainty and the values of one or several influence quantities, but such a relation is just a convenient means of expressing a set of operating uncertainties under different operating conditions, not a functional relation to be used for evaluating the propagation of uncertainty inside the instrument.

Note 2 to entry: An operating uncertainty reflects the quality of the design of a device, and is not the same nature as a performance class or intrinsic uncertainty.

Note 3 to entry: Operating uncertainty can be greater than intrinsic uncertainty and greater than performance class.

Note 4 to entry: The concept of operating uncertainty is related to the concept of maximum permissible error developed in other documents, which is calculated from three influencing quantities only.

**3.2.9****overall uncertainty**

uncertainty including the uncertainty of several separated instruments (voltage sensor, current sensor and PMD)

**3.2.10****function performance class**

number accounting for the performance of a single function, depending on function intrinsic uncertainty, taking into account specified measurement range and limits for variations due to the specified influence quantities

Note 1 to entry: In this document, *C* stands for the numerical value of the function performance class (for instance *C* = 0,2).

**3.2.11****rated frequency** $f_n$ 

value of the frequency at which the specification of the PMD is defined

**3.2.12****rated current** $I_n$ 

value of the current at which the specification of a PMD operated by an external current sensor (PMD Sx) is defined

**3.2.13****basic current** $I_b$ 

value of the current at which the specification of a direct connected PMD (PMD Dx) is defined

**3.2.14****starting current** $I_{st}$ 

lowest value of the current at which the PMD starts and continues to register

[SOURCE: IEC 62052-11:2003, 3.5.1.1, modified – "meter" has been replaced by "PMD".]

**3.2.15****maximum current** $I_{max}$ 

highest value of current at which the PMD meets the uncertainty requirements of this document

### 3.2.16

#### rated voltage

$U_n$

value of the voltage in accordance with which the relevant performances of the PMD are fixed

Note 1 to entry: Depending on the distribution system and its connection to the PMD, this voltage can be either the phase to phase voltage or the phase to neutral voltage.

### 3.2.17

#### nominal voltage

$U_{nom}$

suitable approximate value of voltage used to designate or identify a system

[SOURCE: IEC 60050-601:1985, 601-01-21]

### 3.2.18

#### minimum voltage

$U_{min}$

lowest value of voltage at which the PMD meets the uncertainty requirements of this document

### 3.2.19

#### maximum voltage

$U_{max}$

highest value of voltage at which the PMD meets the uncertainty requirements of this document

### 3.2.20

#### residual voltage

$U_{res}$

minimum value of  $U$  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 a fraction of the rated voltage.

### 3.2.21

#### declared input voltage

$U_{din}$

value obtained from the declared supply voltage by a transducer ratio

[SOURCE: IEC 61000-4-30:2015, 3.2]

### 3.2.22

#### sliding reference voltage

$U_{sr}$

voltage magnitude averaged over one minute, representing the voltage preceding a voltage dip or swell

### 3.2.23

#### demand value

average value of a quantity over a specified period of time

### 3.2.24

#### peak demand value

highest demand value (positive or negative) since the beginning of the measurement or the last reset

**3.2.25****thermal demand**

emulation of a thermal demand meter that provides an exponentially time lagged demand, given a constant load, the indication reading 90 % of the actual demand in a specified time

Note 1 to entry: The time is specified by the manufacturer, usually 15 min.

**3.2.26****three-phase average value**

in a three- or four-wire system, the arithmetical average of all phase value

**3.2.27****maximum value**

highest value measured or calculated since the beginning of the measurement or the last reset

**3.2.28****minimum value**

lowest value measured or calculated since the beginning of the measurement or last reset

**3.2.29****interval**

period of time used by the PMD to integrate RMS or instantaneous values in order to calculate demand values

**3.3 Definitions related to electric phenomena****3.3.1****phase current**

$I$

value of the current flowing in each phase of an electrical distribution system

**3.3.2****neutral current**

$I_N$

value of neutral current of an electrical distribution system

**3.3.3****phase to phase voltage****line to line voltage**

$U$

voltage between phases

[SOURCE: IEC 60050-601:1985, 601-01-29]

**3.3.4****phase to neutral voltage****line to neutral voltage**

$V$

voltage between a phase in a polyphase system and the neutral point

[SOURCE: IEC 60050-601:1985, 601-01-30]

**3.3.5****frequency**

$f$

value of measured frequency in an electrical distribution system

### 3.3.6

#### **power factor**

**PF**

under periodic conditions, ratio of the value of the active power to the apparent power

Note 1 to entry: This power factor is not the displacement power factor. Both are not equal in presence of harmonics.

Note 2 to entry: This note applies to the French language only.

[SOURCE: IEC 60050-131:2002 131-11-46, modified – the formula in the definition has not been included, note 1 has been changed and a note 2 has been added.]

### 3.3.7

#### **amplitude of harmonic current**

**$I_h$**

value of the amplitude of the current at harmonic frequencies in the spectrum obtained from a Fourier transform of a time function

### 3.3.8

#### **amplitude of harmonic voltage**

**$U_h$**

value of the amplitude of the voltage at harmonic frequencies in the spectrum obtained from a Fourier transform of a time function

### 3.3.9

#### **stationary harmonics**

<voltage and current> harmonic content of the signal with the amplitude variation of each harmonic component remaining constant within  $\pm 0,1$  % of the amplitude of the fundamental

### 3.3.10

#### **quasi-stationary harmonics**

<voltage and current> harmonic content of the signal in which the amplitude variation of each harmonic for contiguous 10 (50 Hz systems) or 12 (60 Hz systems) cycles remains within  $\pm 0,1$  % of the amplitude of the fundamental

### 3.3.11

#### **sub-harmonics**

<voltage and current> interharmonic component of harmonic order lower than one

Note 1 to entry: In this document, sub-harmonic components are restricted to ranks being reciprocal of integers.

[SOURCE: IEC 60050-551:2001, 551-20-10, modified – the term has been changed from "sub-harmonic component" to "sub-harmonics" and the domain has been indicated.]

### 3.3.12

#### **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]

### 3.3.13

#### **voltage dip**

temporary reduction of the voltage at a point in the electrical distribution system below a defined 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: In some areas of the world a voltage dip is referred to as sag. The two terms are considered interchangeable; however, this document will only use the term voltage dip.

### 3.3.14

#### **voltage swell**

temporary increase of the voltage at a point in the electrical distribution system above a defined threshold

### 3.3.15

#### **RMS voltage refreshed each half-cycle**

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

value of the RMS 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 RMS values at successive times on different channels for polyphase systems

Note 2 to entry: This RMS voltage value may be a phase to phase value or a phase to neutral value.

### 3.3.16

#### **RMS voltage refreshed each cycle**

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

value of the RMS 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 RMS voltage value can be a phase to phase value or a phase to neutral value.

### 3.3.17

#### **voltage interruption**

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

### 3.3.18

#### **amplitude and phase voltage unbalance**

condition in a three-phase system in which the RMS values of the line voltages (fundamental component), 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-sequence and zero-sequence components to the positive-sequence component.

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

### 3.3.19

#### **amplitude voltage unbalance**

condition in a three-phase system in which the RMS values of the line voltages (fundamental component) are not all equal.

Note 1 to entry: The relative phase between the line voltages is not taken into account.

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

### 3.3.20

#### **transient overvoltage**

short-duration overvoltage of few milliseconds or less, oscillatory or non-oscillatory, usually highly damped.

Note 1 to entry: Transient overvoltages may be immediately followed by temporary overvoltages. In such cases the two overvoltages are considered as separate events.

Note 2 to entry: IEC 60071-1 defines three types of transient overvoltages, namely slow-front overvoltages, fast-front overvoltages and very fast-front overvoltages according to their time to peak, tail or total duration, and possible superimposed oscillations.

[SOURCE: IEC 60050-604:2016, 604-03-14]

### **3.3.21**

#### **crest factor**

peak to RMS ratio

## **3.4 Definitions related to measurement techniques**

### **3.4.1**

#### **measurement window**

interval during which a single measurement is performed, expressed in seconds or in number of fundamental cycles

Note 1 to entry: Depending on the measurement technique the duration of the measurement window may be fixed or variable.

### **3.4.2**

#### **gapless measurement**

measurement technique where the measurement is performed continuously without gap, that is, using contiguous measurement windows

Note 1 to entry: For digital techniques and for a given sampling rate, no sample is missing in the measurement processing.

Note 2 to entry: When gapless measurement techniques are used, no assumption is made regarding the stability of the signal, as opposed to non-gapless measurement techniques, where the signal is considered to be stable during the time where no measurement is done.

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### 3.5 Notations

#### 3.5.1 Functions

| Symbol              | Function                                                                                   |
|---------------------|--------------------------------------------------------------------------------------------|
| $P$                 | total active power                                                                         |
| $E_a$               | total active energy                                                                        |
| $Q_A / Q_V$         | total reactive power arithmetic / total reactive power vector                              |
| $E_{rA} / E_{rV}$   | total reactive energy arithmetic / total reactive energy vector                            |
| $S_A / S_V$         | total apparent power arithmetic / total apparent power vector                              |
| $E_{apA} / E_{apV}$ | total apparent energy arithmetic / total apparent energy vector                            |
| $f$                 | frequency                                                                                  |
| $I$                 | phase current ( $I_p$ : current on line $p$ )                                              |
| $I_N / I_{Nc}$      | measured neutral current / calculated neutral current                                      |
| $U$                 | line to line voltage ( $U_{pg}$ : line $p$ to line $g$ )                                   |
| $V$                 | line to neutral voltage ( $V_p$ : line $p$ to neutral)                                     |
| $PF_A / PF_V$       | arithmetic power factor / vector power factor                                              |
|                     | NOTE $PF_V = \cos(\varphi)$ when no harmonics are present                                  |
| $P_{st} / P_{lt}$   | short term flicker / long term flicker                                                     |
| $U_{dip}$           | voltage dips line to line ( $U_{pg\ dip}$ : line $p$ to line $g$ )                         |
| $V_{dip}$           | voltage dips line to neutral ( $V_{p\ dip}$ : line $p$ to neutral)                         |
| $U_{swl}$           | voltage swells line to line ( $U_{pg\ swl}$ : line $p$ to line $g$ )                       |
| $V_{swl}$           | voltage swells line to neutral ( $V_{p\ swl}$ : line $p$ to neutral)                       |
| $U_{tr}$            | transients overvoltage line to line ( $U_{pg\ tr}$ : line $p$ to line $g$ )                |
| $V_{tr}$            | transients overvoltage line to neutral ( $V_{p\ tr}$ : line $p$ to neutral)                |
| $U_{int}$           | voltage Interruption line to line ( $U_{pg\ int}$ : line $p$ to line $g$ )                 |
| $V_{int}$           | voltage interruption line to neutral ( $V_{p\ int}$ : line $p$ to neutral)                 |
| $U_{nb}$            | amplitude and phase voltage unbalance line to line ( $U_{pg\ nb}$ : line $p$ to line $g$ ) |
| $V_{nb}$            | amplitude and phase voltage unbalance line to neutral ( $V_{p\ nb}$ : line $p$ to neutral) |
| $I_{nb}$            | current unbalance phase and amplitude                                                      |
| $U_{nba}$           | amplitude voltage unbalance line to line ( $U_{pg\ nba}$ : line $p$ to line $g$ )          |
| $V_{nba}$           | amplitude voltage unbalance line to neutral ( $V_{p\ nba}$ : line $p$ to neutral)          |
| $I_{nba}$           | current unbalance amplitude                                                                |
| $U_h$               | voltage harmonics line to line ( $U_{pg\ h}$ : line $p$ to line $g$ )                      |
| $V_h$               | voltage harmonics line to neutral ( $V_{p\ h}$ : line $p$ to neutral)                      |
| $THD_u$             | total harmonic distortion voltage line to line related to fundamental                      |
| $THD-R_u$           | total harmonic distortion voltage line to line related to RMS value                        |
| $THD_v$             | total harmonic distortion voltage line to neutral related to fundamental                   |
| $THD-R_v$           | total harmonic distortion voltage line to neutral related to RMS value                     |
| $THD-R$             | total harmonic current related to RMS value                                                |

#### 3.5.2 Symbols and abbreviations

|         |                     |
|---------|---------------------|
| $\%U_n$ | percentage of $U_n$ |
| $\%I_n$ | percentage of $I_n$ |
| $\%I_b$ | percentage of $I_b$ |

### 3.5.3 Indices

|      |                     |
|------|---------------------|
| a    | active              |
| r    | reactive            |
| ap   | apparent            |
| n    | rated               |
| b    | basic               |
| nom  | nominal             |
| N    | neutral             |
| c    | calculated          |
| h    | harmonic            |
| i    | current             |
| u    | voltage             |
| dip  | dips                |
| swl  | swells              |
| tr   | transient           |
| int  | interruption        |
| nb   | unbalance           |
| nba  | amplitude unbalance |
| A    | arithmetic          |
| V    | vectorial           |
| min  | minimum value       |
| max  | maximum value       |
| avg  | average value       |
| peak | peak value          |
| res  | residual            |

## 4 Requirements

### 4.1 General requirements

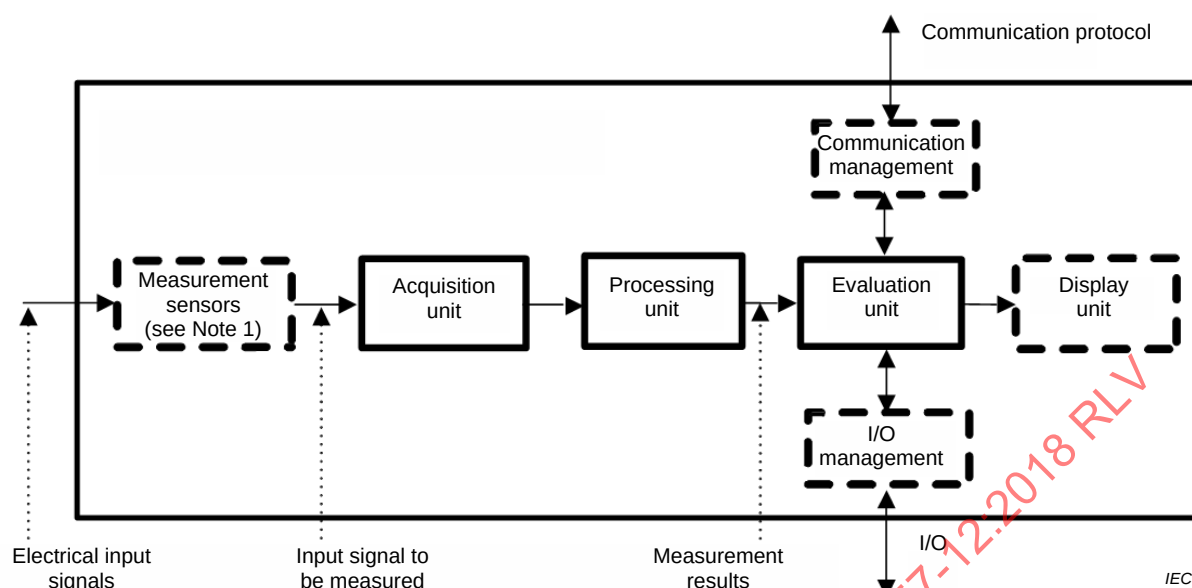
The following requirements shall apply unless otherwise specified hereafter.

### 4.2 PMD general architecture

Organization of the measurement chain: the electrical quantity to be measured may be either directly accessible, as it is generally the case in low-voltage systems, or accessible via measurement sensors like voltage sensors (VS) or current sensors (CS).

Figure 1 shows the common organization of a PMD.

In some cases when a PMD does not include the sensors, their associated uncertainties are not considered. When a PMD includes the sensors, their associated uncertainties are considered.



NOTE 1 It is not necessary that the parts in the dotted lines be included in the PMD.

NOTE 2 I/O are analog and/or digital signals with alarms.

**Figure 1 – PMD generic measurement chain**

#### 4.3 Classification of PMD

PMD are classified according to the applications as defined in Table 1.

**Table 1 – Functional classification of PMD with minimal required functions**

| Functionalities<br>symbol <sup>a</sup>                         | PMD type <sup>b</sup>      |                                     |                                                              |
|----------------------------------------------------------------|----------------------------|-------------------------------------|--------------------------------------------------------------|
|                                                                | PMD-I<br>Energy efficiency | PMD-II<br>Basic power<br>monitoring | PMD-III<br>Advanced power monitoring<br>/network performance |
| $P$                                                            |                            | ■                                   | ■                                                            |
| $Q$                                                            |                            | ■                                   | ■                                                            |
| $S$                                                            |                            | ■                                   | ■                                                            |
| $E_a$                                                          | ■                          | ■                                   | ■                                                            |
| $E_i$                                                          |                            | ■                                   | ■                                                            |
| $E_{ap}$                                                       |                            |                                     | ■                                                            |
| $f$                                                            |                            | ■                                   | ■                                                            |
| $I$                                                            |                            | ■                                   | ■                                                            |
| $I_N$                                                          |                            |                                     | ■                                                            |
| $U$ and/or $V$                                                 |                            | ■                                   | ■                                                            |
| $PF$                                                           |                            | ■                                   | ■                                                            |
| $THD_u$ and/or $THD_v$<br>and/or $THD-R_u$ and/or<br>$THD-R_v$ |                            |                                     | ■                                                            |
| $THD_i$ and/or $THD-R_i$                                       |                            |                                     | ■                                                            |

<sup>a</sup> Only total quantities are mandatory

<sup>b</sup> For PMD other than PMD-I, PMD-II and PMD-III, called PMD-x, other combinations of functions are allowed and shall be specified by the manufacturer.

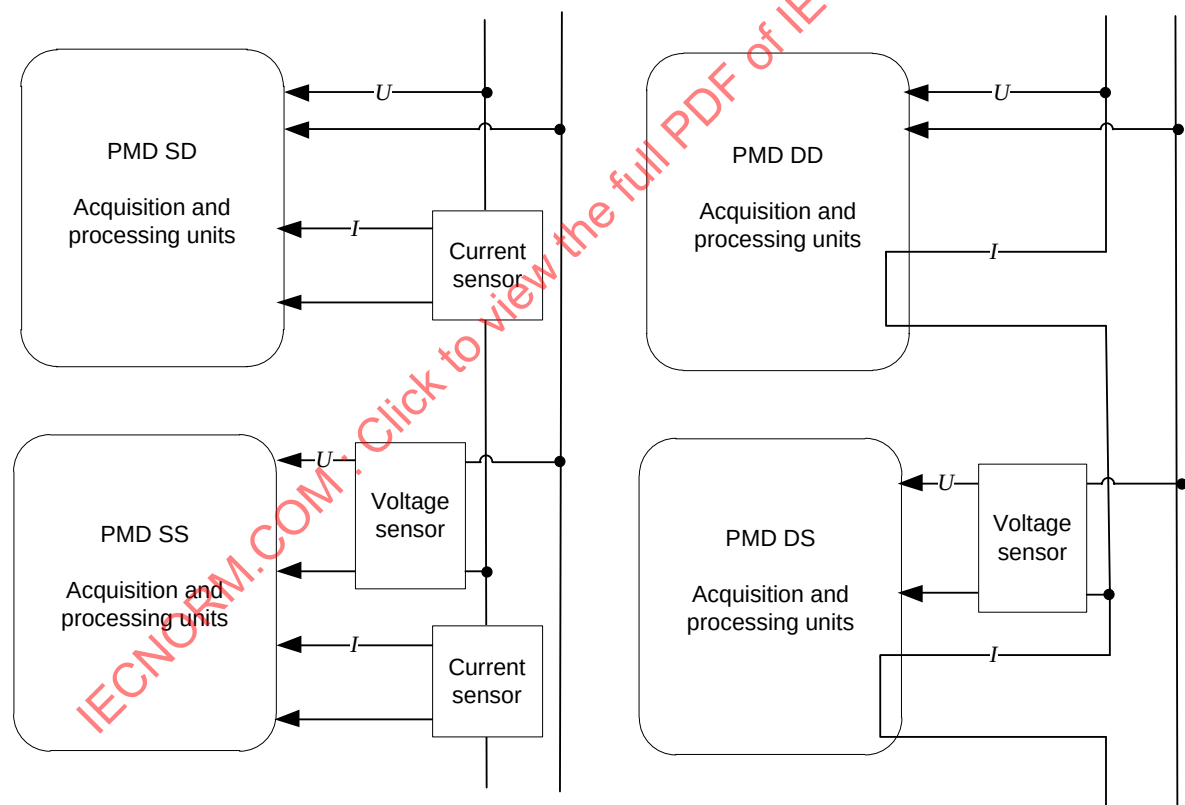
## 4.4 Structure of PMD

### 4.4.1 Structure of PMD related to sensors

PMD can have either an internal sensor, or may need an external sensor, as shown in Figure 2. Depending on these characteristics, PMD can be split in four categories as defined in Table 2.

**Table 2 – Structure of PMD**

|                     |                                                                 | Current measurement                                             |                                                              |
|---------------------|-----------------------------------------------------------------|-----------------------------------------------------------------|--------------------------------------------------------------|
|                     |                                                                 | Sensor operated PMD<br>(current sensors out of PMD)<br>→ PMD Sx | Direct connected PMD<br>(current sensors in PMD)<br>→ PMD Dx |
| Voltage measurement | Direct connected PMD<br>(voltage sensors in PMD)<br>→ PMD xD    | PMD SD<br>(Semi-direct insertion)                               | PMD DD<br>(Direct insertion)                                 |
|                     | Sensor operated PMD<br>(voltage sensors out of PMD)<br>→ PMD xS | PMD SS<br>(Indirect insertion)                                  | PMD DS<br>(Semi-direct insertion)                            |



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NOTE A PMD specified as a PMD Dx (respectively PMD xD) can sometimes, under certain conditions, be used as a PMD Sx (respectively PMD xS) when used with external sensors provided that it complies with both requirements of PMD Sx and Dx (respectively PMD xS and xD).

**Figure 2 – Description of different types of PMD**

### 4.4.2 Requirements for self-powered PMD

Three-phase self-powered PMD shall measure within the specified accuracy limits even in the event one of the three phases or two of the three phases are disconnected.

## 4.5 List of applicable performance classes

Table 3 specifies the list of allowed performance classes.

**Table 3 – List of applicable performance classes**

|                             |      |      |     |     |     |   |   |     |   |   |
|-----------------------------|------|------|-----|-----|-----|---|---|-----|---|---|
| Active energy               |      |      |     | 0,2 | 0,5 | 1 | 2 |     |   |   |
| Active power                |      |      | 0,1 | 0,2 | 0,5 | 1 | 2 | 2,5 |   |   |
| Reactive energy             |      |      |     |     |     |   | 2 |     | 3 |   |
| Reactive power              |      |      |     |     |     | 1 | 2 |     | 3 |   |
| Apparent energy             |      |      |     | 0,2 | 0,5 | 1 | 2 |     |   |   |
| Apparent power              |      |      |     | 0,2 | 0,5 | 1 | 2 |     |   |   |
| Frequency                   | 0,02 | 0,05 | 0,1 | 0,2 | 0,5 |   |   |     |   |   |
| Phase current               |      | 0,05 | 0,1 | 0,2 | 0,5 | 1 | 2 |     |   |   |
| Measured neutral current    |      |      |     | 0,2 | 0,5 | 1 | 2 |     |   |   |
| Calculated neutral current  |      |      | 0,1 | 0,2 | 0,5 | 1 | 2 |     |   |   |
| Voltage                     |      | 0,05 | 0,1 | 0,2 | 0,5 | 1 | 2 |     |   |   |
| Power factor                |      |      |     |     | 0,5 | 1 | 2 |     |   | 5 |
| Flicker                     |      |      |     |     |     |   |   |     |   | 5 |
| Dips and swells measurement |      |      |     |     | 0,5 | 1 | 2 |     |   |   |
| Voltage interruption        |      |      |     |     | 0,5 | 1 | 2 |     |   |   |
| Voltage unbalance           |      |      |     | 0,2 | 0,5 | 1 |   |     |   |   |
| Voltage harmonics           |      |      |     |     |     | 1 | 2 |     | 3 | 5 |
| Voltage THD                 |      |      |     |     |     | 1 | 2 |     | 3 | 5 |
| Current unbalance           |      |      |     | 0,2 | 0,5 | 1 |   |     |   |   |
| Current harmonics           |      |      |     |     |     | 1 | 2 |     | 3 | 5 |
| Current THD                 |      |      |     |     |     | 1 | 2 |     | 3 | 5 |

The requirements for the performance for a PMD associated with a dedicated external sensor are the same as for a direct connected PMD. Each combination of a PMD associated with a dedicated external sensor shall be considered as a PMD DD that needs to comply with the performance requirements of this document.

**EXAMPLE** If a manufacturer provides three different types of dedicated sensors (for example, a 100 A dedicated CT, a 500 A dedicated CT and a 1 000 A dedicated CT), then the manufacturer would provide three separate performance type test reports (one for the tests related to the PMD associated with the 100 A dedicated sensor, one for the tests related to the PMD associated with the 500 A dedicated sensor and one for the tests related to the PMD associated with the 1 000 A dedicated sensor). The manufacturer shall provide proper justification (e.g. simulation results, existing tests results, design notes, schematics...) for extrapolating performance if some physical tests are not performed.

**NOTE** Guidance related to the association of a PMD with a sensor is provided in Annex E and Annex F.

## 4.6 Operating and reference conditions for PMD

### 4.6.1 Reference conditions

Table 4 gives the reference conditions for testing:

**Table 4 – Reference conditions for testing**

| Conditions                                                                                                                                                                                 | Reference conditions                                  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------|
| Operating temperature                                                                                                                                                                      | 23 °C ± 2 °C or otherwise specified by manufacturer   |
| Relative humidity                                                                                                                                                                          | 40 % to 60 % RH                                       |
| Auxiliary supply voltage                                                                                                                                                                   | Rated power supply voltage ± 1 %                      |
| Phases                                                                                                                                                                                     | Three phases available <sup>a</sup>                   |
| Voltages unbalance                                                                                                                                                                         | ≤ 0,1 % <sup>a</sup>                                  |
| External continuous magnetic field                                                                                                                                                         | ≤ 40 A/m DC<br>≤ 3 A/m AC at 50/60 Hz                 |
| DC component on voltage and current                                                                                                                                                        | None                                                  |
| Waveform                                                                                                                                                                                   | Sinusoidal                                            |
| Frequency                                                                                                                                                                                  | Rated frequency (50 Hz or 60 Hz) ± 0,2 % <sup>b</sup> |
| <sup>a</sup> Required only in the case of three-phase systems.                                                                                                                             |                                                       |
| <sup>b</sup> PMD should use the standard rated frequencies of 50 Hz or 60 Hz, where possible, although other rated frequencies, or rated frequency ranges, including DC, may be specified. |                                                       |

## 4.6.2 Rated operating conditions

### 4.6.2.1 General

Tables 5 to 7 give the conditions in which functions shall be performed according to their specifications.

### 4.6.2.2 Rated temperature operating conditions for portable equipment

Table 5 gives the rated operating temperature for portable PMD:

**Table 5 – Rated operating temperatures for portable equipment**

|                                                    | K40 temperature class of PMD |
|----------------------------------------------------|------------------------------|
| Rated operating range (with specified uncertainty) | 0 °C to +40 °C               |
| Limit range of operation (no hardware failures)    | –10 °C to +55 °C             |
| Limit range for storage and shipping               | –25 °C to +70 °C             |

### 4.6.2.3 Rated temperature operating conditions for fixed installed equipment

Table 6 gives the rated operating temperature for fixed installed PMD:

**Table 6 – Rated operating temperatures for fixed installed equipment**

|                                                                                                                                                                                                                                                           | <b>K55 temperature class of PMD</b> | <b>K70 temperature class of PMD</b> | <b>Kx<sup>b</sup> temperature class of PMD</b>         |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------|-------------------------------------|--------------------------------------------------------|
| Rated operating range <sup>c</sup><br>(with specified uncertainty)                                                                                                                                                                                        | –5 °C to +55 °C                     | –25 °C to +70 °C                    | Above +70 °C and/or under –25 °C <sup>a</sup>          |
| Limit range of operation<br>(no hardware failures)                                                                                                                                                                                                        | –5 °C to +55 °C                     | –25 °C to +70 °C                    | Above +70 °C and/or under –25 °C <sup>a</sup>          |
| Limit range for storage and shipping                                                                                                                                                                                                                      | –25 °C to +70 °C                    | –40 °C to +85 °C                    | According to manufacturer's specification <sup>a</sup> |
| <sup>a</sup> Limits are to be defined by the manufacturer according to the application.<br><sup>b</sup> Kx stands for extended conditions.<br><sup>c</sup> The operating temperature is the highest temperature of the air in close proximity to the PMD. |                                     |                                     |                                                        |

**4.6.2.4 Rated humidity and altitude operating conditions**

Table 7 gives the rated operating humidity and altitude conditions for portable and fixed installed PMD:

**Table 7 – Humidity and altitude operating conditions**

|                                                                                                                                                                  | <b>Standard conditions</b>  | <b>Extended conditions</b>          |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------|-------------------------------------|
| Rated operating range<br>(with specified uncertainty)                                                                                                            | 0 % to 75 % RH <sup>b</sup> | 0 % to above 75 % RH <sup>a b</sup> |
| Limit range of operation for 30 days/year                                                                                                                        | 0 % to 90 % RH <sup>b</sup> | 0 % to above 90 % RH <sup>a b</sup> |
| Limit range for storage and shipping                                                                                                                             | 0 % to 90 % RH <sup>b</sup> | 0 % to above 90 % RH <sup>a b</sup> |
| Altitude                                                                                                                                                         | 0 m to 2 000 m              | 0 m to above 2 000 m <sup>a</sup>   |
| <sup>a</sup> Limits are to be defined by manufacturer according to the application.<br><sup>b</sup> Relative humidity values are specified without condensation. |                             |                                     |

The limits of relative humidity as a function of ambient temperature are shown in Figure 3.

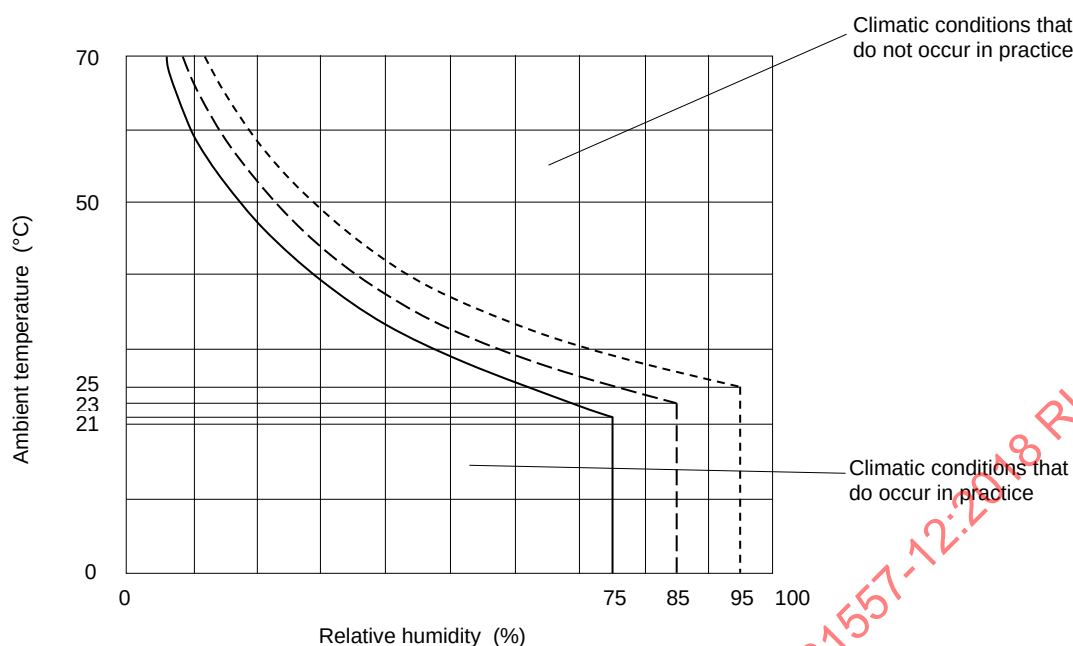


**Figure 3 – Relationship between ambient air temperature and relative humidity**

#### 4.7 Start-up conditions

Measurement readings shall be available via a communication or local user interface 15 s after applying power supply. If the start-up is longer than 15 s, manufacturers shall specify the maximum time until measurement quantities shall be available via a communication or local user interface after power supply is applied.

When no communication or local user interface is available, this requirement shall be verified according to the test procedure given in 6.2.17.

#### 4.8 Requirements for PMD functions

##### 4.8.1 General requirements

##### 4.8.1.1 Coverage requirements

Subclause 4.8 describes a list of functions. Depending on the purpose of the measurement, all or a subset of the functions listed shall be measured.

All functions implemented in the product and covered by this document shall comply with the requirements of this document.

##### 4.8.1.2 Requirements for the measurement window

Unless specified otherwise, the measurement window of a measured quantity shall not be longer than 3 s or 150/180 cycles at rated frequency.

For THD and harmonics, this requirement may not be met. In such case the measurement window for THD and harmonics shall be declared by the manufacturer.

This requirement does not apply to energies and demands, which are obtained by integrating or averaging basic quantities measured on the measurement window.

#### **4.8.1.3 Requirements for the line to neutral voltage quantities**

Unless specified otherwise, if line to neutral voltage functions are implemented they shall comply with the same requirements as the line to line voltage functions.

#### **4.8.1.4 Requirement on variation limits under influence quantities**

For practical reasons, if a calculated variation limit requirement is less than 0,02 %, the requirement shall be set at 0,02 %.

#### **4.8.1.5 Maximum current**

When the PMD is operated from (a) current transformer(s), attention is drawn to the need to match the current range of the PMD in relation to that of the secondary of the current transformer(s). The maximum current of the PMD shall be 120 %  $I_n$  at least.

### **4.8.2 Active power ( $P$ ) and active energy ( $E_a$ ) measurements**

#### **4.8.2.1 Techniques**

See Annex B.

Gapless measurement is required.

#### **4.8.2.2 Rated range of operation**

The intrinsic uncertainty requirements shall apply within the following range:

$$80 \% U_n < U < 120 \% U_n$$

#### **4.8.2.3 Intrinsic uncertainty table**

The intrinsic uncertainty under reference conditions shall not exceed limits given in Table 8:

**Table 8 – Intrinsic uncertainty table for active power and active energy measurement**

| Specified measuring range                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |                                             | Power factor <sup>c</sup>       | Intrinsic uncertainty limits for PMD of function performance class C <sup>a b</sup> |                                                          | Unit |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|---------------------------------|-------------------------------------------------------------------------------------|----------------------------------------------------------|------|
| Value of current for direct connected PMD Dx                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Value of current for sensor operated PMD Sx |                                 | for $C < 1$                                                                         | for $C \geq 1$                                           |      |
| $2 \% I_b \leq I < 10 \% I_b$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | $1 \% I_n \leq I < 5 \% I_n$                | 1                               | $\pm 2,0 \times C$                                                                  | No requirement                                           | %    |
| $5 \% I_b \leq I < 10 \% I_b$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | $2 \% I_n \leq I < 5 \% I_n$                | 1                               | No requirement                                                                      | $\pm (1,0 \times C + 0,5)$                               | %    |
| $10 \% I_b \leq I \leq I_{max}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | $5 \% I_n \leq I \leq I_{max}$              | 1                               | $\pm 1,0 \times C$                                                                  | $\pm 1,0 \times C$                                       | %    |
| $5 \% I_b \leq I < 20 \% I_b$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | $2 \% I_n \leq I < 10 \% I_n$               | 0,5 inductive<br>0,8 capacitive | $\pm (1,7 \times C + 0,15)$<br>$\pm (1,7 \times C + 0,15)$                          | No requirement<br>No requirement                         | %    |
| $10 \% I_b \leq I < 20 \% I_b$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | $5 \% I_n \leq I < 10 \% I_n$               | 0,5 inductive<br>0,8 capacitive | No requirement<br>No requirement                                                    | $\pm (1,0 \times C + 0,5)$<br>$\pm (1,0 \times C + 0,5)$ | %    |
| $20 \% I_b \leq I \leq I_{max}$                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             | $10 \% I_n \leq I \leq I_{max}$             | 0,5 inductive<br>0,8 capacitive | $\pm (1,0 \times C + 0,1)$<br>$\pm (1,0 \times C + 0,1)$                            | $\pm 1,0 \times C$<br>$\pm 1,0 \times C$                 | %    |
| <sup>a</sup> Applicable performance classes are listed in Table 3.<br><sup>b</sup> For active energy measurement classes 1 and 2 of this document, the uncertainty limits of classes 1 and 2 defined in Table 6 of IEC 62053-21:2003 can be used as well as the uncertainty limits given in this table. For active energy measurement classes 0,2 and 0,5 of this document, the uncertainty limits of classes 0,2S and 0,5S defined in Table 4 of IEC 62053-22:2003 can be used as well as the uncertainty limits given in this table.<br><sup>c</sup> In reference conditions, signals are sinusoidal, so in this case the power factor = $\cos \varphi$ . |                                             |                                 |                                                                                     |                                                          |      |

#### 4.8.2.4 Limits of variations due to influence quantities

The additional variations due to influence quantities with respect to reference conditions as given in 4.6.1, shall not exceed the limits for the relevant performance class given in Table 9:

Table 9 – Influence quantities for active power and active energy measurement (1 of 3)

| Influence type                                          | Influence quantities                                                               | Specified measuring range <sup>e</sup>                           |                                                                 | Power factor <sup>j</sup> | Temperature coefficient for PMD of function performance class C <sup>a b</sup> |                                | Unit           |
|---------------------------------------------------------|------------------------------------------------------------------------------------|------------------------------------------------------------------|-----------------------------------------------------------------|---------------------------|--------------------------------------------------------------------------------|--------------------------------|----------------|
|                                                         |                                                                                    | Value of current for direct connected PMD D <sub>x</sub>         | Value of current for sensor operated PMD S <sub>x</sub>         |                           | for C < 1                                                                      | for C ≥ 1                      |                |
| Ambient temperature                                     | according to rated operating range of Table 5 and Table 6                          | 10 % $I_b \leq I \leq I_{max}$<br>20 % $I_b \leq I \leq I_{max}$ | 5 % $I_n \leq I \leq I_{max}$<br>10 % $I_n \leq I \leq I_{max}$ | 1<br>0,5 inductive        | 0,05 x C<br>0,1 x C                                                            | 0,05 x C<br>0,07 x C           | % / K<br>% / K |
|                                                         |                                                                                    |                                                                  |                                                                 |                           | Limits of variation for PMD of function performance class C <sup>a b</sup>     |                                |                |
|                                                         |                                                                                    |                                                                  |                                                                 |                           | for C < 1                                                                      | for C ≥ 1                      |                |
| Auxiliary power supply voltage <sup>i</sup>             | rated voltage ± 15 %                                                               | 10 % $I_b$                                                       | 10 % $I_n$                                                      | 1                         | 0,1 x C                                                                        | 0,1 x C                        | %              |
| Voltage                                                 | 80 % $U_n < U < 120$ % $U_n$                                                       | 5 % $I_b \leq I \leq I_{max}$<br>10 % $I_b \leq I \leq I_{max}$  | 2 % $I_n \leq I \leq I_{max}$<br>5 % $I_n \leq I \leq I_{max}$  | 1<br>0,5 inductive        | 0,3 x C + 0,04<br>0,6 x C + 0,08                                               | 0,3 x C + 0,4<br>0,5 x C + 0,5 | %              |
| Frequency                                               | rated frequency ± 2 %                                                              | 5 % $I_b \leq I \leq I_{max}$<br>10 % $I_b \leq I \leq I_{max}$  | 2 % $I_n \leq I \leq I_{max}$<br>5 % $I_n \leq I \leq I_{max}$  | 1<br>0,5 inductive        | 0,3 x C + 0,04<br>0,3 x C + 0,04                                               | 0,3 x C + 0,2<br>0,3 x C + 0,4 | %              |
| Reversed phase sequence                                 | ---                                                                                | 10 % $I_b$                                                       | 10 % $I_n$                                                      | 1                         | 0,15 x C + 0,02                                                                | 1,5                            | %              |
| Voltage unbalance                                       | 0 % to 10 %                                                                        | $I_b$                                                            | $I_n$                                                           | 1                         | 1,5 x C + 0,2                                                                  | 2,0 x C                        | %              |
| Phase missing <sup>f</sup>                              | one or two phases missing                                                          | $I_b$                                                            | $I_n$                                                           | 1                         | 2,0 x C                                                                        | 2,0 x C                        | %              |
| Harmonic components in the current and voltage circuits | voltage, 5 <sup>th</sup> harmonic: 10 %<br>current, 5 <sup>th</sup> harmonic: 40 % | 50 % $I_{max}$                                                   | 50 % $I_{max}$                                                  | 1                         | 0,4 x C + 0,3                                                                  | 0,2 x C + 0,6                  | %              |

Table 9 (2 of 3)

| Influence quantities                                                       |                                                                              | Specified measuring range <sup>e</sup>                                |                                                                      | Power factor <sup>j</sup> | Limits of variation for PMD of function performance class C <sup>a b</sup> |               | Unit |
|----------------------------------------------------------------------------|------------------------------------------------------------------------------|-----------------------------------------------------------------------|----------------------------------------------------------------------|---------------------------|----------------------------------------------------------------------------|---------------|------|
| Influence type                                                             | Influence range                                                              | Value of current for direct connected PMD D <sub>x</sub> <sup>f</sup> | Value of current for sensor operated PMD S <sub>x</sub> <sup>f</sup> |                           |                                                                            |               |      |
| Odd harmonics in the AC current circuit                                    | see <sup>g</sup>                                                             | 50 % $I_b$                                                            | 50 % $I_n$                                                           | 1                         | 3,0 x C                                                                    | 3,0 x C       | %    |
| Sub-harmonics in the AC current circuit                                    | see <sup>g</sup>                                                             | 50 % $I_b$                                                            | 50 % $I_n$                                                           | 1                         | 3,0 x C                                                                    | 3,0 x C       | %    |
| Common mode voltage rejection on isolated current inputs <sup>k</sup>      | 0 to maximum voltage to earth (depending on measuring category) <sup>i</sup> | 10 % $I_b$                                                            | 5 % $I_n$                                                            | 1                         | 1,0 x C                                                                    | 0,5 x C       | %    |
| Permanent AC magnetic induction of external origin 0,5 mT <sup>c d h</sup> | see <sup>c</sup> and <sup>d</sup>                                            | $I_b$                                                                 | $I_n$                                                                | 1                         | 2,0                                                                        | 1,0 x C + 1,0 | %    |
| Electromagnetic RF fields <sup>c d</sup>                                   | see <sup>c</sup> and <sup>d</sup>                                            | $I_b$                                                                 | $I_n$                                                                | 1                         | 3,4 x C + 0,3                                                              | 1,0 x C + 1,0 | %    |
| Conducted disturbances, induced by radio frequency fields <sup>c d</sup>   | see <sup>c</sup> and <sup>d</sup>                                            | $I_b$                                                                 | $I_n$                                                                | 1                         | 3,4 x C + 0,3                                                              | 1,0 x C + 1,0 | %    |

**Table 9 (3 of 3)**

|   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|---|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| a | Applicable performance classes are listed in Table 3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| b | For active energy measurement classes 1 and 2 of this document, the variation limits of classes 1 and 2 defined in Table 8 of IEC 62053-21:2003 can be used as well as the uncertainty limits given in this table. For active energy measurement classes 0,2 and 0,5 of this document, the variation limits of class 0,2 S and 0,5 S defined in Table 6 of IEC 62053-22:2003 can be used as well as the uncertainty limits given in this table.                                                                                                                                                                                                                                                                                        |
| c | EMC levels and test conditions are defined in IEC 61326-1 relating to industrial location.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| d | The EMC influence quantities are applicable only for energy measurements.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| e | Currents are balanced unless otherwise specified.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| f | <p>Polyphase PMD with three measuring elements shall measure and register, within the limits of variation in percentage error shown in this table, if the following phases are interrupted:</p> <ul style="list-style-type: none"> <li>– in a three-phase, four-wire network one or two phases;</li> <li>– in a three-phase, three-wire network (if the PMD is designed for this service) one of the three phases.</li> </ul> <p>This only covers phase interruptions and does not cover events such as transformer fuse failures.</p> <p>In case of polyphase PMD with two measuring elements the test does not apply.</p> <p>For PMD with auxiliary power supply, the auxiliary power supply is not interrupted during the test.</p> |
| g | See Clause 6.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| h | A magnetic induction of external origin of 0,5 mT produced by a current of the same frequency as that of the voltage applied to the PMD and under the most unfavourable conditions of phase and direction shall not cause a variation exceeding the values shown in this table.                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| i | Measuring category is defined in IEC 61010-2-030, for instance 300 V common mode voltage for 300 V cat III.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| j | In reference conditions, signals are sinusoidal, so in this case the power factor $\approx \cos \varphi$ .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| k | If current inputs are connected internally or externally to the ground, this requirement is not applicable.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| l | These limits are settled for a PMD powered by mains supply voltage. In the case of a larger range of the supply voltage AC or DC, tests shall be done at least at the lower input value and upper input value of this range. In any case, PMD shall comply with the requirement for all the specified supply voltage ranges.                                                                                                                                                                                                                                                                                                                                                                                                           |

#### 4.8.2.5 Starting and no-load condition

##### 4.8.2.5.1 Start-up of the PMD

See 4.7.

##### 4.8.2.5.2 No-load condition (only for energy measurement)

When the voltage is applied with no current flowing in the current circuit, the test output of the PMD shall not produce more than one pulse.

For this test, the current circuit shall be open-circuit and a voltage of 115 % of the rated voltage shall be applied to the voltage circuit.

In the case of an outside shunt, only the input circuit of the PMD shall be opened.

The minimum test period  $\Delta t$  shall be as described in Table 10:

**Table 10 – Minimum test period**

| PMD types | Minimum test period $\Delta t$ (min) for no-load condition                               |                                                                                          |
|-----------|------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
|           | for $C < 1$                                                                              | for $C \geq 1$                                                                           |
| PMD       | $\Delta t = \frac{((100 / C) + 400) \times 10^6}{k \times m \times U_n \times I_{\max}}$ | $\Delta t = \frac{((240 / C) + 360) \times 10^6}{k \times m \times U_n \times I_{\max}}$ |

where

$C$  is the function performance class;

$k$  is the number of pulses emitted by the output device of the PMD per kilowatt-hour (impulse/kWh);

$m$  is the number of measuring elements;

NOTE A measuring element is a part of the meter which produces an output proportional to the energy.

$U_n$  is the rated voltage in volts;

$I_{\max}$  is the maximum current in amperes.

For transformer-operated PMD with primary or half-primary registers, the constant  $k$  shall correspond to the secondary values (voltage and current).

##### 4.8.2.5.3 Starting current

The PMD shall start and continue to register at the starting current values (and in the case of three-phase meters, with balanced load) shown in Table 11.

When starting conditions are met (according to Table 11), intrinsic uncertainty shall be between –40 % and +90 % of measured values.

If the PMD is designed for the measurement of energy in both directions, then this test shall be applied with energy flowing in each direction.

**Table 11 – Starting current for active power and active energy measurement**

| PMD types | Power factor <sup>a</sup> | Starting current for PMD of function performance class C |                                     |
|-----------|---------------------------|----------------------------------------------------------|-------------------------------------|
|           |                           | for $C < 1$                                              | for $C \geq 1$                      |
| PMD Dx    | 1                         | $2 \times 10^{-3} \times I_b$                            | $(C + 3) \times 10^{-3} \times I_b$ |
| PMD Sx    | 1                         | $1 \times 10^{-3} \times I_n$                            | $(C + 1) \times 10^{-3} \times I_n$ |

<sup>a</sup> In reference conditions, signals are sinusoidal, so in this case the power factor =  $\cos \varphi$ .

### 4.8.3 Reactive power ( $Q_A$ , $Q_V$ ) and reactive energy ( $E_{rA}$ , $E_{rV}$ ) measurements

#### 4.8.3.1 Techniques

See Annex B.

Gapless measurement is required.

#### 4.8.3.2 Rated range of operation

The intrinsic uncertainty requirements shall apply within the following rated range:

$$80 \% U_n < U < 120 \% U_n$$

#### 4.8.3.3 Intrinsic uncertainty table

The intrinsic uncertainty under reference conditions shall not exceed the limits given in Table 12:

**Table 12 – Intrinsic uncertainty table for reactive power and reactive energy measurement**

| Specified measuring range                    |                                             | $\sin \varphi$ (inductive or capacitive) | Intrinsic uncertainty limits for PMD of function performance class C <sup>a b</sup> |                     | Unit |
|----------------------------------------------|---------------------------------------------|------------------------------------------|-------------------------------------------------------------------------------------|---------------------|------|
| value of current for direct connected PMD Dx | value of current for sensor operated PMD Sx |                                          | for $C < 3$                                                                         | for $C \geq 3$      |      |
| $5 \% I_b \leq I < 10 \% I_b$                | $2 \% I_n \leq I < 5 \% I_n$                | 1                                        | $\pm 1,25 \times C$                                                                 | $\pm 1,33 \times C$ | %    |
| $10 \% I_b \leq I \leq I_{\max}$             | $5 \% I_n \leq I \leq I_{\max}$             | 1                                        | $\pm 1,0 \times C$                                                                  | $\pm 1,0 \times C$  | %    |
| $10 \% I_b \leq I < 20 \% I_b$               | $5 \% I_n \leq I < 10 \% I_n$               | 0,5                                      | $\pm 1,25 \times C$                                                                 | $\pm 1,33 \times C$ | %    |
| $20 \% I_b \leq I \leq I_{\max}$             | $10 \% I_n \leq I \leq I_{\max}$            | 0,5                                      | $\pm 1,0 \times C$                                                                  | $\pm 1,0 \times C$  | %    |
| $20 \% I_b \leq I \leq I_{\max}$             | $10 \% I_n \leq I \leq I_{\max}$            | 0,25                                     | $\pm 1,25 \times C$                                                                 | $\pm 1,33 \times C$ | %    |

<sup>a</sup> Applicable performance classes are listed in Table 3.

<sup>b</sup> For reactive energy measurement classes 2 and 3 of this document, the uncertainty limits of classes 2 and 3 defined in Table 6 of IEC 62053-23:2003 can be used as well as the uncertainty limits given in this table.

#### 4.8.3.4 Limits of variation due to influence quantities

The additional variations due to change of influence quantities with respect to reference conditions as given in 4.6.1, shall not exceed the limits for the relevant performance class given in Table 13:

Table 13 – Influence quantities for reactive power and reactive energy measurement

| Influence quantities                                                     |                                                           | Specified measuring range <sup>d</sup>                           |                                                                 | sin φ<br>(inductive or capacitive) | Temperature coefficient for PMD of function performance class $C^{a e}$ |                      | Unit           |
|--------------------------------------------------------------------------|-----------------------------------------------------------|------------------------------------------------------------------|-----------------------------------------------------------------|------------------------------------|-------------------------------------------------------------------------|----------------------|----------------|
| Influence type                                                           | Influence range                                           | Value of current for direct connected PMD $D_x$                  | Value of current for sensor operated PMD $S_x$                  |                                    | for $C < 3$                                                             | for $C \geq 3$       |                |
| Ambient temperature                                                      | According to rated operating range of Table 5 and Table 6 | 10 % $I_b \leq I \leq I_{max}$<br>20 % $I_b \leq I \leq I_{max}$ | 5 % $I_n \leq I \leq I_{max}$<br>10 % $I_n \leq I \leq I_{max}$ | 1<br>0,5                           | 0,05 × C<br>0,075 × C                                                   | 0,05 × C<br>0,08 × C | % / K<br>% / K |
|                                                                          |                                                           |                                                                  |                                                                 |                                    | Limits of variation for PMD of function performance class $C^{a b}$     |                      |                |
|                                                                          |                                                           |                                                                  |                                                                 |                                    | for $C < 3$                                                             | for $C \geq 3$       |                |
| Auxiliary power supply voltage <sup>f</sup>                              | Rated voltage ± 15 %                                      | 10 % $I_b$                                                       | 10 % $I_n$                                                      | 1                                  | 0,1 × C                                                                 | 0,1 × C              | %              |
| Voltage                                                                  | 80 % $U_n < U < 120$ % $U_n$                              | 5 % $I_b \leq I \leq I_{max}$<br>10 % $I_b \leq I \leq I_{max}$  | 2 % $I_n \leq I \leq I_{max}$<br>5 % $I_n \leq I \leq I_{max}$  | 1<br>0,5 inductive                 | 0,5 × C<br>0,75 × C                                                     | 0,66 × C<br>1,0 × C  | %<br>%         |
| Frequency                                                                | Rated frequency<br>± 2 %                                  | 5 % $I_b \leq I \leq I_{max}$<br>10 % $I_b \leq I \leq I_{max}$  | 2 % $I_n \leq I \leq I_{max}$<br>5 % $I_n \leq I \leq I_{max}$  | 1<br>0,5 inductive                 | 1,25 × C<br>1,25 × C                                                    | 2,5<br>2,5           | %              |
| Permanent AC magnetic induction of external origin 0,5 mT <sup>b c</sup> | see <sup>b</sup> and <sup>c</sup>                         | $I_b$                                                            | $I_n$                                                           | 1                                  | 1,5 × C                                                                 | 3,0                  | %              |
| Electromagnetic RF fields <sup>b c</sup>                                 | see <sup>b</sup> and <sup>c</sup>                         | $I_b$                                                            | $I_n$                                                           | 1                                  | 1,5 × C                                                                 | 3,0                  | %              |
| Conducted disturbances, induced by radio frequency fields <sup>b c</sup> | see <sup>b</sup> and <sup>c</sup>                         | $I_b$                                                            | $I$                                                             | 1                                  | 1,5 × C                                                                 | 3,0                  | %              |

<sup>a</sup> Applicable performance classes are listed in Table 3.

<sup>b</sup> EMC levels and test conditions are defined in IEC 61326-1 relating to industrial location.

<sup>c</sup> The EMC influence quantities are applicable only for energy measurements.

<sup>d</sup> Currents are balanced unless otherwise specified.

<sup>e</sup> For reactive energy measurement classes 2 and 3 of this document, the variation limits of classes 2 and 3 defined in Table 8 of IEC 62053-23:2003 can be used as well as the uncertainty limits given in this table.

<sup>f</sup> These limits are settled for a PMD powered by mains supply voltage. In the case of a larger range of the supply voltage AC or DC, tests shall be done at least at the lower input value and upper input value of this range. In any case, the PMD shall comply with the requirement for all the specified supply voltage ranges.

### 4.8.3.5 Starting and no-load condition

#### 4.8.3.5.1 Start-up of the PMD

See 4.7.

#### 4.8.3.5.2 No-load condition

When the voltage is applied with no current flowing in the current circuit, the test output of the PMD shall not produce more than one pulse.

For this test, the current circuit shall be open-circuit and a voltage of 115 % of the rated voltage shall be applied to the voltage circuit.

In case of an outside shunt, only the input circuit shall be open circuited.

The minimum test period  $\Delta t$  shall be as described in Table 14:

**Table 14 – Minimum test period**

| PMD types | Minimum test period $\Delta t$ (min) for no-load condition                               |                                                                                            |
|-----------|------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------|
|           | for $C < 3$                                                                              | for $C \geq 3$                                                                             |
| PMD       | $\Delta t = \frac{((240 / C) + 360) \times 10^6}{k \times m \times U_n \times I_{\max}}$ | $\Delta t = \frac{((1\,080 / C) - 60) \times 10^6}{k \times m \times U_n \times I_{\max}}$ |

where

$C$  is the function performance class;

$k$  is the number of pulses emitted by the output device of the PMD per kilovar-hour (impulse/kvarh);

$m$  is the number of measuring elements;

$U_n$  is the rated voltage in volts;

$I_{\max}$  is the maximum current in amperes.

For transformer-operated PMD with primary or half-primary registers, the constant  $k$  shall correspond to the secondary values (voltage and current).

#### 4.8.3.5.3 Starting current

The PMD shall start and continue to register at the starting current values (and in case of three-phase meters, with balanced load) shown in Table 15.

When starting conditions are met (according to Table 15) intrinsic uncertainty shall be between –40 % and +90 % of measured values.

If the PMD is designed for the measurement of energy in both directions, then this test shall be applied with energy flowing in each direction.

**Table 15 – Starting current for reactive energy measurement**

| PMD types | $\sin \phi$ (inductive or capacitive) | Starting current for PMD of function performance class $C$ |                                              |
|-----------|---------------------------------------|------------------------------------------------------------|----------------------------------------------|
|           |                                       | for $C < 3$                                                | for $C \geq 3$                               |
| PMD Dx    | 1                                     | $(C + 3) \times 10^{-3} \times I_b$                        | $(5 \times C - 5) \times 10^{-3} \times I_b$ |
| PMD Sx    | 1                                     | $(C + 1) \times 10^{-3} \times I_n$                        | $(2 \times C - 1) \times 10^{-3} \times I_n$ |

#### 4.8.4 Apparent power ( $S_A$ , $S_V$ ) and apparent energy ( $E_{apA}$ , $E_{apV}$ ) measurements

##### 4.8.4.1 Techniques

See Annex B.

Gapless measurement is required.

##### 4.8.4.2 Rated range of operation

The intrinsic uncertainty requirements shall apply within the following range:

$$80 \% U_n < U < 120 \% U_n$$

##### 4.8.4.3 Intrinsic uncertainty table

The intrinsic uncertainty under reference conditions shall not exceed the limits given in Table 16:

**Table 16 – Intrinsic uncertainty table for apparent power and apparent energy measurement**

| Specified measuring range                    |                                             | Intrinsic uncertainty limits for PMD of function performance class $C^a$ |                            | Unit |
|----------------------------------------------|---------------------------------------------|--------------------------------------------------------------------------|----------------------------|------|
| Value of current for direct connected PMD Dx | Value of current for sensor operated PMD Sx | for $C < 1$                                                              | for $C \geq 1$             |      |
| $5 \% I_b < I \leq 10 \% I_b$                | $2 \% I_n < I \leq 5 \% I_n$                | $\pm 2,0 \times C$                                                       | $\pm (1,0 \times C + 0,5)$ | %    |
| $10 \% I_b < I \leq I_{\max}$                | $5 \% I_n < I \leq I_{\max}$                | $\pm 1,0 \times C$                                                       | $\pm 1,0 \times C$         | %    |

<sup>a</sup> Applicable performance classes are listed in Table 3.

##### 4.8.4.4 Limits of variation due to influence quantities

The additional variations due to the change of influence quantities with respect to reference conditions as given in 4.6.1, shall not exceed the limits for the relevant performance class given in Table 17:

Table 17 – Influence quantities for apparent power and apparent energy measurement

| Influence quantities<br>Influence type                                   | Influence range                                           | Specified measuring range <sup>d</sup>                          |                                                                | Power factor <sup>e</sup> | Temperature coefficient for PMD of function performance class $C^a$ |                                              | Unit  |
|--------------------------------------------------------------------------|-----------------------------------------------------------|-----------------------------------------------------------------|----------------------------------------------------------------|---------------------------|---------------------------------------------------------------------|----------------------------------------------|-------|
|                                                                          |                                                           | Value of current for direct connected PMD Dx                    | Value of current for sensor operated PMD Sx                    |                           | for $C < 1$                                                         | for $C \geq 1$                               |       |
| Ambient temperature                                                      | According to rated operating range of Table 5 and Table 6 | $10\% I_b \leq I \leq I_{max}$                                  | $5\% I_n \leq I \leq I_{max}$                                  | 1                         | $0,05 \times C$                                                     | $0,05 \times C$                              | % / K |
|                                                                          |                                                           |                                                                 |                                                                |                           | Limits of variation for PMD of function performance class $C^{a,b}$ |                                              |       |
|                                                                          |                                                           |                                                                 |                                                                |                           | for $C < 1$                                                         | for $C \geq 1$                               |       |
| Auxiliary power supply voltage <sup>f</sup>                              | Rated voltage $\pm 15\%$                                  | $10\% I_b$                                                      | $10\% I_n$                                                     | 1                         | $0,1 \times C$                                                      | $0,1 \times C$                               | %     |
| Voltage                                                                  | $80\% U_n < U < 120\% U_n$                                | $5\% I_b \leq I \leq I_{max}$<br>$10\% I_b \leq I \leq I_{max}$ | $2\% I_n \leq I \leq I_{max}$<br>$5\% I_n \leq I \leq I_{max}$ | 1<br>0,5 inductive        | $0,3 \times C + 0,04$<br>$0,6 \times C + 0,08$                      | $0,3 \times C + 0,4$<br>$0,5 \times C + 0,5$ | %     |
| Continuous magnetic induction of external origin $0,5 \text{ mT}^{c,d}$  | see <sup>c</sup> and <sup>d</sup>                         | $I_b$                                                           | $I_n$                                                          | 1                         | 2,0                                                                 | $1,0 \times C + 1,0$                         | %     |
| Electromagnetic RF fields <sup>c,d</sup>                                 | see <sup>c</sup> and <sup>d</sup>                         | $I_b$                                                           | $I_n$                                                          | 1                         | $3,4 \times C + 0,3$                                                | $1,0 \times C + 1,0$                         | %     |
| Conducted disturbances, induced by radio frequency fields <sup>c,d</sup> | see <sup>c</sup> and <sup>d</sup>                         | $I_b$                                                           | $I_n$                                                          | 1                         | $3,4 \times C + 0,3$                                                | $1,0 \times C + 1,0$                         | %     |

<sup>a</sup> Applicable performance classes are listed in Table 3.

<sup>b</sup> EMC levels and test conditions are defined in IEC 61326-1 relating to industrial location.

<sup>c</sup> The EMC influence quantities are applicable only for energy measurements.

<sup>d</sup> Currents are balanced unless otherwise specified.

<sup>e</sup> In reference conditions, signals are sinusoidal, so in this case the power factor =  $\cos \varphi$ .

<sup>f</sup> These limits are settled for a PMD powered by mains supply voltage. In the case of a larger range of the supply voltage AC or DC, tests shall be done at least at the lower input value and upper input value of this range. In any case, PMD shall comply with the requirements for all the specified supply voltage ranges.

## 4.8.5 Frequency ( $f$ ) measurements

### 4.8.5.1 Techniques

Gapless measurement is not required.

The measurement window for the frequency measurement may be longer than 3 s but cannot exceed 20 s at rated frequency.

### 4.8.5.2 Rated range of operation

The intrinsic uncertainty requirements shall apply within the following rated range:

- Voltage: 50 %  $U_n$  to  $U_{max}$ .

If the frequency measure is using the current the following range shall apply:

- Current: for PMD Dx: 20 %  $I_b$  to  $I_{max}$ , for PMD Sx: 10 %  $I_n$  to  $I_{max}$ .

NOTE Frequency is usually measured from the voltage function of the PMD; the current rated range of operation is considered only if this function does not exist in the PMD.

### 4.8.5.3 Intrinsic uncertainty table

The intrinsic uncertainty under reference conditions shall not exceed the limits given in Table 18:

**Table 18 – Intrinsic uncertainty table for frequency measurement**

| Specified measuring range                                          | Intrinsic uncertainty limits<br>for PMD of function performance class C <sup>a</sup> | Unit |
|--------------------------------------------------------------------|--------------------------------------------------------------------------------------|------|
| 45 Hz to 55 Hz or 55 Hz to 65 Hz                                   | $\pm 1,0 \times C$                                                                   | %    |
| <sup>a</sup> Applicable performance classes are listed in Table 3. |                                                                                      |      |

### 4.8.5.4 Limits of variation due to influence quantities

The additional variations due to the change of influence quantities with respect to reference conditions as given in 4.6.1, shall not exceed the limits for the relevant performance class given in Table 19:

**Table 19 – Influence quantities for frequency measurement**

| Influence quantities                                                                                                                                                                                                       |                                                                                                                                                                                                                                    | Temperature coefficient for PMD of function performance class C <sup>a</sup>   | Unit  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------|-------|
| Influence type                                                                                                                                                                                                             | Influence range or influence level                                                                                                                                                                                                 |                                                                                |       |
| Ambient temperature                                                                                                                                                                                                        | According to rated operating range of Table 5 and Table 6                                                                                                                                                                          | $0,1 \times C$                                                                 | % / K |
|                                                                                                                                                                                                                            |                                                                                                                                                                                                                                    | <b>Limits of variation for PMD of function performance class C<sup>a</sup></b> |       |
| Voltage                                                                                                                                                                                                                    | 50 % $U_n$ to $U_{max}$                                                                                                                                                                                                            | $0,2 \times C$                                                                 | %     |
| Harmonics in the voltage circuits <sup>b</sup>                                                                                                                                                                             | 3 <sup>rd</sup> harmonic 10 %<br>5 <sup>th</sup> harmonic 12 %<br>7 <sup>th</sup> harmonic 10 %<br>9 <sup>th</sup> harmonic 3 %<br>11 <sup>th</sup> harmonic 7 %<br>13 <sup>th</sup> harmonic 6 %<br>15 <sup>th</sup> harmonic 1 % | $0,2 \times C$                                                                 | %     |
| <sup>a</sup> Applicable performance classes are listed in Table 3.<br><sup>b</sup> All harmonics components should have zero phase referred to the fundamental.<br>The resulting waveform and equation are shown in 6.2.9. |                                                                                                                                                                                                                                    |                                                                                |       |

#### 4.8.6 RMS phase current ( $I$ ) and neutral current ( $I_N$ , $I_{Nc}$ ) measurements

##### 4.8.6.1 Techniques

See Annex B.

Gapless measurement is not required.

##### 4.8.6.2 Rated range of operation

###### 4.8.6.2.1 General

The intrinsic uncertainty requirements shall apply within the rated ranges given in Table 20 and Table 21:

###### 4.8.6.2.2 Rated range of operation for phase current

**Table 20 – Rated range of operation for phase current measurement**

| PMD types | Specified measuring range | Minimum bandwidth (harmonic)                                                     | Crest factor |
|-----------|---------------------------|----------------------------------------------------------------------------------|--------------|
| PMD Sx    | 10 % $I_n$ to 120 % $I_n$ | 45 Hz to 15 times rated frequency or<br>DC and 45 Hz to 15 times rated frequency | 2            |
| PMD Dx    | 20 % $I_b$ to $I_{max}$   | 45 Hz to 15 times rated frequency or<br>DC and 45 Hz to 15 times rated frequency | 2            |

#### 4.8.6.2.3 Rated range of operation for measured neutral current (with a sensor) and calculated neutral current (from phase currents)

**Table 21 – Rated range of operation for neutral current (calculated or measured)**

| PMD types | Specified measuring range <sup>a</sup> | Minimum bandwidth (harmonic)                                                     | Crest factor |
|-----------|----------------------------------------|----------------------------------------------------------------------------------|--------------|
| PMD Sx    | 10 % $I_n$ to 120 % $I_n$              | 45 Hz to 15 times rated frequency or<br>DC and 45 Hz to 15 times rated frequency | 2            |
| PMD Dx    | 20 % $I_b$ to $I_{max}$                | 45 Hz to 15 times rated frequency or<br>DC and 45 Hz to 15 times rated frequency | 2            |

<sup>a</sup> The nominal current of the neutral current sensor can be different from the one for the phase current sensor.

#### 4.8.6.3 Intrinsic uncertainty table

##### 4.8.6.3.1 General

The intrinsic uncertainty under reference conditions shall not exceed the limits given in Table 22, Table 23 and Table 24.

##### 4.8.6.3.2 Intrinsic uncertainty table for phase current

**Table 22 – Intrinsic uncertainty table for phase current**

| Specified measuring range                    |                                             | Intrinsic uncertainty limits for PMD of function performance class C <sup>a</sup> | Unit |
|----------------------------------------------|---------------------------------------------|-----------------------------------------------------------------------------------|------|
| value of current for direct connected PMD Dx | value of current for sensor operated PMD Sx |                                                                                   |      |
| 20 % $I_b \leq I \leq I_{max}$               | 10 % $I_n \leq I \leq I_{max}$              | $\pm 1,0 \times C$                                                                | %    |

<sup>a</sup> Applicable performance classes are listed in Table 3.

##### 4.8.6.3.3 Intrinsic uncertainty table for measured neutral current (with a sensor)

**Table 23 – Intrinsic uncertainty table for neutral current measurement**

| Specified measuring range                    |                                             | Intrinsic uncertainty limits for PMD of function performance class C <sup>a</sup> | Unit |
|----------------------------------------------|---------------------------------------------|-----------------------------------------------------------------------------------|------|
| value of current for direct connected PMD Dx | value of current for sensor operated PMD Sx |                                                                                   |      |
| 20 % $I_b \leq I_N \leq I_{max}$             | 10 % $I_n \leq I_N \leq I_{max}$            | $\pm 1,0 \times C$                                                                | %    |

<sup>a</sup> Applicable performance classes are listed in Table 3.

#### 4.8.6.3.4 Intrinsic uncertainty table for calculated neutral current (from phase currents)

**Table 24 – Intrinsic uncertainty table for neutral current calculation**

| Specified measuring range                                                                                                                                                                                                                                                |                                                | Intrinsic uncertainty limits<br>for PMD of function performance<br>class C <sup>a b c</sup> | Unit     |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------|---------------------------------------------------------------------------------------------|----------|
| value of current for direct<br>connected PMD Dx                                                                                                                                                                                                                          | value of current for sensor<br>operated PMD Sx |                                                                                             |          |
| $20 \% I_b \leq I_p^c \leq I_{\max}$                                                                                                                                                                                                                                     | $10 \% I_n \leq I_p^c \leq I_{\max}$           | $\pm 1,0 \times C$                                                                          | $\% I^b$ |
| <sup>a</sup> Applicable performance classes are listed in Table 3.<br><sup>b</sup> Uncertainty shall be expressed as a percentage of the phase current, whose current is the largest.<br><sup>c</sup> Performance class C refers to the phase current performance class. |                                                |                                                                                             |          |

#### 4.8.6.4 Limits of variation due to influence quantities

The additional variations due to the change of influence quantities with respect to reference conditions as given in 4.6.1, shall not exceed the limits for the relevant performance class given in Table 25:

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Table 25 – Influence quantities for phase current and neutral current measurement

| Influence quantities                                                                                                                                                                                                                                                                                                                         |                                                           | Specified measuring range <sup>b</sup> |                                    | Temperature coefficient for PMD of function performance class C <sup>a</sup> | Unit  |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------|----------------------------------------|------------------------------------|------------------------------------------------------------------------------|-------|
| Influence type                                                                                                                                                                                                                                                                                                                               | Influence range                                           | For current direct connected PMD Dx    | For current sensor operated PMD Sx |                                                                              |       |
| Ambient temperature                                                                                                                                                                                                                                                                                                                          | According to rated operating range of Table 5 and Table 6 | $20 \% I_b \leq I \leq I_{max}$        | $10 \% I_n \leq I \leq I_{max}$    | $0,05 \times C$                                                              | % / K |
|                                                                                                                                                                                                                                                                                                                                              |                                                           |                                        |                                    | Limits of variation for PMD of function performance class C <sup>a</sup>     |       |
| Auxiliary power supply voltage <sup>c</sup>                                                                                                                                                                                                                                                                                                  | Rated voltage $\pm 15 \%$                                 | $20 \% I_b$                            | $10 \% I_n$                        | $0,1 \times C$                                                               | %     |
| <sup>a</sup> Applicable performance classes are listed in Table 3.                                                                                                                                                                                                                                                                           |                                                           |                                        |                                    |                                                                              |       |
| <sup>b</sup> Influence quantities for phase current are defined with balanced currents in the three-phase distribution system.                                                                                                                                                                                                               |                                                           |                                        |                                    |                                                                              |       |
| <sup>c</sup> These limits are settled for a PMD powered by a mains supply voltage. In the case of a larger range of the supply voltage AC or DC, tests shall be done at least at the lower input value and upper input value of this range. In any case, PMD shall comply with the requirements for all the specified supply voltage ranges. |                                                           |                                        |                                    |                                                                              |       |

## 4.8.7 RMS voltage ( $U$ ) measurements

### 4.8.7.1 Technique

See Annex B.

Gapless measurement is not required.

### 4.8.7.2 Rated range of operation

The intrinsic uncertainty requirements shall apply within the rated ranges given in Table 26:

**Table 26 – Rated range of operation for RMS voltage measurement**

| PMD types | Specified measuring range              | Minimum bandwidth (harmonic)                                                     | Crest factor <sup>a</sup> |
|-----------|----------------------------------------|----------------------------------------------------------------------------------|---------------------------|
| PMD xS    | 20 % $U_n$ to 120 % $U_n$ <sup>a</sup> | 45 Hz to 15 times rated frequency or<br>DC and 45 Hz to 15 times rated frequency | 1,5                       |
| PMD xD    | As specified by manufacturer           | 45 Hz to 15 times rated frequency or<br>DC and 45 Hz to 15 times rated frequency | 1,5                       |

<sup>a</sup> The PMD using frequency detection circuits not operating in all the rated range can measure voltage with the last consistent measured value of frequency between 20 % of  $U_n$  and 50 % of  $U_n$ .

### 4.8.7.3 Intrinsic uncertainty table

The intrinsic uncertainty under reference conditions shall not exceed the limits given in Table 27:

**Table 27 – Intrinsic uncertainty table for RMS voltage measurement**

| Specified measuring range                    |                                              | Intrinsic uncertainty limits for PMD of function performance class C <sup>a</sup> | Unit |
|----------------------------------------------|----------------------------------------------|-----------------------------------------------------------------------------------|------|
| Value of voltage for direct connected PMD xD | Value of voltage for sensor operated PMD xS  |                                                                                   |      |
| $U_{\min} \leq U \leq U_{\max}$ <sup>b</sup> | $U_{\min} \leq U \leq U_{\max}$ <sup>b</sup> | $\pm 1,0 \times C$                                                                | %    |

<sup>a</sup> Applicable performance classes are listed in Table 3.

<sup>b</sup> The manufacturer can define  $U_{\max}$  and  $U_{\min}$ , taking into account the minimum measuring range of Table 26.

### 4.8.7.4 Limits of variation due to influence quantities

The additional variations due to the change of influence quantities with respect to reference conditions as given in 4.6.1, shall not exceed the limits for the relevant performance class given in Table 28:

Table 28 – Influence quantities for RMS voltage measurement

| Influence quantities                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |                                                                 | Specified measuring range <sup>b</sup><br>value of voltage for<br>direct connected<br>PMD xD | Temperature coefficient for<br>PMD of function performance<br>class C <sup>a</sup> | Unit  |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------|----------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|-------|
| Influence type                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      | Influence range                                                 |                                                                                              |                                                                                    |       |
| Ambient temperature                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 | According to rated<br>operating range of Table 5<br>and Table 6 | $U_{\min} \leq U \leq U_{\max}$                                                              | $0,05 \times C$                                                                    | % / K |
|                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |                                                                 |                                                                                              | Limits of variation for PMD of<br>function performance<br>class C <sup>a</sup>     |       |
| Auxiliary power supply voltage <sup>c</sup>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | Rated voltage $\pm 15$ %                                        | $U_{\min} \leq U \leq U_{\max}$                                                              | $0,1 \times C$                                                                     | %     |
| <sup>a</sup> Applicable performance classes are listed in Table 3.<br><sup>b</sup> The manufacturer can define $U_{\max}$ and $U_{\min}$ , taking into account the specified measuring range of Table 26.<br><sup>c</sup> These limits are settled for a PMD powered by a mains supply voltage. In the case of a large dynamic supply voltage AC or DC, tests shall be done at least at the lower input value and upper input value of this range. In any case, PMD shall comply with the requirements for all the specified supply voltage ranges. |                                                                 |                                                                                              |                                                                                    |       |

## 4.8.8 Power factor ( $PF_A$ , $PF_V$ ) measurements

### 4.8.8.1 Techniques

See Annex B for methods and Annex C for conventions related to the sign of Power factor.

### 4.8.8.2 Rated range of operation

The intrinsic uncertainty requirements shall apply within the following rated ranges:

- voltage: 50 %  $U_n$  to  $U_{max}$ ; or
- current: for PMD Dx: 20 %  $I_b$  to  $I_{max}$   
for PMD Sx: 10 %  $I_n$  to  $I_{max}$

### 4.8.8.3 Intrinsic uncertainty table

The intrinsic uncertainty under reference conditions shall not exceed the limits given in Table 29:

**Table 29 – Intrinsic uncertainty table for power factor measurement**

| Specified measuring range                                          | Intrinsic uncertainty limits for PMD of function performance class C <sup>a</sup> | Unit                 |
|--------------------------------------------------------------------|-----------------------------------------------------------------------------------|----------------------|
| From 0,5 inductive to 0,8 capacitive                               | $\pm 0,01 \times C$                                                               | No unit <sup>b</sup> |
| <sup>a</sup> Applicable performance classes are listed in Table 3. |                                                                                   |                      |
| <sup>b</sup> No unit because power factor is a ratio.              |                                                                                   |                      |

### 4.8.8.4 Limits of variation due to influence quantities

The additional variations from intrinsic uncertainties shall be calculated according to Table 9 and Table 17 for power factor 1 and 0,5 inductive, within the rated ranges of operation, taking into account the worst case combination of uncertainties.

## 4.8.9 Short term flicker ( $P_{st}$ ) and long term flicker ( $P_{lt}$ ) measurements

### 4.8.9.1 Techniques

See IEC 61000-4-15.

### 4.8.9.2 Rated range of operation

The intrinsic uncertainty requirements shall apply within the following rated range:

- voltage: 80 %  $U_n$  to  $U_{max}$

### 4.8.9.3 Intrinsic uncertainty table

The intrinsic uncertainty under reference conditions shall not exceed the limits given in Table 30:

**Table 30 – Intrinsic uncertainty table for flicker measurement**

| Specified measuring range                                          | Intrinsic uncertainty limits for PMD of function performance class C <sup>a</sup> | Unit |
|--------------------------------------------------------------------|-----------------------------------------------------------------------------------|------|
| From 0,4 to 2                                                      | $\pm 1,0 \times C$                                                                | %    |
| <sup>a</sup> Applicable performance classes are listed in Table 3. |                                                                                   |      |

#### 4.8.10 Voltage dip ( $U_{\text{dip}}$ ) and voltage swell ( $U_{\text{swl}}$ ) measurements

NOTE Requirements for voltage dip and voltage swell are equivalent to Class S in IEC 61000-4-30.

##### 4.8.10.1 Measurement method

Gapless measurement is required.

The basic measurement  $U_{\text{rms}}$  of a voltage dip and swell shall be either the  $U_{\text{rms}(\frac{1}{2})}$  on each measurement channel (see 3.3.15), or the  $U_{\text{rms}(1)}$  on each measurement channel (see 3.3.16). The manufacturer shall specify which measurement is used.

NOTE The  $U_{\text{rms}(1)}$  or  $U_{\text{rms}(\frac{1}{2})}$  value includes, by definition, harmonics, interharmonics, mains signalling voltage, etc.

##### 4.8.10.2 Detection and evaluation of a voltage dip

###### 4.8.10.2.1 Voltage dip detection

The dip threshold is a percentage of either  $U_{\text{din}}$  or the sliding voltage reference  $U_{\text{sr}}$  (see 4.8.10.4).

NOTE The sliding voltage reference  $U_{\text{sr}}$  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  $U_{\text{rms}}$  voltage falls below the dip threshold, and ends when the  $U_{\text{rms}}$  voltage is equal to or above the dip threshold plus some hysteresis voltage.
- On polyphase systems, a dip begins when the  $U_{\text{rms}}$  voltage of one or more channels is below the dip threshold and ends when the  $U_{\text{rms}}$  voltage on all measured channels is equal to or above the dip threshold plus some hysteresis voltage.

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

###### 4.8.10.2.2 Voltage dip evaluation

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

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

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

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

The start time of a dip shall be time stamped with the time of the start of the  $U_{\text{rms}}$  of the channel that initiated the event and the end time of the dip shall be the time stamped with the

time of the end of the  $U_{\text{rms}}$  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  $U_{\text{din}}$ .

NOTE 6 Dip thresholds are typically in the range of 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.

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

### 4.8.10.3 Detection and evaluation of a voltage swell

#### 4.8.10.3.1 Voltage swell detection

The swell threshold is a percentage of either  $U_{\text{din}}$  or the sliding reference voltage  $U_{\text{sr}}$  (see 4.8.10.4). The user shall declare the reference voltage in use.

NOTE Sliding reference voltage  $U_{\text{sr}}$  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  $U_{\text{rms}}$  voltage rises above the swell threshold, and ends when the  $U_{\text{rms}}$  voltage is equal to or below the swell threshold minus the hysteresis voltage.
- On polyphase systems, a swell begins when the  $U_{\text{rms}}$  voltage of one or more channels is above the swell threshold and ends when the  $U_{\text{rms}}$  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.

#### 4.8.10.3.2 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  $U_{\text{rms}}$  value measured on any channel during the swell;
- the start time of a swell shall be time stamped with the time of the start of the  $U_{\text{rms}}$  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  $U_{\text{rms}}$  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 It is possible that the voltage swell envelope is not 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.

#### 4.8.10.4 Calculation of a sliding reference voltage

The sliding reference voltage implementation is optional. 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.

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 not updated during a voltage dip or swell or interruption.

#### 4.8.10.5 Measurement uncertainty and measuring range

##### 4.8.10.5.1 Residual voltage and swell voltage magnitude measurement uncertainty

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

NOTE If  $U_{rms(1)}$  is used, this uncertainty is only valid for rectangular dips or swell lasting at least 4 cycles.

##### 4.8.10.5.2 Duration measurement uncertainty

If  $U_{rms(1/2)}$  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  $U_{rms(1)}$  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).

#### 4.8.10.6 Rated range of operation

The intrinsic uncertainty requirements shall apply within the rated ranges given in Table 31:

**Table 31 – Rated range of operation for voltage dips and swells measurement**

| PMD types | Minimum threshold range settable for voltage dip | Minimum threshold range settable for voltage swell |
|-----------|--------------------------------------------------|----------------------------------------------------|
| PMD xS    | from 5 % $U_n$ to 100 % $U_n$                    | from 100 % $U_n$ to 120 % $U_n$                    |
| PMD xD    | as specified by manufacturer                     | as specified by manufacturer                       |

Minimum detectable duration shall be equal at least to one period of the measured voltage.

#### 4.8.10.7 Intrinsic uncertainty table

The intrinsic uncertainty under reference conditions shall not exceed the limits given in Table 32:

**Table 32 – Intrinsic uncertainty table for voltage dips and swells measurement**

| Specified measuring range                                                                                                                                                                                                                                                                                    | Intrinsic uncertainty limits for PMD of function performance class C <sup>a b</sup> | Unit            |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|-----------------|
| Dips, residual voltage and swells overvoltage                                                                                                                                                                                                                                                                | $\pm 1,0 \times C$                                                                  | % $U_n$         |
| Dips duration and swells duration                                                                                                                                                                                                                                                                            | One period at the network frequency                                                 | ms <sup>c</sup> |
| <sup>a</sup> Applicable performance classes are listed in Table 3.<br><sup>b</sup> 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).<br><sup>c</sup> This is a fixed uncertainty. |                                                                                     |                 |

#### 4.8.10.8 Limits of variation due to influence quantities

The additional variations due to the change of influence quantities with respect to reference conditions as given in 4.6.1, shall not exceed the limits for the relevant performance class given in Table 33:

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Table 33 – Influence quantities for dips and swells measurement

| Influence quantities                        |  | Influence range                                           | Specified measuring range <sup>b</sup>       |                                             | Temperature coefficient for PMD of function performance class C <sup>a</sup> | Unit    |
|---------------------------------------------|--|-----------------------------------------------------------|----------------------------------------------|---------------------------------------------|------------------------------------------------------------------------------|---------|
| Influence type                              |  |                                                           | value of voltage for direct connected PMD xD | value of voltage for sensor operated PMD xS |                                                                              |         |
| Ambient temperature                         |  | according to rated operating range of Table 5 and Table 6 | $U_{\min} \leq U \leq U_{\max}$              | $U_{\min} \leq U \leq U_{\max}$             | $0,05 \times C$                                                              | % / K   |
|                                             |  |                                                           |                                              |                                             | Limits of variation for PMD of function performance class C <sup>a</sup>     |         |
| Auxiliary power supply voltage <sup>c</sup> |  | rated voltage $\pm 15$ %                                  | $U_{\min} \leq U \leq U_{\max}$              | $U_{\min} \leq U \leq U_{\max}$             | $0,1 \times C$                                                               | % $U_n$ |
| Frequency                                   |  | rated frequency $\pm 10$ %                                | $U_{\min} \leq U \leq U_{\max}$              | $U_{\min} \leq U \leq U_{\max}$             | $0,5 \times C$                                                               | % $U_n$ |

<sup>a</sup> Applicable performance classes are listed in Table 3.

<sup>b</sup> The manufacturer can define  $U_{\max}$  and  $U_{\min}$ , taking into account the minimum measuring range of Table 31.

<sup>c</sup> These limits are settled for a PMD powered by a mains supply voltage. In the case of a larger range of the supply voltage AC or DC, tests shall be done at least at the lower input value and upper input value of this range. In any case, PMD shall comply with the requirements for all the specified supply voltage ranges.

#### 4.8.11 Voltage interruption ( $U_{\text{int}}$ ) measurements

NOTE Requirements for voltage interruption are equivalent to Class S in IEC 61000-4-30.

##### 4.8.11.1 Measurement method

Gapless measurement is required.

The basic measurement of the voltage shall be as defined in 4.8.10.1.

##### 4.8.11.2 Evaluation of a voltage interruption

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

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

On polyphase systems, a voltage interruption begins when the  $U_{\text{rms}}$  voltages of all channels fall below the voltage interruption threshold, and ends when the  $U_{\text{rms}}$  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  $U_{\text{din}}$ .

The start time of a voltage interruption shall be the time stamped with the time of the start of the  $U_{\text{rms}}$  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  $U_{\text{rms}}$  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  $U_{\text{din}}$ .

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.

##### 4.8.11.3 Measurement uncertainty and measuring range

For duration measurement uncertainty, see 4.8.10.5.2.

##### 4.8.11.4 Rated range of operation

The manufacturer shall choose at least one value for the threshold of voltage interruption detection included in the range of 1 % to 5 % of  $U_{\text{n}}$ .

Minimum detectable duration shall be equal at least to one period of the measured voltage.

##### 4.8.11.5 Intrinsic uncertainty table

The intrinsic uncertainty under reference conditions shall not exceed the limits given in Table 34.

**Table 34 – Intrinsic uncertainty table for voltage interruption measurement**

| Specified measuring range                                          | Intrinsic uncertainty limits for PMD of function performance class C <sup>a</sup> | Unit            |
|--------------------------------------------------------------------|-----------------------------------------------------------------------------------|-----------------|
| Interruptions from 0 % to 5 % of $U_n$                             | $\pm 1,0 \times C$                                                                | % $U_n$         |
| Interruption duration                                              | Less than two periods at the network frequency                                    | ms <sup>b</sup> |
| <sup>a</sup> Applicable performance classes are listed in Table 3. |                                                                                   |                 |
| <sup>b</sup> This is a fixed uncertainty.                          |                                                                                   |                 |

**4.8.12 Transient overvoltage ( $U_{tr}$ ) measurements****4.8.12.1 Techniques**

See Annex A of IEC 61000-4-30:2015.

Gapless measurement is required.

Reference waveform: 1,2/50  $\mu$ s as defined in IEC 61000-4-5.

**4.8.12.2 Rated range of operation**

The intrinsic uncertainty requirements shall apply within the rated ranges given in Table 35.

**4.8.12.3 Intrinsic uncertainty table**

The intrinsic uncertainty under reference conditions shall not exceed the limits given in Table 35:

**Table 35 – Intrinsic uncertainty table for transient overvoltage measurement**

| Specified measuring range for PMD of function performance class C                                                              | Intrinsic uncertainty limits for PMD | Resolution for duration measurement <sup>b</sup> |
|--------------------------------------------------------------------------------------------------------------------------------|--------------------------------------|--------------------------------------------------|
| 0 to $U_{tr}$ <sup>a</sup>                                                                                                     | $\pm 3,0 \% \times U_{tr}$           | 5 $\mu$ s                                        |
| <sup>a</sup> The recommended values for the specified measuring range are 6 kV – 4 kV – 2,5 kV – 1,5 kV – 0,8 kV.              |                                      |                                                  |
| <sup>b</sup> Duration measurement is optional. If it is provided, it shall be made at 50 % of the peak value of the transient. |                                      |                                                  |

**4.8.13 Voltage unbalance ( $U_{nb}$ ,  $U_{nba}$ ) measurements****4.8.13.1 Techniques**

Gapless measurement is not required.

According to the manufacturer specification, one of the following functions shall be implemented:

- amplitude voltage unbalance ( $U_{nba}$ ,  $V_{nba}$ ): see Annex B
- amplitude and phase voltage unbalance ( $U_{nb}$ ,  $V_{nb}$ ): see IEC 61000-4-30

**4.8.13.2 Rated range of operation**

The intrinsic uncertainty requirements shall apply within the following rated range:

- between 80 % and 120 % of  $U_n$

#### 4.8.13.3 Intrinsic uncertainty table

The intrinsic uncertainty under reference conditions shall not exceed the limits given in Table 36:

**Table 36 – Intrinsic uncertainty table for voltage unbalance measurement**

| Indicated range of $U_{nb}$ or $U_{nba}$ | Intrinsic uncertainty limits for PMD of function performance class C <sup>a</sup> | Resolution | Unit  |
|------------------------------------------|-----------------------------------------------------------------------------------|------------|-------|
| 0 % to 10 %                              | $\pm 1 \times C$ <sup>b</sup>                                                     | $\pm 0,1$  | point |

<sup>a</sup> Applicable performance classes are listed in Table 3.

<sup>b</sup> The diagram below shows an example of uncertainty limits for class 0,5:

Intrinsic uncertainty limits for PMD of function performance class 0,5

#### 4.8.14 Voltage harmonics ( $U_h$ ) and voltage THD ( $THD_u$ and $THD-R_u$ ) measurements

##### 4.8.14.1 Techniques

The manufacturer shall specify the standard with which the product complies or, alternatively, shall specify the number of ranks, and if applicable filtering methods and aggregation method.

Gapless measurement is not required.

NOTE  $THD_u$  and  $THD-R_u$  is a generic notation. This is also applied to  $THD_v$  and  $THD-R_v$ .

##### 4.8.14.2 Rated range of operation

The intrinsic uncertainty requirements shall apply within the rated range given in Table 37:

**Table 37 – Rated range of operation for voltage harmonics measurement**

| PMD types | Minimum bandwidth            | Fundamental frequency range |
|-----------|------------------------------|-----------------------------|
| PMD       | 15 times the rated frequency | 45 Hz to 65 Hz              |

#### 4.8.14.3 Intrinsic uncertainty table

The uncertainty indicated in Table 38 and Table 39 applies for a single tone stationary harmonic signal over the whole working conditions.

**Table 38 – Intrinsic uncertainty table for voltage harmonics measurement**

| Specified measuring range              | Intrinsic uncertainty limits for PMD of function performance class C <sup>a</sup> | Unit    |
|----------------------------------------|-----------------------------------------------------------------------------------|---------|
| $U_h > 3 \times U_n \times C / 100$    | $\pm 5,0$                                                                         | % $U_h$ |
| $U_h \leq 3 \times U_n \times C / 100$ | $\pm 0,15 \times C$                                                               | % $U_n$ |

<sup>a</sup> Applicable performance classes are listed in Table 3.

**Table 39 – Intrinsic uncertainty table for voltage  $THD_U$  or  $THD-R_U$  measurement**

| Specified measuring range for voltage $THD$                                                                                                                                                                                     | Intrinsic uncertainty limits for PMD of function performance class $C^a$ | Unit               |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|--------------------|
| $3 \times C \% < THD \leq 20 \%$                                                                                                                                                                                                | $\pm 5$                                                                  | %                  |
| $THD \leq 3 \times C \%$                                                                                                                                                                                                        | $\pm 0,15 \times C$                                                      | point <sup>b</sup> |
| <sup>a</sup> Applicable performance classes are listed in Table 3.<br><sup>b</sup> $0,15 \times C$ is a constant uncertainty. For example with 1 % of $THD$ , if $C = 1$ , the measured value may be between 0,85 % and 1,15 %. |                                                                          |                    |

#### 4.8.15 Current unbalance ( $I_{nb}$ , $I_{nba}$ ) measurements

##### 4.8.15.1 Techniques

Gapless measurement is not required.

According to the manufacturer specification, one of the following functions shall be implemented:

- amplitude current unbalance ( $I_{nba}$ ): see Annex B
- amplitude and phase current unbalance ( $I_{nb}$ ): see IEC 61000-4-30, only replacing voltage by current.

##### 4.8.15.2 Rated range of operation

The intrinsic uncertainty requirements shall apply within the following rated range:

- between 10 % and 120 % of  $I_n$
- between 20 % of  $I_b$  and  $I_{max}$

##### 4.8.15.3 Intrinsic uncertainty table

The intrinsic uncertainty under reference conditions shall not exceed the limits given in Table 40:

**Table 40 – Intrinsic uncertainty table for current unbalance measurement**

| Indicated range of $I_{nb}$ or $I_{nba}$                                                                                                                                                                                                                                                                                                                      | Intrinsic uncertainty limits for PMD of function performance class $C^a$ | Resolution | Unit   |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------|------------|--------|
| 0 % to 50 %                                                                                                                                                                                                                                                                                                                                                   | $\pm 1 \times C^b$                                                       | $\pm 0,1$  | Points |
| <sup>a</sup> Applicable performance classes are listed in Table 3.<br><sup>b</sup> The diagram below shows an example of uncertainty limits for class 0,5: <div style="text-align: center;"> <p>Intrinsic uncertainty limits for PMD of function performance class 0,5</p> <p>True value</p> <p>4,5% 5,5%</p> <p>0% 1% 2% 3% 4% 5% 6% 7% 8% 9% 10%</p> </div> |                                                                          |            |        |

#### 4.8.16 Current harmonics ( $I_h$ ) and current THD ( $THD_i$ and $THD-R_i$ ) measurements

##### 4.8.16.1 Techniques

The manufacturer shall specify the standard with which the product complies or, alternatively, shall specify the number of ranks, and if applicable filtering methods and aggregation method.

Gapless measurement is not required.

##### 4.8.16.2 Rated range of operation

The intrinsic uncertainty requirements shall apply within the rated range given in Table 41:

**Table 41 – Rated range of operation for current harmonics measurement**

| PMD types | Minimum bandwidth            | Fundamental frequency range |
|-----------|------------------------------|-----------------------------|
| PMD       | 15 times the rated frequency | 45 Hz to 65 Hz              |

##### 4.8.16.3 Intrinsic uncertainty table

The uncertainty indicated in Table 42 and Table 43 applies for a single tone stationary harmonic signal over the whole working condition.

**Table 42 – Intrinsic uncertainty table for current harmonics measurement**

| PMD types | Specified measuring range               | Intrinsic uncertainty limits for PMD of function performance class C <sup>a</sup> | Unit    |
|-----------|-----------------------------------------|-----------------------------------------------------------------------------------|---------|
| PMD-Sx    | $I_h > 10 \times I_n \times C / 100$    | $\pm 5,0$                                                                         | % $I_h$ |
|           | $I_h \leq 10 \times I_n \times C / 100$ | $\pm 0,5 \times C$                                                                | % $I_n$ |
| PMD-Dx    | $I_h > 10 \times I_b \times C / 100$    | $\pm 5,0$                                                                         | % $I_h$ |
|           | $I_h \leq 10 \times I_b \times C / 100$ | $\pm 0,5 \times C$                                                                | % $I_b$ |

<sup>a</sup> Applicable performance classes are listed in Table 3.

**Table 43 – Intrinsic uncertainty table for current  $THD_i$  and  $THD-R_i$  measurement**

| PMD types | Specified measuring range <sup>c d</sup>            | Intrinsic uncertainty limits for PMD of function performance class C <sup>a</sup> | Unit               |
|-----------|-----------------------------------------------------|-----------------------------------------------------------------------------------|--------------------|
| PMD Sx    | $200 \% \geq THD > 10 \times (I_n/I_1) \times C \%$ | $\pm 5,0$                                                                         | %                  |
|           | $THD \leq 10 \times (I_n/I_1) \times C \%$          | $\pm 0,5 \times C \times (I_n/I_1)$                                               | Point <sup>b</sup> |
| PMD Dx    | $200 \% \geq THD > 10 \times (I_b/I_1) \times C \%$ | $\pm 5,0$                                                                         | %                  |
|           | $THD \leq 10 \times (I_b/I_1) \times C \%$          | $\pm 0,5 \times C \times (I_b/I_1)$                                               | Point <sup>b</sup> |

<sup>a</sup> Applicable performance classes are listed in Table 3.

<sup>b</sup>  $0,5 \times C$  is an absolute uncertainty. For example with 10 % of  $THD$ , if  $C = 10$ , and  $I_1 = I_n$  the measured value may be between 5 % and 15 %.

<sup>c</sup>  $THD$  is the measured value of current  $THD$  expressed in %.

<sup>d</sup>  $I_1$  is the fundamental (50 Hz or 60 Hz).

#### 4.8.17 Minimum, maximum, peak, three-phases average and demand measurements

##### 4.8.17.1 Rated range of operation

The manufacturer shall specify the rated range of operation.

##### 4.8.17.2 Intrinsic uncertainty table

The uncertainty on these values (minimum, maximum, ...) shall be the same as that from the corresponding measurements used to calculate these values.

For instance, a PMD claiming a class C performance on power measurement shall have to comply with the same performance class C for the power demand measurement if any.

Calculation methods are specified in Annex D.

#### 4.9 General mechanical requirements

##### 4.9.1 Vibration requirements

In addition to the mechanical resistance test specified in IEC 61010-1, the PMD shall pass the following vibration test:

- amplitude: 0,35 mm for fixed equipment, 1 mm for portable equipment;
- frequency: 25 Hz;
- duration: 20 min in each 3 directions;
- PMD under test shall be powered on.

The PMD functions shall remain in their specifications during the test.

##### 4.9.2 IP requirements

The manufacturer shall document equipment IP according to IEC 60529. The minimum requirements are given in Table 44, which specifies minimum IP requirements for the different kind of housings of PMD:

**Table 44 – Minimum IP requirements for PMD**

| Type of PMD                                                                              | Front panel | Housing, except front panel |
|------------------------------------------------------------------------------------------|-------------|-----------------------------|
| Fixed installed PMD<br>→ panel mounted devices.                                          | IP 40       | IP 2X                       |
| Fixed installed PMD<br>→ modular devices snapped on DIN rails within distribution panel. | IP 40       | IP 2X                       |
| Fixed installed PMD<br>→ housing devices snapped on DIN rails within distribution panel. | IP 2X       | IP 2X                       |
| Portable PMD                                                                             | IP 40       | IP 40                       |

## **4.10 Safety requirements**

### **4.10.1 Protection against electrical hazards**

#### **4.10.1.1 General**

PMD shall comply with the applicable safety requirements of IEC 61010-1 and IEC 61010-2-030 and with additional requirements specified hereafter.

#### **4.10.1.2 Clearances and creepage distances**

Clearances and creepage distances shall be selected at least in accordance with:

- pollution degree 2;
- measurement category III for measuring input circuits;
- overvoltage category III for mains circuits.

For portable equipment, overvoltage category II is acceptable only for mains circuits powered from socket outlets.

For plug-in PMD for socket outlets, overvoltage category II and measurement category II are acceptable.

NOTE Measurement category is defined in IEC 61010-2-030.

#### **4.10.1.3 Connection of a fixed installed PMD with a current transformer**

When a hazardous situation can be the result of an unintended disconnection of a current transformer from its PMD, connections of the current inputs shall be designed in such a way to prevent open circuit condition. This condition may be achieved either by removable auto short-circuiting connectors, screwable connectors, fixed connections, external protective devices, or protective devices integrated in the current transformer.

#### **4.10.1.4 Connection of a PMD with a sensor in high voltage networks**

The connection of a PMD xS or a PMD xD with external high voltage sensors (e.g. for systems with rated voltages higher than 1 000 V AC and 1 500 V DC) is allowed, provided that design features of such sensors prevent any hazards.

NOTE IEC 61010-1 gives guidance for system safety aspects including the sensors used with the PMD.

#### **4.10.1.5 Accessible parts**

Requirements for accessible parts as defined in IEC 61010-1 apply.

Circuits intended to be connected to an external accessible circuit shall be considered as accessible conductive parts, for example communication circuits.

A communication port that may be connected to a data system shall also be considered as an accessible conductive part.

These accessible conductive parts require protection against single fault condition.

NOTE Basic insulation is not a sufficient protection against single fault condition. An example of relevant insulation is double insulation or reinforced insulation, etc., see IEC 61010-1.

#### **4.10.1.6 Hazardous live parts**

In a distribution system, a neutral conductor shall be considered as a hazardous live part.

#### **4.10.2 Protection against mechanical hazards**

The requirements of IEC 61010-1 apply.

#### **4.10.3 Protection against other hazards**

PMDs shall be assessed against potential hazards specified in IEC 61010-1. If any hazard is deemed to be relevant, then it shall be covered by the corresponding IEC 61010-1 requirements.

Special attention will be paid to devices embedding batteries.

### **4.11 EMC requirements**

#### **4.11.1 Immunity**

For immunity, Table 2 of IEC 61326-1:2012 shall apply. For testing, see 6.2.16.

#### **4.11.2 Emission**

For emissions either class A or class B limits as defined in IEC 61326-1 shall apply.

### **4.12 Inputs and/or outputs**

#### **4.12.1 General**

The manufacturer shall specify the characteristics and the performance of the inputs and outputs of the PMD.

NOTE Digital and analog inputs/outputs are defined in IEC 61131-2.

#### **4.12.2 Analog outputs**

##### **4.12.2.1 General requirements**

The global uncertainty of each analog output representing a measured parameter shall be in the uncertainty limits specified for the measurement of that parameter in Clause 4 unless otherwise specified.

For testing of analog outputs, see 6.2.14. For a PMD fitted with analog outputs the requirements specified in 4.12.2.5 apply.

The current analog output signal is 4 mA to 20 mA, but 0 mA to 20 mA is also possible.

The preferred voltage output signal is 0 V to 10 V. Voltages 0 V to  $\pm 1$  V and 0 V to -10 V are also possible.

##### **4.12.2.2 Compliance voltage**

Current output signals shall have a compliance voltage of at least 10 V. The actual compliance voltage shall be specified in the accompanying documentation (see 5.3).

When tested in accordance with the compliance voltage tests of 6.2.14.2 the uncertainty of the analog output shall not exceed  $(2 \times C)$  % of full scale for a PMD with an analog output of performance class C.

#### **4.12.2.3 Analog output ripple content**

When tested in accordance with 6.2.14.3 the maximum ripple content in the output signal for an output of performance class *C* shall not exceed  $(2 \times C)$  % of full scale of the maximum specified output signal.

#### **4.12.2.4 Analog output response time**

The response time of the analog output, in accordance with 6.2.14.4, for both increasing and decreasing inputs if different, shall be specified in the accompanying documentation (see 5.3).

#### **4.12.2.5 Limiting value of the analog output signal**

The output signal shall be limited to a maximum of twice the rated maximum output signal. For bipolar outputs, this shall apply in both directions.

When tested in accordance with 6.2.14.5 and when the measurement is not between the lower and upper values represented by the maximum and minimum output signals, the PMD shall not, under any conditions of operation except loss of auxiliary power, produce an output having a value between its maximum and minimum output signals.

#### **4.12.3 Pulse outputs**

For these outputs, 4.1 of IEC 62053-31:1998 (functional requirements) shall apply.

However for some specific applications, deviations are possible and the level of these outputs has to be declared and compliance to IEC 62053-31 cannot be declared.

#### **4.12.4 Control outputs**

When such output is available, the level shall be declared in the documentation.

#### **4.12.5 Analog inputs**

The current analog input should be 4 mA to 20 mA, but 0 mA to 20 mA is also possible.

For testing of analog inputs, the product should be able to measure signals transmitted by analog output as specified in 4.12.2.

#### **4.12.6 Pulse and control inputs**

For these inputs, PMD shall accept signals as defined in IEC 62053-31.

However for some specific applications, deviations are possible and the level of these outputs has to be declared and compliance to IEC 62053-31 cannot be declared.

### **5 Marking and operating instructions**

#### **5.1 General**

Marking and operating instructions shall comply with IEC 61010-1 and IEC 61010-2-030, unless otherwise specified in Clause 5.

#### **5.2 Marking**

Marking requirements as defined in IEC 61010-1 and IEC 61010-2-030 shall apply. In addition the equipment shall be marked with:

- a) wiring diagrams or symbol 14 according to IEC 61010-1;
- b) serial number.

It is recommended to provide also the year of manufacturing.

### 5.3 Operating, installation and maintenance instructions

#### 5.3.1 General

Operating instructions, including maintenance aspects, defined in IEC 61010-1 and IEC 61010-2-030 shall apply. In addition, the following requirements apply:

#### 5.3.2 General characteristics

The following characteristics shall be documented:

- a) calibration period, if a periodic calibration is necessary;
- b) the rated voltage in one of the following forms:
  - 1) the number of active conductors of the connecting system, if more than one, and the applicable voltage at the PMD terminals of the voltage circuit(s);
  - 2) the nominal voltage of the system or the secondary voltage of the instrument transformer to which the PMD is intended to be connected;
- c) for direct connected PMD, the basic current ( $I_b$ ) and the maximum current ( $I_{max}$ ). For example: 10 A to 40 A or 10(40) A for a PMD having a basic current of 10 A and a maximum current of 40 A;
- d) for current transformer-operated PMD, the rated secondary current ( $I_n$ ) of the transformer(s) and the maximum secondary current ( $I_{max}$ ) of the transformer which the PMD should be connected to. For example: 5(6) A;
- e) for sensor-operated PMD, the main characteristics of the corresponding PMD input. For example: 1 V / 1 000 A;
- f) the rated frequency or frequency range in Hz;
- g) for energy measurement, the meter constant if any;
- h) start-up time, if it is longer than 15 s;
- i) for PMD with pulse inputs and/or outputs, the class A or class B classification;
- j) for PMD with control outputs, the maximum level of the outputs. For example: 1 A / 230 V AC;
- k) overcurrent protection specification.

#### 5.3.3 Essential characteristics

##### 5.3.3.1 Characteristics of PMD

The characteristics of the PMD shall be specified in a table as specified in Table 45 with the following items:

- a) power quality assessment function (if any);
- b) classification of PMD according to 4.3 and to 4.4;
- c) temperature according to 4.6.2.2 and 4.6.2.3;
- d) humidity and altitude conditions according to 4.6.2.4;
- e) active power or active energy function (if existing) performance class according to 4.8.2.

The sequence of function symbols shall be the following:

**Table 45 – PMD specification form**

| Type of characteristic                                                           | Examples of possible characteristic value | Other complementary characteristics |
|----------------------------------------------------------------------------------|-------------------------------------------|-------------------------------------|
| Classification of PMD according to 4.3                                           | PMD-I or PMD-II or PMD-III or PMD-x       |                                     |
| Classification of PMD according to 4.4                                           | SD or DS or DD or SS                      |                                     |
| Temperature                                                                      | K40 or K55 or K70 or Kx                   |                                     |
| Humidity + altitude                                                              | Blank or extended values                  |                                     |
| Active power or active energy function (if function available) performance class | 0,1 or 0,2 or 0,5 or 1 or 2               |                                     |

It is strongly recommended that all items be listed, and only existing ones be specified.

### 5.3.3.2 Characteristics of functions

The characteristics of functions of the PMD shall be specified in a table as specified in Table 46 with the following items:

- function symbols as defined in Table 46;
- function performance class according to this document;
- measuring range for the specified performance class;
- other complementary characteristics.

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The sequence of function symbols shall be the following:

**Table 46 – Characteristics specification template**

| Function symbols           | Function performance class according to IEC 61557-12 | Measuring range | Other complementary characteristics |
|----------------------------|------------------------------------------------------|-----------------|-------------------------------------|
| $P$                        |                                                      |                 |                                     |
| $Q_A$ or/and $Q_V$         |                                                      |                 |                                     |
| $S_A$ or/and $S_V$         |                                                      |                 |                                     |
| $E_a$                      |                                                      |                 |                                     |
| $E_{rA}$ or/and $E_{rV}$   |                                                      |                 |                                     |
| $E_{apA}$ or/and $E_{apV}$ |                                                      |                 |                                     |
| $f$                        |                                                      |                 |                                     |
| $I$                        |                                                      |                 |                                     |
| $I_N$ or/and $I_{Nc}$      |                                                      |                 |                                     |
| $U$ or/and $V$             |                                                      |                 |                                     |
| $PF_A$ or/and $PF_V$       |                                                      |                 |                                     |
| $U_{dip}$ or/and $V_{dip}$ |                                                      |                 |                                     |
| $U_{swl}$ or/and $V_{swl}$ |                                                      |                 |                                     |
| $U_{tr}$ or/and $V_{tr}$   |                                                      |                 |                                     |
| $U_{int}$ or/and $V_{int}$ |                                                      |                 |                                     |
| $U_{nba}$ or/and $V_{nba}$ |                                                      |                 |                                     |
| $U_{nb}$ or/and $V_{nb}$   |                                                      |                 |                                     |
| $U_h$ or/and $V_h$         |                                                      |                 |                                     |
| $THD_U$ or/and $THD_V$     |                                                      |                 |                                     |
| $THD-R_U$ or/and $THD-R_V$ |                                                      |                 |                                     |
| $I_h$                      |                                                      |                 |                                     |
| $THD_i$                    |                                                      |                 |                                     |
| $THD-R_i$                  |                                                      |                 |                                     |
| $P_{st}$                   |                                                      |                 |                                     |
| $P_{lt}$                   |                                                      |                 |                                     |

It is strongly recommended that all functions be listed, and only existing ones be specified.

## 6 Tests

### 6.1 General

All tests shall be carried out under reference conditions unless otherwise specified. The reference conditions are stated in 4.6.1.

## **6.2 Type tests of PMD**

### **6.2.1 General**

Type tests shall be executed to check the compliance with the requirements of Clauses 4 and 5.

### **6.2.2 Tests of intrinsic uncertainty**

#### **6.2.2.1 General requirements**

As a general principle, each line of the intrinsic uncertainty tables in Clause 4 shall be associated to a test.

#### **6.2.2.2 Minimum test points**

The intrinsic uncertainty shall be verified at least at the limits of the measuring range specified in the intrinsic uncertainty tables in Clause 4.

#### **6.2.2.3 Acceptance criterion**

For each test, the absolute value of the measurement uncertainty shall be less than the specified intrinsic uncertainty limit.

NOTE See G.3.2 and G.4.1 for more information.

### **6.2.3 Tests of variation of uncertainty with influence quantities**

#### **6.2.3.1 General requirements**

As a general principle, each line of the uncertainty with influence quantities tables in Clause 4 shall be associated to a test.

Tests of the influence quantities on several functions can be combined if applicable (e.g. the test of influence of temperature done on active power measurement can be done at the same time as those of voltage and current).

#### **6.2.3.2 Minimum test points**

The variation of uncertainty with influence quantities shall be verified at least at the limits of the specified influence range and measuring range.

#### **6.2.3.3 Acceptance criterion**

For each test, the absolute value of the variation of the measurement uncertainty shall be less than the limits of variation specified in the influence quantities tables in Clause 4.

NOTE See G.3.2 and G.4.1 for more information.

### **6.2.4 Test of temperature influence**

The temperature coefficient shall be determined for the whole operating range. The operating temperature range shall be divided into 20 K wide ranges. The temperature coefficient shall then be determined for each of these ranges, by taking measurements 10 K above and 10 K below the middle of the range. During the test, the temperature shall be in no case outside the specified operating temperature range.

The indicated temperature coefficient shall be the greatest one.

## 6.2.5 Active power

### 6.2.5.1 Influence of harmonics in current and voltage circuits

Test conditions shall be:

- fundamental frequency current:  $I_1 = 50\%$  of  $I_{\max}$ ;
- fundamental frequency voltage:  $U_1 = U_n$ ;
- fundamental frequency power factor: 1;
- content of 5<sup>th</sup> harmonic voltage:  $U_5 = 10\%$  of  $U_n$ ;
- content of 5<sup>th</sup> harmonic current:  $I_5 = 40\%$  of  $I_1$ ;
- harmonic power factor: 1;
- fundamental and harmonic voltages in phase, at positive zero crossing;
- total active power:  $1,04 \times P_1 = 1,04 \times U_1 \times I_1$ .

### 6.2.5.2 Influence of odd harmonics in the current circuit

The peak value of the test waveform shall be equal to  $\sqrt{2} \times I_b$  or to  $\sqrt{2} \times I_n$ .

The current test waveform shall be generated according to Figure 4 and Figure 5.

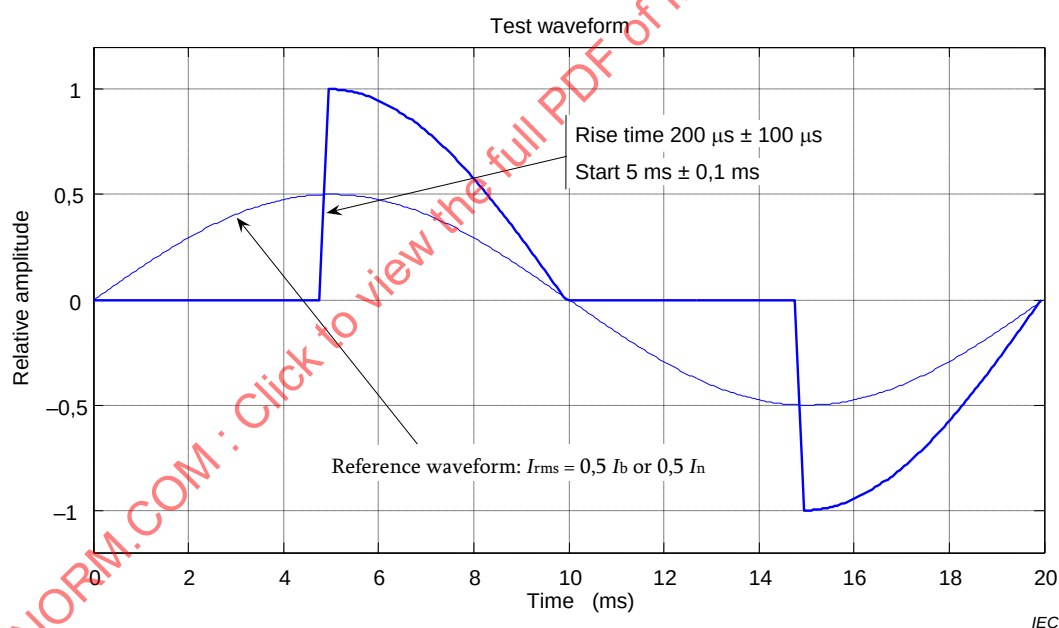


**Figure 4 – Waveform for odd harmonics influence test on active power measurement**

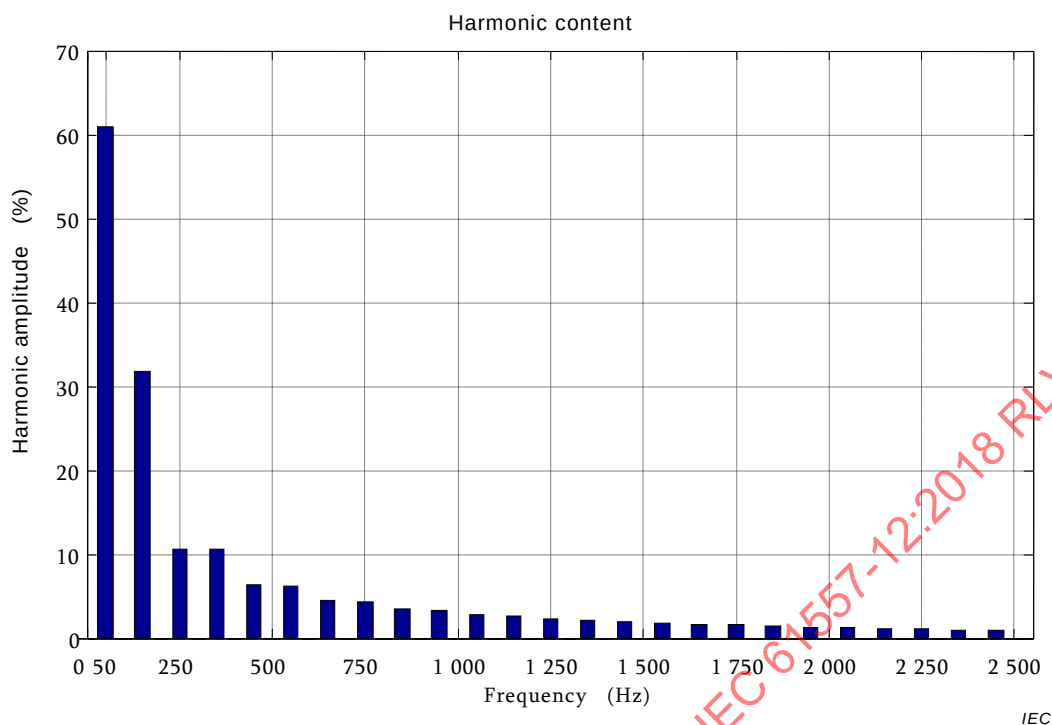


**Figure 5 – Spectral content for odd harmonics influence test on active power measurement**

The reference waveform and the distorted waveform result in approximately the same active power or active energy, but some variation is expected due to the variation in rise time and start time shown in Figure 4. It is recommended to use a reference meter to verify test results.

The curve, diagram and values are given at 50 Hz. For other frequencies, they shall be adapted accordingly.

### 6.2.5.3 Influence of sub-harmonics

The peak value shall be equal to  $\sqrt{2} \times I_b$  or to  $\sqrt{2} \times I_n$ . The cycle of the signal is made of two full waves followed by two non-signal periods.

The test waveform shall be generated according to Figure 6 and Figure 7.

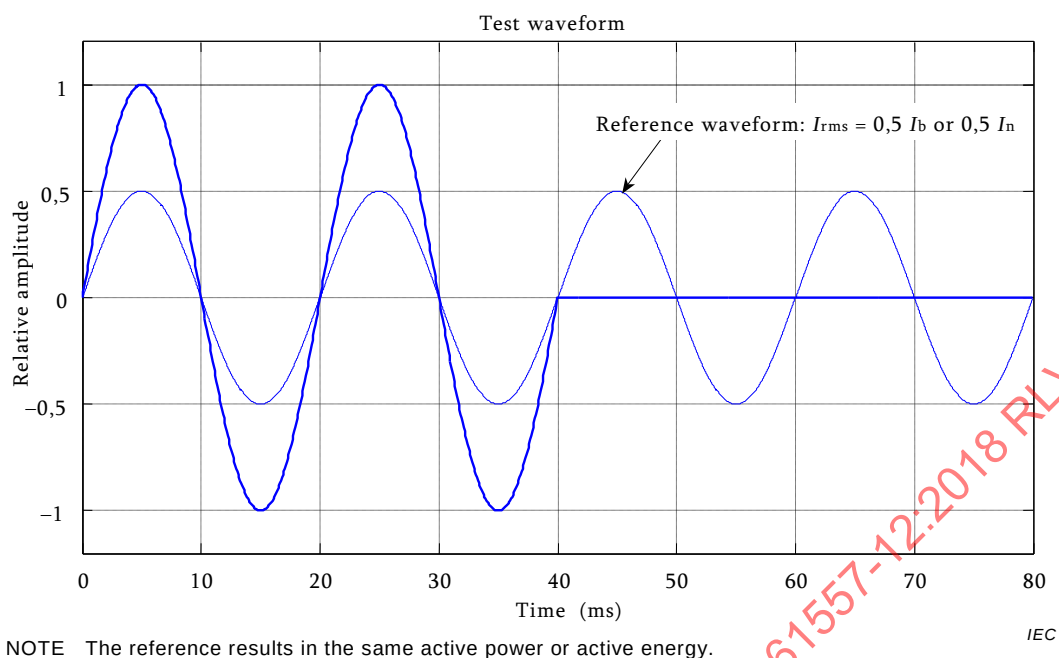


**Figure 6 – Waveform for sub-harmonics influence test on active power measurement**

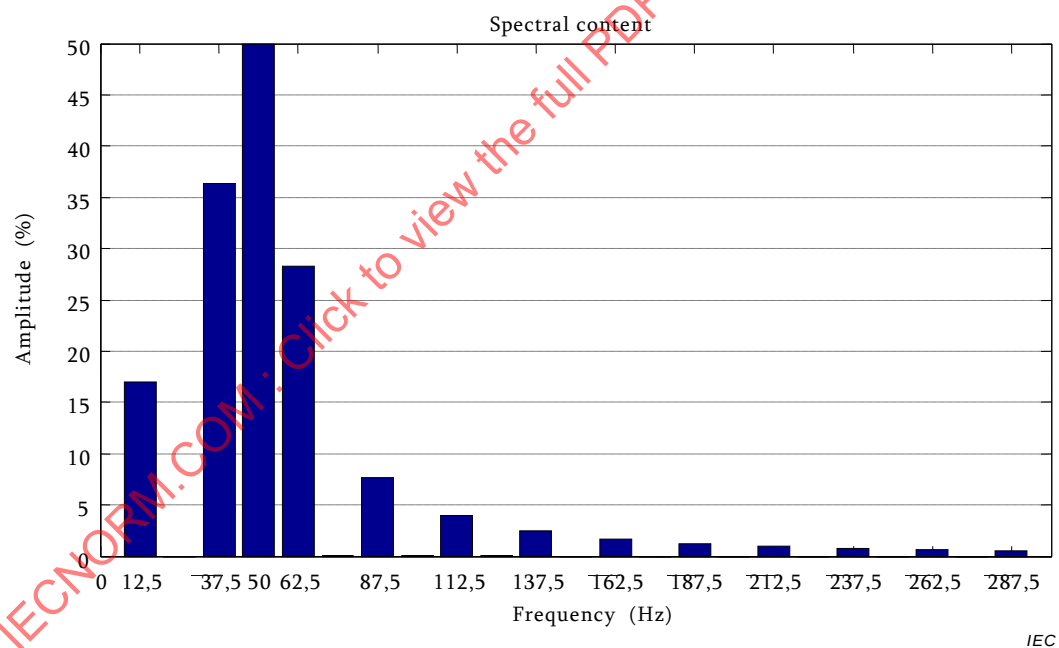


**Figure 7 – Spectral content for sub-harmonics influence test on active power measurement**

The curve, diagram and values are given at 50 Hz. For other frequencies, they shall be adapted accordingly.

## 6.2.6 Apparent power

The test on the apparent power is not mandatory if at least two of the following functions are tested:

- active power;
- reactive power;
- power factor.

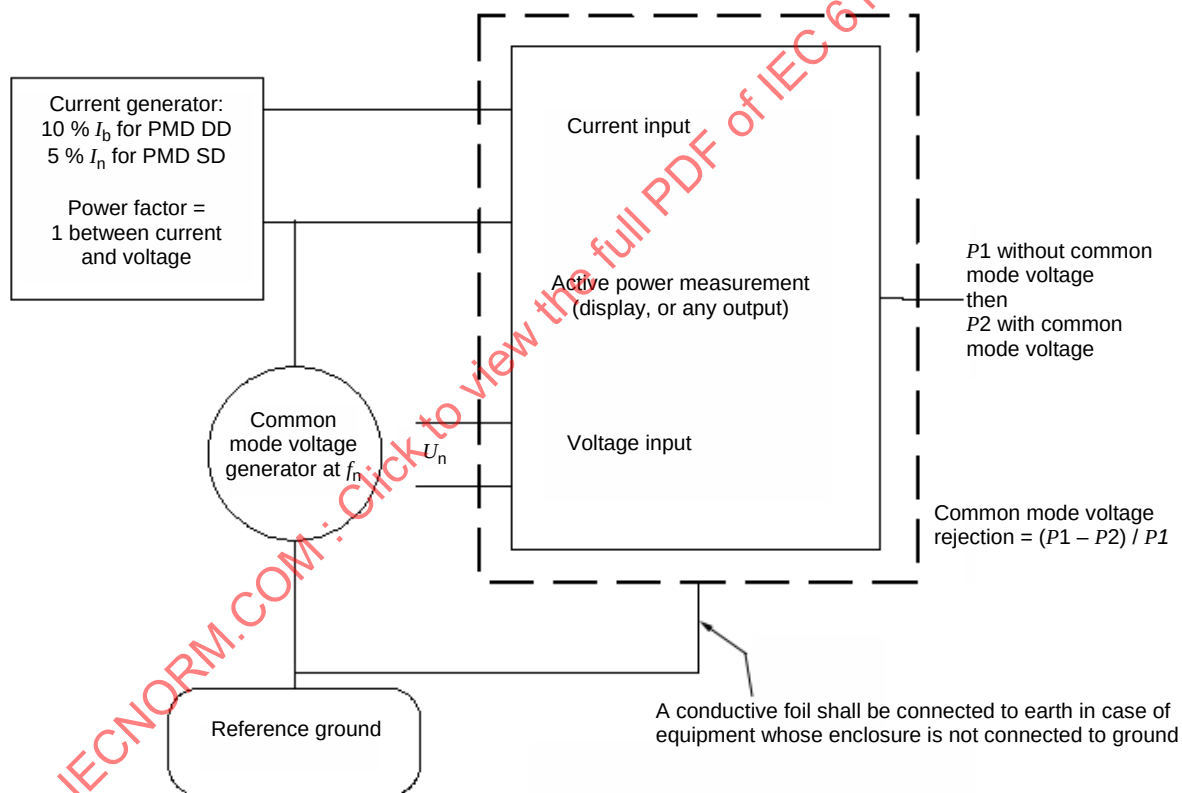
### 6.2.7 Power factor

The test on the power factor is not mandatory if at least two of the following functions are tested:

- active power;
- reactive power;
- apparent power.

### 6.2.8 Common mode voltage rejection test

For each isolated current input, the following test (as described in Figure 8) shall be made. It consists in calculating the difference between two measurements,  $P1$  without common mode voltage and  $P2$  with a common mode voltage applied between the current inputs and the reference ground.

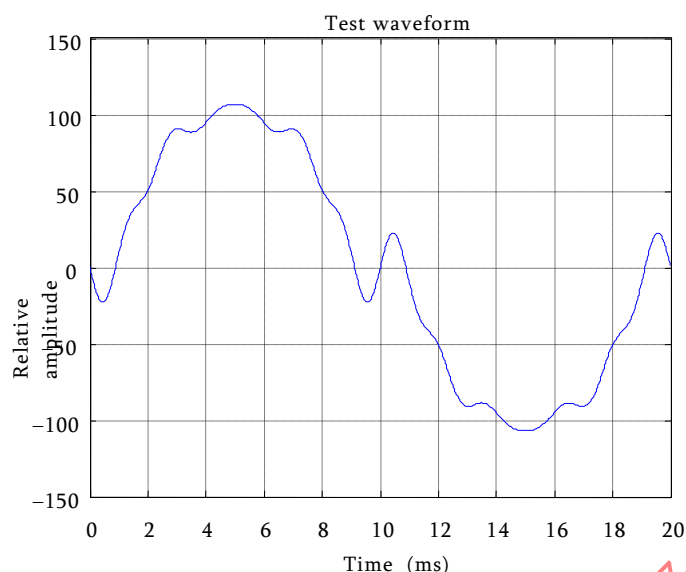


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Figure 8 – Common mode voltage influence testing

### 6.2.9 Frequency

With the set-up of Table 19, the waveform in Figure 9 is generated:



The relative amplitude is expressed in percent of fundamental peak value.

The curve is given at 50 Hz. For other frequencies, it shall be adapted accordingly.

The curve has the following expression:

$$x(t) = 100 \sin(\omega t) - \sum_{k=1}^7 a_{2k+1} \sin((2k+1)\omega t)$$

with  $a_3 = 10$ ,  $a_5 = 12$ ,  $a_7 = 10$ ,  $a_9 = 3$ ,  $a_{11} = 7$ ,  $a_{13} = 6$ ,  $a_{15} = 1$

**Figure 9 – Waveform for harmonics influence test on frequency measurement**

## 6.2.10 Measurement of voltage harmonics and $THD_u$

### 6.2.10.1 General

The following tests shall be performed at rated voltage  $U_n$  at 45 Hz, 50 Hz and 55 Hz for 50 Hz rated frequency, and at 55 Hz, 60 Hz and 65 Hz for 60 Hz rated frequency.

### 6.2.10.2 Test with a sinusoidal waveform

The test shall be performed with a pure sinusoidal voltage waveform, with frequencies taken from 6.2.10. The PMD shall not measure any voltage harmonics component and  $THD_u$  with amplitude above  $0,0015 \times C \times U_n$  ( $C$  is the function performance class).

### 6.2.10.3 Test with a distorted waveform

The test shall be performed with at least one distorted waveform with fundamental frequencies taken from 6.2.10. All the specified harmonics and  $THD$  shall be tested with respect to the uncertainty limits defined in Table 38 and Table 39 respectively.

## 6.2.11 Measurement of current harmonics and $THD_i$

### 6.2.11.1 General

The following tests shall be performed at rated current  $I_n$  or  $I_b$  and at 45 Hz, 50 Hz and 55 Hz for 50 Hz rated frequency, and at 55 Hz, 60 Hz and 65 Hz for 60 Hz rated frequency.

### 6.2.11.2 Test with a sinusoidal waveform

The test shall be performed with a pure sinusoidal current waveform, with frequencies taken from 6.2.11. The PMD shall not measure any current harmonics component and  $THD_i$  with amplitude above  $0,005 \times C \times I_n$  (or  $I_b$ ). ( $C$  is the function performance class).

### 6.2.11.3 Test with a distorted waveform

The test shall be performed with at least one distorted waveform with fundamental frequencies taken from 6.2.11. All the specified harmonics and  $THD$  shall be tested with respect to the uncertainty limits defined in Table 42 and Table 43 respectively.

### 6.2.12 Dips and swells

The tests shall at least be done with rectangular dip or swell modulation and with a dip or swell duration of one full cycle.

The test of the influence quantities can be omitted if this test has been done during the voltage RMS measurements.

### 6.2.13 Voltage interruptions

The tests shall at least be done for a voltage interruption of one full cycle.

### 6.2.14 Outputs tests

#### 6.2.14.1 General

PMD shall be tested under reference conditions.

#### 6.2.14.2 Test of compliance voltage and effect of variation of load.

This test shall only be carried out on a PMD with analog outputs that are a current signal.

Testing shall be carried out at the minimum and maximum (low and high) values of the analog output. At each point the output load resistance shall be set at 10 % and 90 % of its specified maximum value:

- the supply voltage for the analog output, if supplied from a source external to the PMD, shall be set to its minimum and maximum specified values;
- the supply of the PMD shall be set to its specified minimum and maximum values or in accordance with the rated voltage  $\pm 15$  %.

The worst case maximum and minimum readings at the low and high outputs shall be noted. The percentage uncertainty  $E$  shall be determined using the following formula:

$$E = \frac{N - W}{U} \times 100$$

where  $N$  is the rated signal,  $W$  is the worst case signal and  $U$  is the output span.

#### 6.2.14.3 Test of ripple content

The ripple content of the analog output shall be tested at rated minimum and maximum values of the output. The ripple content shall be measured as a peak-to-peak value.

#### 6.2.14.4 Tests of analog output response time

The response time for an increasing input shall be determined for an input step intended to produce a change in output signal from 0 % to 100 % of the output range as the time for the output to reach 90 % of the output range.

The response time for a decreasing input shall be determined for an input step intended to produce a change in output signal from 100 % to 0 % of the output range as the time for the output to reach 10 % of the output range.

#### 6.2.14.5 Test of limit value of analog output

The limit value of the analog output shall be tested by varying the input parameter between minimum and maximum values. Any programmable features of the output, such as input offset or full-scale value, shall be set so as to provide the maximum overloads.

### 6.2.15 Climatic tests

#### 6.2.15.1 General

After an appropriate recovering time after each climatic test, the PMD shall show no damage or change of the information and shall operate within its specifications.

#### 6.2.15.2 Dry heat test

The test shall be carried out according to IEC 60068-2-2, under the following conditions:

- PMD in non-operating condition;
- temperature: +70 °C ± 2 °C for K40 PMD and K55 PMD;  
+85 °C ± 2 °C for K70 PMD;
- duration of test: 16 h.

#### 6.2.15.3 Cold test

The test shall be carried out according to IEC 60068-2-1, under the following conditions:

- PMD in non-operating condition;
- temperature: –25 °C ± 3 °C for K40 PMD and K55 PMD;  
–40 °C ± 3 °C for K70 PMD;
- duration of test: 16 h.

#### 6.2.15.4 Damp heat cyclic test

The test shall be carried out according to IEC 60068-2-30, under the following conditions:

- voltage and auxiliary circuits energised with rated voltage;
- without any current in the current circuits;
- variant 1;
- upper temperature: +40 °C ± 2 °C for K40 PMD;  
+55 °C ± 2 °C for K55 PMD;  
+70 °C ± 2 °C for K70 PMD;
- no special precautions shall be taken regarding the removal of surface moisture;
- duration of the test: 6 cycles.

The damp heat test also serves as a corrosion test. The result is judged visually. No trace of corrosion likely to affect the functional properties of the PMD shall be apparent.

#### 6.2.16 EMC tests

For EM RF fields and conducted RF the following requirements apply:

- the auxiliary circuits of the PMD shall be energised with the rated voltage,
- the PMD shall be tested in its operating conditions,

with basic current  $I_b$ , respectively rated current  $I_n$ , rated voltage, power factor equal to 1 (or equal to 0 for reactive power) whichever is applicable.

Variations due to the EM influence quantities as defined in Table 9, Table 13 and Table 17 (limits of variation due to influence quantities) apply.

#### 6.2.17 Start-up tests

The starting time of PMD without communication or local user interface shall be tested with the following procedure:

- configure PMD scales to maximum possible values without causing calculation overflows;
- set up the kWh/pulse value to the minimum possible value;
- set up the optical pick up probe or other pulse pick-up device; a solid state relay or a mechanical relay may be used as the energy pulse output device;
- power down the PMD;
- apply  $U_{max}$  and  $I_{max}$ ,  $PF = 1,0$  on all voltage and current measurement inputs;
- power up the PMD and measure the time from the application of power until the first energy pulse registered by the probe.

#### 6.2.18 Gapless measurement test

The gapless nature of the measurement process shall be tested using:

- a) voltage waveform as in reference conditions
- b) current varying between two levels:
  - 1)  $I_b$  or  $I_n$  over periods of 1 s
  - 2) 50 %  $I_b$  or 50 %  $I_n$  over periods of 0,2 s

The measurement uncertainty of the following quantities shall be checked against the intrinsic uncertainty limits after a test period of at least 1 min: active energy, reactive energy, apparent energy according to Table 8, Table 12, Table 16.

It is recommended to use a reference meter to perform the test.

#### 6.2.19 Safety tests

Tests shall be conducted according to IEC 61010-1 and IEC 61010-2-030 test requirements.

### 6.3 Routine tests

#### 6.3.1 Protective bonding test

The PMD shall be tested in accordance with Annex F of IEC 61010-1:2010.

### **6.3.2 Dielectric strength test**

The PMD shall be tested in accordance with Annex F of IEC 61010-1:2010.

### **6.3.3 Uncertainty test**

The intrinsic uncertainty of each main function (e.g. voltage, current or power measurement) which is accessible to the user shall be verified throughout the measuring range.

For each test, it is recommended to verify the intrinsic uncertainty at a minimum of three test points spanning the measurement range.

The operating uncertainty can be evaluated according to Annex G on a statistical basis.

It is recommended to record the test results of the routine test.

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## Annex A (informative)

### Metering, measuring and monitoring applications

#### A.1 Applications on demand side and supply side

Measurement applications can be roughly summarized according to Figure A.1.

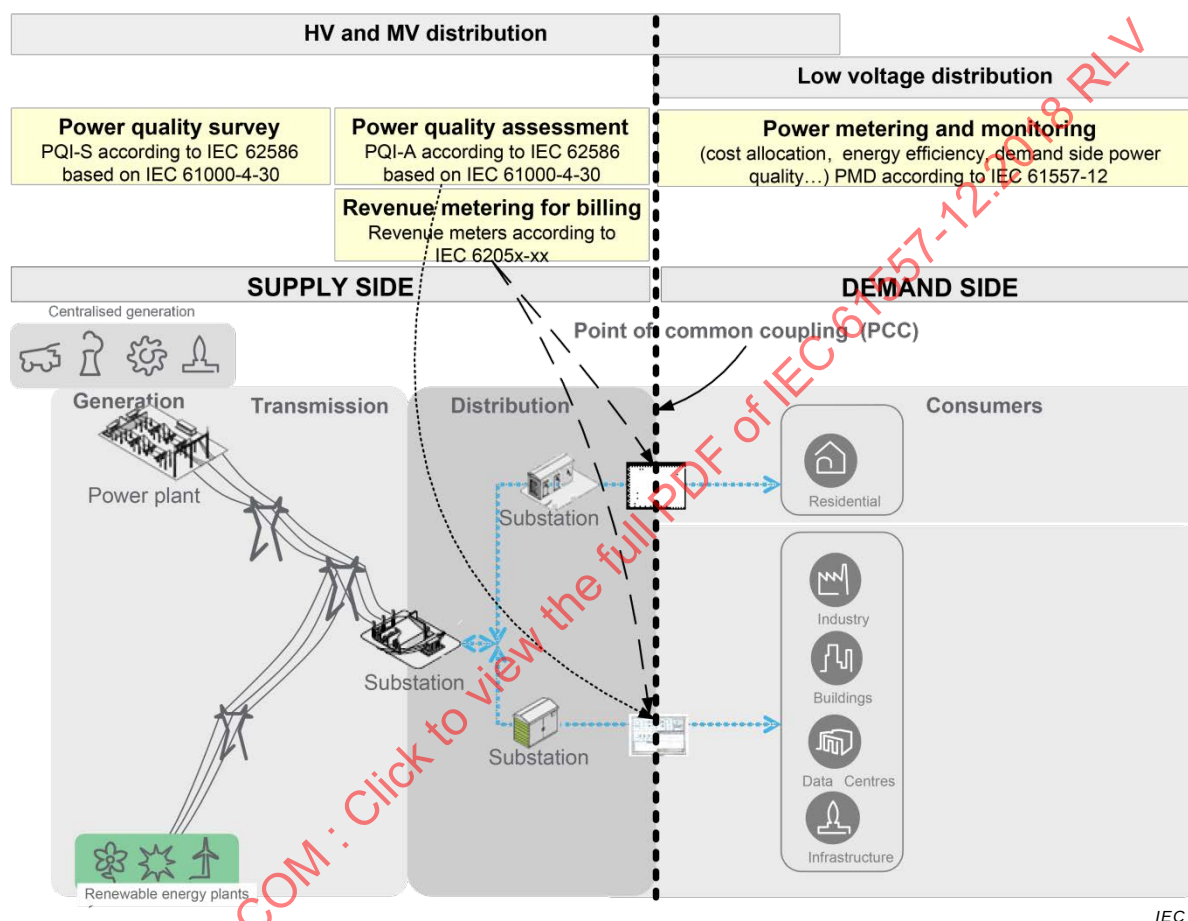


Figure A.1 – Simplified overview of measurement applications on supply side and demand side

#### A.2 Link between applications, devices and standards

Table A.1 shows the relevant device and associated standards related to the main measurement applications.

**Table A.1 – Main measurement applications**

| Measurement Application                                                                                                                                                                                                                                    | Relevant IEC product standards             | Device name according to standards             | Usual device name                                                                                                                                                    | Complementary explanations                                                                                                                                 |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------|------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Billing                                                                                                                                                                                                                                                    | IEC 62052-11 and IEC 62053-2x <sup>a</sup> | Electricity metering equipment                 | Revenue meter<br>Electricity meter for billing<br>Utility meter<br>Billing meter                                                                                     | Energy metering for billing applications (e.g. utility billing a landlord or a mall owner).<br><br>Transmission grid-level metering.<br><br>Shadow-billing |
| Energy usage analysis                                                                                                                                                                                                                                      | IEC 61557-12 <sup>b</sup>                  | Power metering and monitoring device (PMD-I)   | Power meter<br>Energy meter                                                                                                                                          | Energy cost and usage analysis (for cost allocation within a company or for energy efficiency purposes)                                                    |
| Basic power monitoring                                                                                                                                                                                                                                     | IEC 61557-12                               | Power metering and monitoring device (PMD-II)  | Power meter<br>Power monitor<br>Power monitor device<br>Power energy monitoring device<br>Power analyser<br>Multifunction meter<br>Measuring multifunction equipment | Basic demand side quality analysis + energy cost and usage analysis                                                                                        |
| Advanced power monitoring                                                                                                                                                                                                                                  | IEC 61557-12                               | Power metering and monitoring device (PMD-III) | Power meter<br>Power monitor<br>Power monitor device<br>Power energy monitoring device<br>Power analyser<br>Multifunction meter<br>Measuring multifunction equipment | Advanced demand side quality analysis + energy cost and usage analysis                                                                                     |
| Power quality analysis                                                                                                                                                                                                                                     | IEC 62586-1                                | Power quality instrument (PQI)                 | Power quality instrument<br>Power quality analyser<br>Power analyser<br>Network analyser                                                                             | Power quality analysis according to IEC 61000-4-30 for power quality survey (e.g. according to EN 50160)                                                   |
| <sup>a</sup> Regional regulations or standards may apply, for example MID, ANSI,... as well as utility specifications.<br><sup>b</sup> Energy meters complying with IEC 62052-11 and IEC 62053-2x can also be used for energy usage analysis applications. |                                            |                                                |                                                                                                                                                                      |                                                                                                                                                            |

## Annex B (informative)

### Definitions of electrical parameters

#### B.1 General

Annex B gives the common definitions and methods for measuring electrical quantities. Some of these definitions can be found in IEEE 1459. Manufacturers using other methods should specify their own methods in the technical documentation.

#### B.2 Definitions in the presence of a neutral

Table B.1 gives the list of symbols used in Annex B. Table B.2 specifies how to calculate the parameters.

**Table B.1 – Definition of symbols**

| Symbol           | Definition                                                                                                                                                                                                    |
|------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| $N$              | Number of samples in one fundamental period                                                                                                                                                                   |
| $M$              | Number of samples used for measurement (length of measurement window)                                                                                                                                         |
| $\Delta t$       | Duration of the measurement window in seconds                                                                                                                                                                 |
| $k$              | Index of a sample within the measurement window ( $0 \leq k \leq M-1$ )                                                                                                                                       |
| $p$              | Index of a phase ( $p = 1, 2$ or $3$ ; or $p = a, b, c$ ; or $p = r, s, t$ ; or $p = R, Y, B$ )                                                                                                               |
| $g$              | Index of a phase ( $g = 1, 2$ or $3$ ; or $g = a, b, c$ ; or $g = r, s, t$ ; or $g = R, Y, B$ )                                                                                                               |
| $N_{ph}$         | Number of phases excluding neutral (generally 1 or 3)                                                                                                                                                         |
| $i_{pk}$         | Phase $p$ current sample number $k$                                                                                                                                                                           |
| $i_{Nk}$         | Measured neutral current sample number $k$                                                                                                                                                                    |
| $v_{pk}$         | Phase $p$ to neutral voltage sample number $k$                                                                                                                                                                |
| $v_{gk}$         | Phase $g$ to neutral voltage sample number $k$                                                                                                                                                                |
| $u_{pgk}$        | Phase $p$ to phase $g$ voltage sample number $k$ : $u_{pgk} = v_{pk} - v_{gk}$                                                                                                                                |
| $\varphi_p$      | Phase angle between the fundamental current and the fundamental voltage for phase $p$                                                                                                                         |
|                  |                                                                                                                                                                                                               |
| $h_{max}$        | Maximum harmonic rank used for harmonic measurements                                                                                                                                                          |
| $I_{i,p}$        | Harmonic current of rank $i$ in phase $p$ (RMS value)                                                                                                                                                         |
| $I_{N,i}$        | Harmonic current of rank $i$ in the neutral (RMS value)                                                                                                                                                       |
| $V_{i,p}$        | Harmonic phase $p$ to neutral voltage of rank $i$ (RMS value)                                                                                                                                                 |
| $\phi_{i,p}$     | Phase angle between harmonic current and harmonic voltage at rank $i$ on phase $p$                                                                                                                            |
| $U_{i,pg}$       | Harmonic phase $p$ to phase $g$ voltage of rank $i$ (RMS value)                                                                                                                                               |
| $I_{1,p,maxdem}$ | Maximum 15 min or 30 min demand value of fundamental current for phase $p$                                                                                                                                    |
|                  |                                                                                                                                                                                                               |
| $X$              | Generic symbol of an electrical quantity within a formula, to be replaced by $I$ , $I_p$ or $I_N$ for current, by $V$ or $V_p$ for phase to neutral voltage, or by $U$ or $U_{pg}$ for phase to phase voltage |
| $X_{neg}$        | Negative-sequence component of electrical quantity $X$ considering its decomposition into symmetrical components                                                                                              |
| $X_{pos}$        | Postive-sequence component of electrical quantity $X$ considering its decomposition into symmetrical components                                                                                               |

| Symbol                              | Definition                                                                                                                |
|-------------------------------------|---------------------------------------------------------------------------------------------------------------------------|
| $X_{\text{zero}}$                   | Zero-sequence component of electrical quantity $X$ considering its decomposition into symmetrical components              |
| $X_{1\text{cy}} (X_{1/2\text{cy}})$ | RMS value of electrical quantity $X$ (current or voltage) measured over 1(1/2) fundamental cycle and refreshed each cycle |
| $X_{\text{ref}}$                    | Reference r.m.s value used to detect and characterize dips and swells, may be a fixed value or a time-varying value       |
| $X_{\text{res}}$                    | Lowest $X_{1\text{cy}}$ or $X_{1/2\text{cy}}$ value measured during a dip event                                           |
| $X_{\text{swell}}$                  | Highest $X_{1\text{cy}}$ value measured during a swell event                                                              |

The calculation methods in Table B.2 are reference algorithms for computing electrical quantities in the general case.

Depending on the characteristics of a PMD, different implementations are possible. Manufacturers of PMD not using these formulas should document the calculation methods used in the product.

**Table B.2 – Calculation definitions for electrical parameters**

| Item                                      | Symbol and definition                                            |
|-------------------------------------------|------------------------------------------------------------------|
| <b>RMS values</b>                         |                                                                  |
| RMS current in phase $p$                  | $I_p = \sqrt{\frac{\sum_{k=0}^{M-1} ip_k^2}{M}}$                 |
| Phase $p$ to neutral RMS voltage          | $V_p = \sqrt{\frac{\sum_{k=0}^{M-1} vp_k^2}{M}}$                 |
| Phase $p$ to phase $g$ RMS voltage        | $U_{pg} = \sqrt{\frac{\sum_{k=0}^{M-1} (upg_k)^2}{M}}$           |
| Total (or average) RMS current or voltage | $X = \frac{\sum_{p=1}^{N_{ph}} X_p}{N_{ph}}$                     |
| Calculated RMS neutral current            | $I_N = \sqrt{\frac{\sum_{k=0}^{M-1} (i1_k + i2_k + i3_k)^2}{M}}$ |
| <b>Phase powers</b>                       |                                                                  |
| Active power for phase $p$                | $P_p = \frac{1}{M} \cdot \sum_{k=0}^{M-1} (vp_k \times ip_k)$    |
| Apparent power for phase $p$              | $S_p = V_p \times I_p$                                           |

| Item                                                                                                  | Symbol and definition                                                                                                                                                                                                                                                                                                       |
|-------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Reactive power for phase $p$ , power triangle formula (also known as Fryze's definition) <sup>a</sup> | $Q_p = Q_{p_{\text{trian}}} = \text{Sign}Q(\phi_p) \times \sqrt{S_p^2 - P_p^2}$ <p>with</p> $\text{Sign}Q(\phi_p) = +1 \text{ if } \phi_p \in [0^\circ - 180^\circ]$ $\text{Sign}Q(\phi_p) = -1 \text{ if } \phi_p \in [180^\circ - 360^\circ]$ <p>NOTE This quantity is sometimes referred to as the non-active power.</p> |
| Reactive power for phase $p$ , quadrature phase shift formula <sup>a,c</sup>                          | $Q_p = Q_{p_{\text{quad}}} = \frac{1}{M} \cdot \sum_{k=0}^{M-1} (v_{p_{k-N/4}} \times i_{p_k})$                                                                                                                                                                                                                             |
| Reactive power for phase $p$ , Budeanu's harmonic definition <sup>a,c</sup>                           | $Q_p = Q_{p_{\text{harm}}} = \sum_{i=1}^{h_{\max}} I_{i,p} \cdot V_{i,p} \cdot \sin(\phi_{i,p})$                                                                                                                                                                                                                            |
| Distortion power                                                                                      | $D_p = \sqrt{S^2 - P^2 - Q^2}$                                                                                                                                                                                                                                                                                              |
| <b>Phase energies</b>                                                                                 |                                                                                                                                                                                                                                                                                                                             |
| Active energy for phase $p$                                                                           | $E_p = P_p \cdot \Delta t$                                                                                                                                                                                                                                                                                                  |
| Reactive energy for phase $p$                                                                         | $E_{rp} = Q_p \cdot \Delta t$                                                                                                                                                                                                                                                                                               |
| Apparent energy for phase $p$                                                                         | $E_{ap} = S_p \cdot \Delta t$                                                                                                                                                                                                                                                                                               |
| <b>Total powers</b>                                                                                   |                                                                                                                                                                                                                                                                                                                             |
| Total active power                                                                                    | $P = \sum_{p=1}^{N_{\text{ph}}} P_p$                                                                                                                                                                                                                                                                                        |
| Total reactive power (vector)                                                                         | $Q_V = \sum_{p=1}^{N_{\text{ph}}} Q_p$                                                                                                                                                                                                                                                                                      |
| Total apparent power (vector)                                                                         | $S_V = \sqrt{P^2 + Q_V^2}$                                                                                                                                                                                                                                                                                                  |
| Total apparent power (arithmetic)                                                                     | $S_A = \sum_{p=1}^{N_{\text{ph}}} S_p$                                                                                                                                                                                                                                                                                      |
| Total reactive power (arithmetic) <sup>b</sup>                                                        | $Q_A = \sqrt{S_A^2 - P^2}$                                                                                                                                                                                                                                                                                                  |
| <b>Power factors</b>                                                                                  |                                                                                                                                                                                                                                                                                                                             |
| Power factor for phase $p$                                                                            | $PF_p = \frac{P_p}{S_p}$ <p>NOTE The power factor is sometimes defined with an absolute value on the numerator.</p>                                                                                                                                                                                                         |
| Displacement power factor for phase $p$                                                               | $DPF_p = \cos(\phi_p)$                                                                                                                                                                                                                                                                                                      |
| Total power factor (vector)                                                                           | $PF_V = \frac{P}{S_V}$                                                                                                                                                                                                                                                                                                      |
| Total power factor (arithmetic)                                                                       | $PF_A = \frac{P}{S_A}$                                                                                                                                                                                                                                                                                                      |
| <b>Fundamental powers</b>                                                                             |                                                                                                                                                                                                                                                                                                                             |
| Fundamental active power on phase $p$                                                                 | $P_{1,p} = I_{1,p} \cdot V_{1,p} \cdot \cos(\phi_p)$                                                                                                                                                                                                                                                                        |
| Fundamental reactive power on phase $p$                                                               | $Q_{1,p} = I_{1,p} \cdot V_{1,p} \cdot \sin(\phi_p)$                                                                                                                                                                                                                                                                        |

| Item                                                                                                            | Symbol and definition                                                                                                                                                     |
|-----------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Fundamental apparent power on phase $p$                                                                         | $S_{1,p} = I_{1,p} \cdot V_{1,p}$                                                                                                                                         |
| <b>Distortion indicators</b>                                                                                    |                                                                                                                                                                           |
| Harmonic distortion of electrical quantity $X$ ( $I_p$ , $V_p$ , or $U_{pg}$ ) – Phase quantity                 | $THDX_p = \frac{\sqrt{\sum_{i=2}^{h_{\max}} X_{i,p}^2}}{X_{1,p}}$                                                                                                         |
| Harmonic distortion referred to RMS of electrical quantity $X$ ( $I_p$ , $V_p$ , or $U_{pg}$ ) – Phase quantity | $THD\_RX_p = \frac{\sqrt{\sum_{i=2}^{h_{\max}} X_{i,p}^2}}{X_p}$                                                                                                          |
| Total harmonic distortion of electrical quantity $X$ ( $I$ , $V$ , or $U$ )                                     | $THDX = \frac{\sum_{p=1}^{N_{ph}} THDX_p}{N_{ph}}$                                                                                                                        |
| Total harmonic distortion referred to RMS of electrical quantity $X$ ( $I$ , $V$ , or $U$ )                     | $THD\_RX = \frac{\sum_{p=1}^{N_{ph}} THD\_RX_p}{N_{ph}}$                                                                                                                  |
| Total distortion ratio of electrical quantity $X$ ( $I$ , $V$ , or $U$ ) – Phase quantity                       | $TDRX_p = \frac{\sqrt{X_p^2 - X_{1,p}^2}}{X_{1,p}}$ <p>NOTE Unlike the <math>THD</math>, this distortion ratio contains the contribution of interharmonic components.</p> |
| Total distortion ratio of electrical quantity $X$ ( $I$ , $V$ , or $U$ )                                        | $TDRX = \frac{\sum_{p=1}^{N_{ph}} TDRX_p}{N_{ph}}$                                                                                                                        |
| Distortion active power on phase $p$                                                                            | $PD_p = P_p - P_{1,p}$                                                                                                                                                    |
| Total distortion active power                                                                                   | $PD = \sum_{p=1}^{N_{ph}} PD_p$                                                                                                                                           |
| Total demand distortion (current) on phase $p$                                                                  | $TDD_p = \frac{\sqrt{\sum_{i=2}^{h_{\max}} I_{i,p}^2}}{I_{1,p,maxdem}}$                                                                                                   |
| <b>Unbalance indicators</b>                                                                                     |                                                                                                                                                                           |
| Amplitude unbalance for electrical quantity $X$ ( $I_p$ , $V_p$ , or $U_{pg}$ ) – Phase quantity, in percent    | $X_{nba,p} = 100 \cdot \frac{X_p - X_{avg}}{X_{avg}} \quad \text{where} \quad X_{avg} = \frac{\sum_{p=1}^{N_{ph}} X_p}{N_{ph}}$                                           |
| Total amplitude unbalance for electrical quantity $X$ ( $I$ , $V$ , or $U$ ), in percent                        | $X_{nba} = \max \left\{ \left  X_{nba,p} \right  \right\}_{p=1..N_{ph}}$                                                                                                  |
| Amplitude and angle unbalance for electrical quantity $X$ ( $I$ , $V$ , or $U$ )                                | $X_{nb} = 100 \cdot \frac{X_{neg}}{X_{pos}}$                                                                                                                              |
| NOTE There is no phase quantity for this type of unbalance.                                                     |                                                                                                                                                                           |

| Item                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | Symbol and definition                                         |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------|
| <b>Internal power quality indicators</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |                                                               |
| 1-cycle RMS value of electrical quantity $X$ (generally voltage) on phase $p$ .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     | $X_{p1cy} = \sqrt{\frac{\sum_{k=0}^{N-1} x_{p_k}^2}{N}}$      |
| Dip depth for electrical quantity $X$ (generally voltage)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           | $X_{dip}(\%) = 100 \cdot \frac{X_{ref} - X_{resid}}{X_{ref}}$ |
| Swell depth for electrical quantity $X$ (generally voltage)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         | $X_{swl}(\%) = 100 \cdot \frac{X_{swell} - X_{ref}}{X_{ref}}$ |
| <p><sup>a</sup> See Figure B.1. Reactive power is a controversial notion, there is no “true” definition in non-sinusoidal conditions. This table only gives the most common definitions. Different standards or measurement products may use different definitions for the reactive power, or consider only the fundamental reactive power. Under sinusoidal voltage and current these definitions are equivalent.</p> <p><sup>b</sup> This power is unsigned.</p> <p><sup>c</sup> Under sinusoidal voltage, these definitions are equivalent even with non-sinusoidal current.</p> |                                                               |

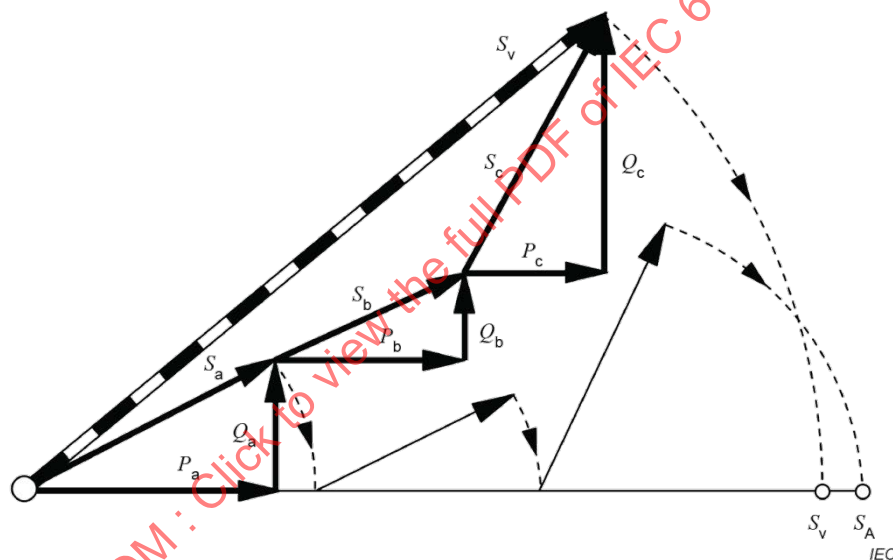


**Figure B.1 – Arithmetic and vector apparent powers in sinusoidal situation**

### B.3 Power measurement in three-phase three-wire systems using the two-wattmeter method

#### B.3.1 General

If no neutral is present, the three-phase techniques in Clause B.2 may still be used to compute the total powers provided a virtual neutral is used in the measurement process. Otherwise, for three-phase systems without neutral the two-wattmeter method can be used.

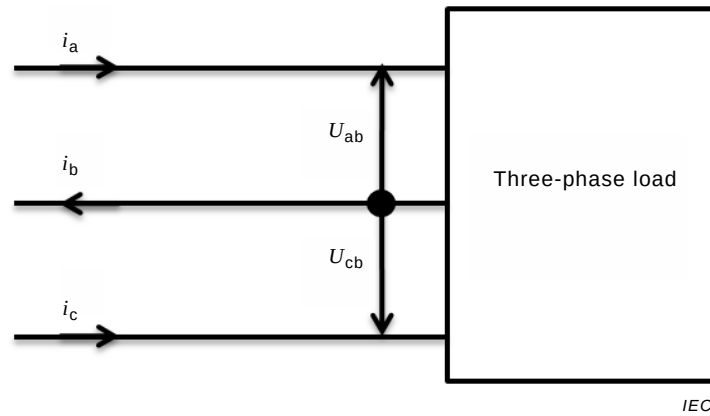


**Figure B.2 – Three-phase circuit without neutral**

Considering the circuit in Figure B.2, the measurement device can measure the current in all three phases ( $i_a$ ,  $i_b$  and  $i_c$ ) but, since no neutral is present, can only measure line to line voltages. Taking phase b as a reference, let's consider the measured voltages are  $U_{ab}$  and  $U_{cb}$ .

If a neutral were present, these line to line voltages would write:

$$u_{ab} = v_a - v_b \quad \text{and} \quad u_{cb} = v_c - v_b$$

Furthermore, since there is no neutral, the following property is always true:

$$i_a + i_b + i_c = 0$$

The purpose is to use the available quantities and these properties to obtain an accurate measurement of the total powers consumed by the load.

### B.3.2 Total active power

Suppose the measuring instrument measures two-phase active powers using the available line to line voltages:

$$P_1 = \mu(i_a \cdot u_{ab}) \quad \text{and} \quad P_2 = \mu(i_c \cdot u_{cb})$$

where the  $\mu$  operator stands for the averaging over the measurement window of  $M$  samples.

These phase active powers are physically meaningless in the sense that they are not individually related to the total active power drawn by the load.

However, using the properties in B.3.1, it can be shown that:

$$P_1 + P_2 = \mu(i_a \cdot v_a) + \mu(i_b \cdot v_b) + \mu(i_c \cdot v_c) = P_a + P_b + P_c = P$$

The total active power drawn by the load can be determined as the algebraic sum of the phase active powers measured using the two currents and the two line to line voltages.

### B.3.3 Total vector reactive power using quadrature phase shift definition

If the phase reactive powers are measured using the quadrature formula, the total vector reactive power can be determined from the phase reactive powers:

$$Q_{1,\text{quad}} = \mu(i'_a \cdot u_{ab}) \quad \text{and} \quad Q_{2,\text{quad}} = \mu(i'_c \cdot u_{cb})$$

where  $i'_a$  and  $i'_c$  stand for the phase a current in quadrature and the phase b current in quadrature. Using the properties in B.3.1, it can be shown that:

$$Q_{1,\text{quad}} + Q_{2,\text{quad}} = \mu(i'_a \cdot v_a) + \mu(i'_b \cdot v_b) + \mu(i'_c \cdot v_c) = Q_{a,\text{quad}} + Q_{b,\text{quad}} + Q_{c,\text{quad}} = Q_v$$

### B.3.4 Total vector reactive power using Budeanu's definition

If the phase reactive powers are measured using Budeanu's formula, the total vector reactive power can be determined from the phase reactive powers:

$$Q_{1,\text{harm}} = \sum_{i=1}^{h_{\max}} I_{i,a} \cdot U_{i,ab} \cdot \sin(\varphi_{i,ab}) \quad \text{and} \quad Q_{2,\text{harm}} = \sum_{i=1}^{h_{\max}} I_{i,c} \cdot U_{i,cb} \cdot \sin(\varphi_{i,cb})$$

It can be shown that the total reactive power using Budeanu's definition is the sum of both measured phase reactive powers:

$$Q_{1,\text{harm}} + Q_{2,\text{harm}} = Q_{a,\text{harm}} + Q_{b,\text{harm}} + Q_{c,\text{harm}} = Q_v$$

NOTE There is no simple formula for the total vector reactive power in the general case if the phase reactive powers are measured using the triangle formula definition.

### B.4 Additional relationships in case of sinusoidal voltage

If the voltage can be considered sinusoidal, the power comes from the fundamental current and the fundamental voltage only.

The following additional relationships between the electrical quantities hold, even if the current is not sinusoidal and/or in the presence of current and/or voltage unbalance:

$$P_p = P_{1,p}$$

$$Q_{p,\text{harm}} = Q_{p,\text{quad}} = Q_{1,p}$$

$$V_a = \frac{\sqrt{2}}{3} \cdot \sqrt{U_{ab}^2 + U_{ac}^2 - \frac{U_{bc}^2}{2}}$$

$$V_b = \frac{\sqrt{2}}{3} \cdot \sqrt{U_{ab}^2 + U_{bc}^2 - \frac{U_{ac}^2}{2}}$$

$$V_c = \frac{\sqrt{2}}{3} \cdot \sqrt{U_{ac}^2 + U_{bc}^2 - \frac{U_{ab}^2}{2}}$$

## Annex C (informative)

### Convention about the sign of the power factor

#### C.1 General

The formatting of the power factor is just a question of convention. Manufacturers need to define the convention used on their devices, or need to let customers know the conventions selectable on their devices.

Table C.1 shows the conventions IEC-C and IEEE-C available with a consumer perspective, according to a scheme given in Figure C.1.

Table C.2 shows the conventions IEC-P available with a producer perspective, according to a scheme given in Figure C.2.

#### C.2 Convention for power factor (consumer perspective)

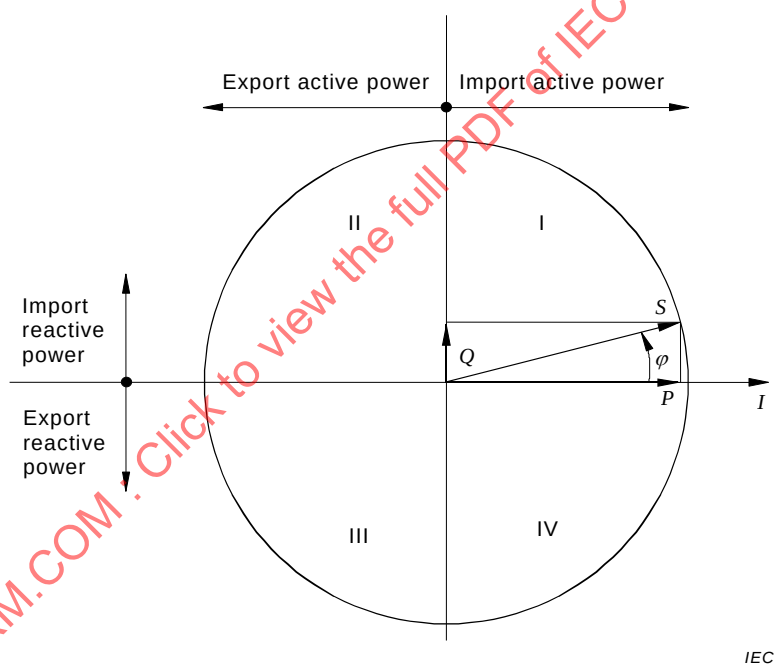


Figure C.1 – Formatting of power factor with a consumer perspective

**Table C.1 – Conventions for the sign of Power factor with a Consumer perspective**

| Quadrant     | Meaning with a consumer perspective | IEC consumer convention for sign (IEC-C convention) | IEEE consumer convention for sign (IEEE-C convention) |
|--------------|-------------------------------------|-----------------------------------------------------|-------------------------------------------------------|
| Quadrant I   | Import $P$ ; Import $Q$             | +<br>(Inductive)                                    | -<br>(Lagging)                                        |
| Quadrant II  | Export $P$ ; Import $Q$             | -<br>(Capacitive)                                   | +<br>(Leading)                                        |
| Quadrant III | Export $P$ ; Export $Q$             | -<br>(Inductive)                                    | -<br>(Lagging)                                        |
| Quadrant IV  | Import $P$ ; Export $Q$             | +<br>(Capacitive)                                   | +<br>(Leading)                                        |

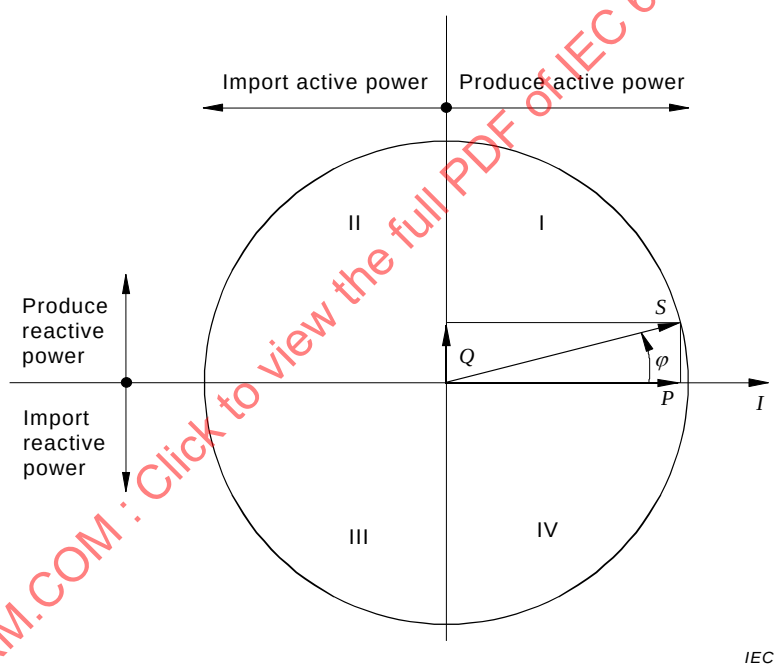
**C.3 Convention for power factor (producer reference frame)****Figure C.2 – Convention for power factor with a producer perspective**

**Table C.2 – Conventions for the sign of power factor  
with a producer perspective**

| Quadrant     | Meaning with a producer perspective | IEC producer convention for sign<br>(IEC-P convention) |
|--------------|-------------------------------------|--------------------------------------------------------|
| Quadrant I   | Produce $P$ ; Produce $Q$           | +<br>(Overexcited)                                     |
| Quadrant II  | Import $P$ ; Produce $Q$            | -<br>(Overexcited)                                     |
| Quadrant III | Import $P$ ; Import $Q$             | -<br>(Under excited)                                   |
| Quadrant IV  | Produce $P$ ; Import $Q$            | +<br>(Under excited)                                   |

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## Annex D (normative)

### Definitions of minimum, maximum, peak and demand values

#### D.1 Demand quantities

##### D.1.1 General

A demand is the average value of a quantity over a specified period of time.

##### D.1.2 Power demand

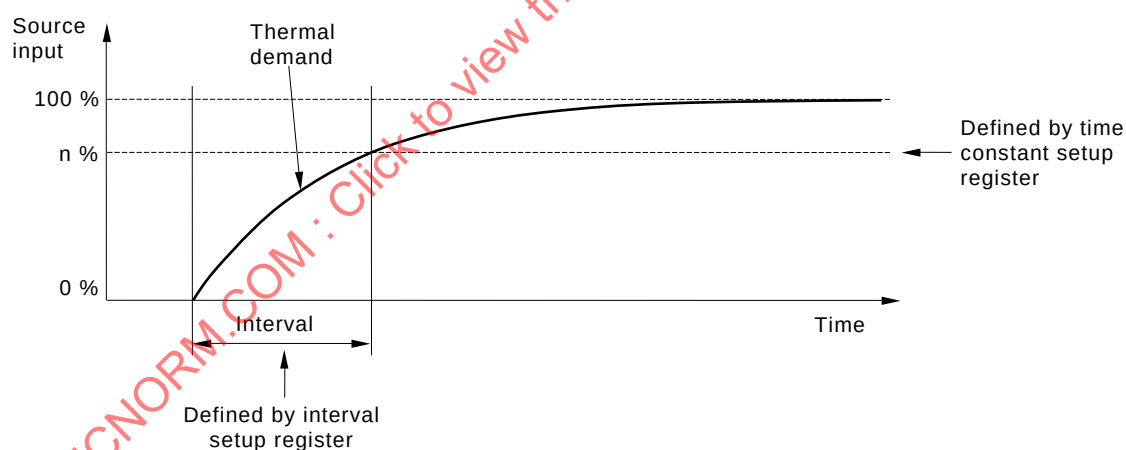
Power demand is calculated using arithmetical integration of power values during a period of time divided by the length of the period. The result is equivalent to the energy accumulated during the period of time divided by the length of the period.

##### D.1.3 Current demand

Current demand is calculated using arithmetical integration of the current RMS values during a period of time, divided by the length of the period.

##### D.1.4 Thermal current demand (or bi-metal current demand)

Thermal current demand calculates the demand based on a thermal response, which mimics the analog thermal demand meters as described in Figure D.1.



IEC

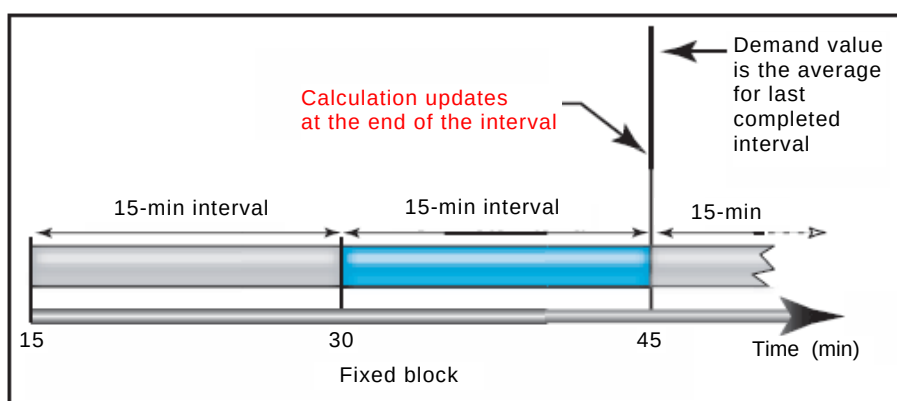
NOTE The value of  $n$  is usually 90 %; the time interval is usually 15 min.

**Figure D.1 – Thermal current demand**

##### D.1.5 Specified intervals for demand calculation

The PMD handle the duration of intervals to calculate the demand. PMD can implement several methods:

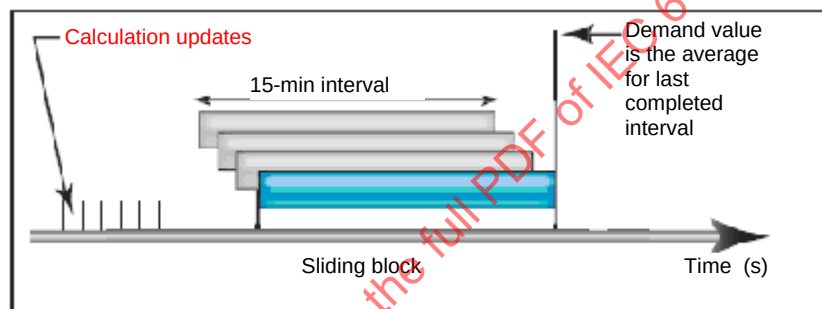
- fixed block interval: the intervals are consecutive; the PMD calculates and updates the demand at the end of each interval as described in Figure D.2;



NOTE 15 min is only an example.

**Figure D.2 – Fixed block interval**

- sliding block interval: the intervals are sliding; the PMD calculates and updates the demand at the sliding speed as described in Figure D.3.



NOTE 15 min is only an example.

**Figure D.3 – Sliding block interval**

## D.2 Peak demand quantities

Peak demand is the highest demand value (positive or negative) since the beginning of the measurement or the last reset.

## D.3 Three-phase average quantities

In a three- or four-wire system, the average value of a quantity is the arithmetical average of each phase value.

EXAMPLE: Three-phase average line to neutral voltage =  $(V1 \text{ RMS voltage} + V2 \text{ RMS voltage} + V3 \text{ RMS voltage}) / 3$

## D.4 Maximum and minimum quantities

The maximum value of a quantity is the highest value measured or calculated since the beginning of the measurement or the last reset.

The minimum value of a quantity is the lowest value measured or calculated since the beginning of the measurement or the last reset.

## Annex E (informative)

### Intrinsic uncertainty and operating uncertainty

#### E.1 General

The operating uncertainty of a monitoring instrument is defined by a specification of:

- uncertainty limits over a measuring range;
- maximum deviations in the presence of influencing quantities (power system parameters or external conditions).

Annex E provides guidance on the calculation of operating uncertainty and does not address the additional concept of a measurement performance class. An operating uncertainty is a quality indicator, not comparable with a measurement performance class, because they are different in nature and are not used for the same purposes.

Figure E.1 below describes different kinds of uncertainties:

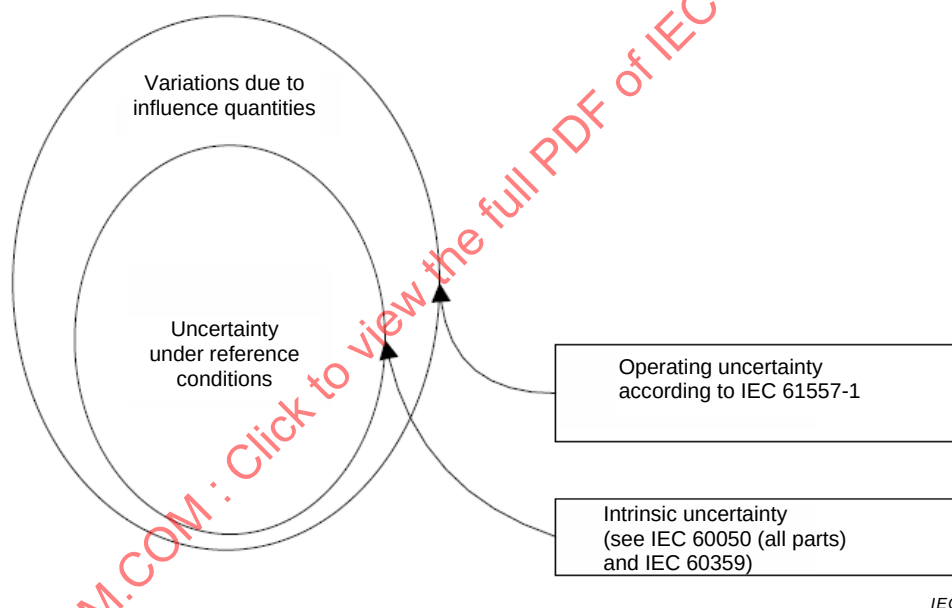


**Figure E.1 – Different kinds of uncertainties**

#### E.2 Operating uncertainty calculation

Operating uncertainty includes intrinsic uncertainty (under reference conditions) and variation due to influence quantities.

$$\text{Operating uncertainty} = \sqrt{(\text{PMD intrinsic uncertainty})^2 + \frac{4}{3} \sum_{i=1}^{NIQ} (\text{variation due to influence quantity})^2}$$

NOTE 1  $NIQ$  = number of influence quantities.

NOTE 2 This formula is derived from ISO/IEC Guide 98-3:2008, 6.2, taking into account a coverage probability of 95 %.

In this formula the PMD intrinsic measurement uncertainty is determined at two standard deviations as described in G.3.2. In order to take into account a coverage factor of 95,45 % in the formula, the variation of the uncertainty due to the influence quantity shall be determined at one standard deviation. The process of determining the operating uncertainty is shown in Figure E.2. The correction factors to be applied to the calculated standard deviations are tabulated in Table G.1.

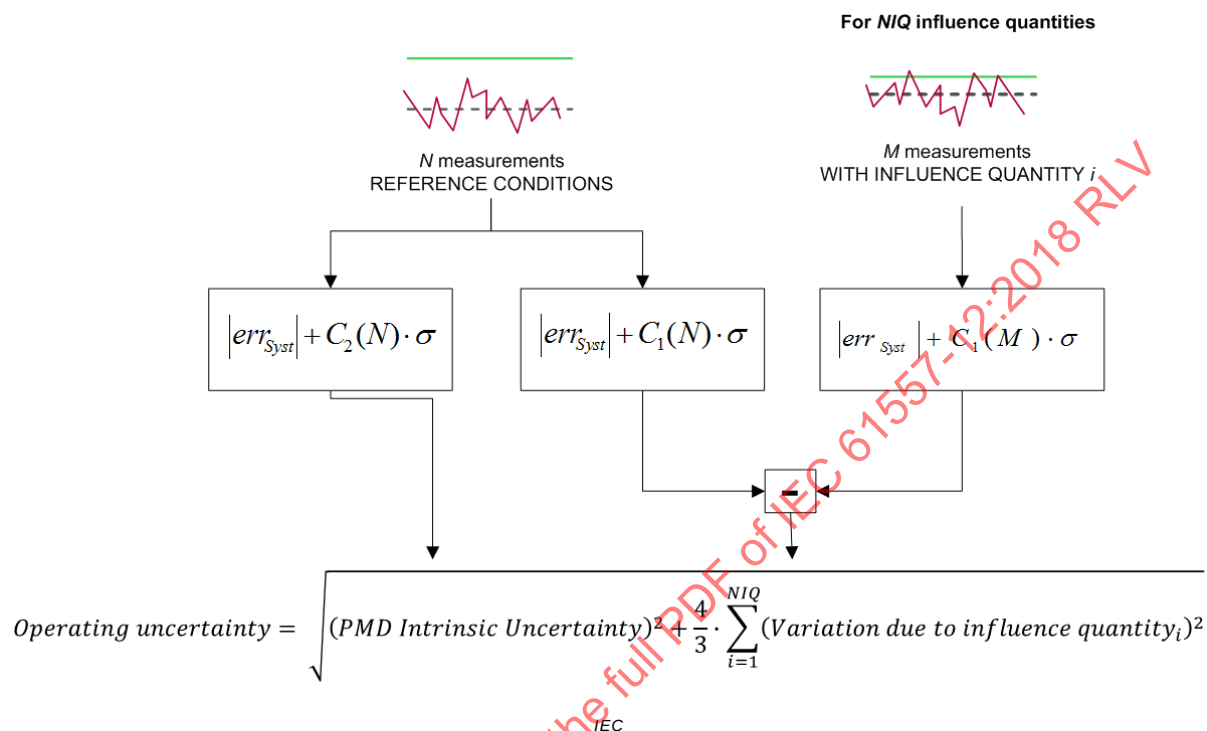


Figure E.2 – Flowchart for the determination of the operating uncertainty

## Annex F (informative)

### Recommended sensor classes for the different kinds of PMD

#### F.1 General considerations

The association of a PMD Sx, PMD xS and PMD SS with external current and/or voltage sensors builds a system. The performance of that system depends on the measurement itself (active energy, frequency, harmonic voltage ...), the sensor class and the PMD performance class.

Overall uncertainty of the measurement chain formed by this association includes uncertainty due to the PMD and uncertainty due to the sensors under reference conditions.

For PMD DD: overall uncertainty = intrinsic uncertainty

For PMD xS, PMD Sx and PMD SS, typical overall uncertainty values for relevant combinations are shown in Table F.1.

#### F.2 Specific case of an active power and energy measurement, achieved by a PMD associated with an external current sensor or/and a voltage sensor

Table F.1 provides information about associating a PMD with external sensors.

**Table F.1 – PMD SD associated with current sensor or PMD DS associated with voltage sensor or PMD SS associated with voltage and current sensors**

| Performance class of the PMD<br>(for active power and energy<br>measurement) without external sensors<br>(PMD-Sx or PMD-xS or PMD SS)                                                                           | Recommended sensor class to<br>associate to the PMD <sup>a b c</sup> | Typical overall uncertainty<br>(for active power and energy<br>measurement) |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------|-----------------------------------------------------------------------------|
| 0,1                                                                                                                                                                                                             | 0,1 or better                                                        | 0,2 %                                                                       |
| 0,2                                                                                                                                                                                                             | 0,2 or better                                                        | 0,5 %                                                                       |
| 0,5                                                                                                                                                                                                             | 0,5 or better                                                        | 1 %                                                                         |
| 1                                                                                                                                                                                                               | 1 or better                                                          | 2 %                                                                         |
| 2                                                                                                                                                                                                               | 2 or better                                                          | 5 %                                                                         |
| For other combinations, manufacturers should provide information or recommended sensors for association.                                                                                                        |                                                                      |                                                                             |
| <sup>a</sup> This induces an acceptable loss of performance of the system.                                                                                                                                      |                                                                      |                                                                             |
| <sup>b</sup> For power and energy measurements 0,2 S and 0,5 S class sensors are usually required.                                                                                                              |                                                                      |                                                                             |
| <sup>c</sup> Class sensor refers to classes defined in IEC 61869-2, IEC 61869-3, IEC 60044-7 and IEC 60044-8. When transducers replace sensors, class sensor refers to intrinsic uncertainty of the transducer. |                                                                      |                                                                             |

#### F.3 List of functions affected by uncertainty of external sensors

Table F.2 defines the influence of each kind of sensor on each function of a PMD.

**Table F.2 – List of functions affected by uncertainty of external sensors**

| Symbol                                                                           | Function                                                                                                    | Current sensor | Voltage sensor |
|----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|----------------|----------------|
| $P_a$                                                                            | Total active power                                                                                          | x              | x              |
| $Q_A, Q_V$                                                                       | Total reactive power (arithmetic or vector)                                                                 | x              | x              |
| $S_A, S_V$                                                                       | Total apparent power (arithmetic or vector)                                                                 | x              | x              |
| $E_a$                                                                            | Total active energy                                                                                         | x              | x              |
| $E_{rA}, E_{rV}$                                                                 | Total reactive energy (arithmetic or vector)                                                                | x              | x              |
| $E_{apA}, E_{apV}$                                                               | Total apparent energy (arithmetic or vector)                                                                | x              | x              |
| $f$                                                                              | Frequency                                                                                                   | -              | -              |
| $I$                                                                              | Phase current                                                                                               | x              | -              |
| $I_N, I_{Nc}$                                                                    | Neutral current (measured, calculated)                                                                      | x              | -              |
| $U$ or $V$                                                                       | Voltage ( $L_p-L_g$ or $L_p-N$ )                                                                            | -              | x              |
| $PF_A, PF_V$                                                                     | Power factor (arithmetic, vector)                                                                           | x              | x              |
| $P_{st}, P_{lt}$                                                                 | Flicker (short term, long term)                                                                             | -              | -              |
| $U_{dip}$ or $V_{dip}$                                                           | Voltage dips ( $L_p-L_g$ or $L_p-N$ )                                                                       | -              | x              |
| $U_{swl}$ or $V_{swl}$                                                           | Voltage swells ( $L_p-L_g$ or $L_p-N$ )                                                                     | -              | x              |
| $U_{int}$ or $V_{int}$                                                           | Voltage interruption ( $L_p-L_g$ or $L_p-N$ )                                                               | -              | x              |
| $U_{nba}$ or $V_{nba}$                                                           | Amplitude voltage unbalance ( $L_p-L_g$ or $L_p-N$ )                                                        | -              | x              |
| $U_{nb}$ or $V_{nb}$                                                             | Amplitude and phase voltage unbalance ( $L_p-L_g$ or $L_p-N$ )                                              | -              | x              |
| $U_h$ or $V_h$                                                                   | Voltage harmonics                                                                                           | -              | x              |
| $THD_U, THD-R_U$<br>or $THD_V, THD-R_V$                                          | Voltage <i>THD</i> (referred to fundamental, referred to RMS value)                                         | -              | x              |
| $I_h$                                                                            | Current harmonics                                                                                           | x              | -              |
| $THD_i, THD-R_i$                                                                 | Current <i>THD</i> ( $THD_i$ referred to the fundamental, $THD-R_i$ referred to the RMS value respectively) | x              | -              |
| NOTE "x" means "affects the function", "-" means "does not affect the function". |                                                                                                             |                |                |

## Annex G (informative)

### Notion of measurement uncertainty

#### G.1 General considerations

Annex G is intended to become normative for the next edition of this document.

For this document, the level of confidence is 95,45 %, meaning that 95,45 % of the measurements are expected to lie within the interval defined by the average of the measurements plus or minus the calculated expanded uncertainty. This corresponds to two times the standard deviation.

Annex G provides information about how a number  $N$  of values measured on one PMD can be used to determinate the measurement uncertainty of that device. Using measurements to derive the uncertainty is generally referred to as “Type A” method of evaluation of uncertainty. Qualifying a product typically requires applying this procedure on several product samples.

The uncertainty of a measurement under certain operating conditions is a value that characterizes the dispersion of the values that could reasonably be attributed to the measurand. It is a measure of the bounds within which a value may be reasonably (with a certain level of confidence) presumed to lie.

The measurement uncertainty is not the measurement error, which characterizes the difference between a measured value and the conventional true value.

In the calculations below, it is assumed that the distribution of the measurements around their mean reasonably follows a normal distribution. If this is not the case, the estimated standard deviation shall be corrected appropriately (e.g. by dividing by  $\sqrt{3}$  if the actual distribution is uniform).

#### G.2 Computing the expanded uncertainty

##### G.2.1 General

The expanded uncertainty is an estimate of the uncertainty taking into account important parameters such as:

- the number  $N$  of measured values available from the test
- the level of confidence desired for the uncertainty results

##### G.2.2 Estimated standard deviation

The sample standard deviation of the set of  $N$  measurements  $\{x_i\}_{i=1..N}$  is computed as follows:

$$\sigma = \sqrt{\frac{\sum_{i=1}^N (x_i - \bar{x})^2}{N - 1}} \quad \text{with} \quad \bar{x} = \frac{1}{N} \cdot \sum_{i=1}^N x_i$$

### G.2.3 Expanded uncertainty

The expanded uncertainty takes into account both the number  $N$  of measurements and the desired level of confidence in the final uncertainty. The level of confidence indicates how many of the measurements are likely to be within the calculated uncertainty limits.

The correction factor  $C(N)$  to be applied to the estimated standard deviation for the number of measurements  $N$  is the Student t-factor. It compensates for the underestimation of the standard deviation when calculated on a reduced set of measurements. It is specified in Table G.1. Values not tabulated can be recalculated or interpolated from the tabulated values.

**Table G.1 – Correction factor  $C(N)$  for sample size  $N$**

| Number of measurements $N$ | Correction factor $C_1(N)$ for one standard deviation | Correction factor $C_2(N)$ for two standard deviations |
|----------------------------|-------------------------------------------------------|--------------------------------------------------------|
| 3                          | 1,321                                                 | 4,527                                                  |
| 4                          | 1,197                                                 | 3,307                                                  |
| 5                          | 1,142                                                 | 2,869                                                  |
| 6                          | 1,111                                                 | 2,649                                                  |
| 7                          | 1,091                                                 | 2,517                                                  |
| 8                          | 1,077                                                 | 2,429                                                  |
| 9                          | 1,067                                                 | 2,366                                                  |
| 10                         | 1,059                                                 | 2,320                                                  |
| 11                         | 1,053                                                 | 2,284                                                  |
| 12                         | 1,048                                                 | 2,255                                                  |
| 13                         | 1,043                                                 | 2,231                                                  |
| 14                         | 1,040                                                 | 2,212                                                  |
| 15                         | 1,037                                                 | 2,195                                                  |
| 16                         | 1,034                                                 | 2,181                                                  |
| 17                         | 1,032                                                 | 2,169                                                  |
| 18                         | 1,030                                                 | 2,158                                                  |
| 19                         | 1,029                                                 | 2,149                                                  |
| 20                         | 1,027                                                 | 2,140                                                  |
| 30                         | 1,018                                                 | 2,090                                                  |
| 40                         | 1,013                                                 | 2,066                                                  |
| 50                         | 1,010                                                 | 2,052                                                  |
| 100                        | 1,005                                                 | 2,026                                                  |

The expanded uncertainty is calculated as:

$$unc_{Exp} = C_2(N) \cdot \sigma$$

The estimated standard deviation and the expanded uncertainty are measures of the dispersion of the measurements (taken in identical conditions) around their average value. It characterizes the random error, sometimes called the precision of the measurement.

### G.3 Determining the measurement uncertainty

#### G.3.1 Systematic error

The systematic error is the difference between the conventional true value and the average of the measured values. It can be determined as:

$$err_{Syst} = x_{true} - \bar{x}$$

It can be positive or negative. It can be expressed in physical units or as a percentage of the true value. In statistics, the systematic error is also called a bias.

The conventional true value is typically estimated using a reference power meter. The accuracy of the reference meter should typically be better than the expected accuracy of the PMD under test, by at least a factor 10.

The systematic error is a measure of the accuracy of the measurement. Values of the systematic error significantly different from zero typically result from imperfect or invalid calibration in the operating conditions of the test, or from considering too small a number of measurements.

#### G.3.2 Measurement uncertainty

The difference between the measurements and the true value of the measurand is characterized by both the systematic error and the random error. A good measurement is a measurement that is both true and precise.

Both indicators can be combined to provide an estimate of the overall uncertainty, which will be considered as the measurement uncertainty. The measurement uncertainty in absolute value can be computed as:

$$unc_{Meas} = |err_{Syst}| + unc_{Exp}$$

This concept is shown in Figure G.1.

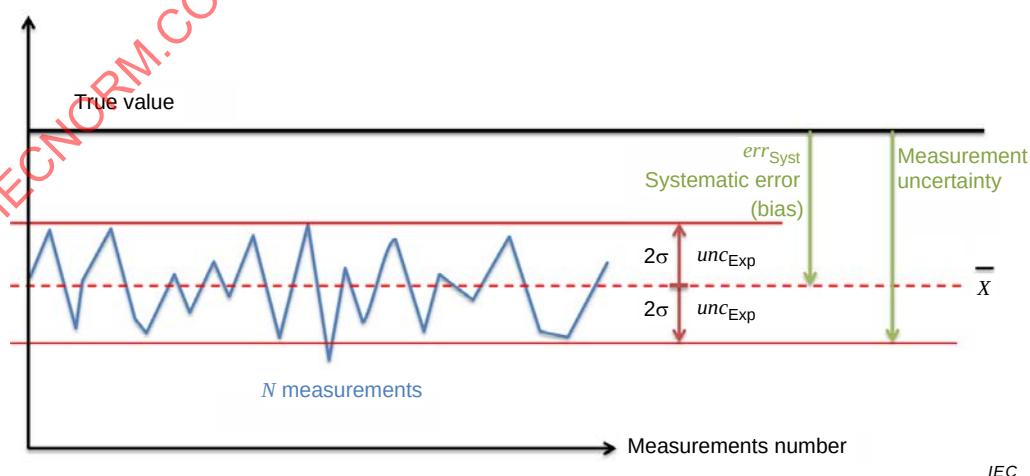


Figure G.1 – Illustration of the notion of measurement uncertainty

The value of the measurement uncertainty depends on:

- the systematic error, reflecting the quality of the calibration of the product in the operating conditions of the test,
- the random error, reflecting the quality of the measurement process and the level of noise in the operating conditions of the test,
- the number  $N$  of measurements made during the test,
- the resolution of the measurement

and therefore provides a good indicator of the overall quality of the measurement.

NOTE Other sources of uncertainty are normally taken into account but are disregarded in this edition:

- uncertainty of the reference meter,
- uncertainty on the estimated mean  $\bar{x}$  due to a limited number of measurements.

## **G.4 Using the measurement uncertainty as a pass/fail criterion**

### **G.4.1 Intrinsic uncertainty tests**

The measurement uncertainty calculated for each intrinsic uncertainty test conducted needs to be compared to the uncertainty limit specified in the intrinsic uncertainty table, in order to assess the class of the measurement.

- If the measurement uncertainty is smaller than the specified uncertainty limit of class  $C$  for all the intrinsic uncertainty tests, then compliance to class  $C$  for intrinsic uncertainty is granted.
- Otherwise, i.e. if the measurement uncertainty is greater than the specified uncertainty limit for at least one of the intrinsic uncertainty tests, compliance to class  $C$  is not granted and a larger class should be considered.

### **G.4.2 Tests with influence quantities**

The measurement uncertainty calculated for a test with influence quantities can be compared to the intrinsic measurement uncertainty.

- If the variation of measurement uncertainty is smaller than the specified limit of variation of class  $C$  for all the tests with influence quantity, then compliance to class  $C$  is granted for the uncertainty under influence quantities.
- Otherwise, compliance to class  $C$  is not granted and a larger class should be considered.

### **G.4.3 Overall pass/fail criterion**

Compliance to a class requires that the product meet the performance requirements in terms of both intrinsic uncertainty and variation of uncertainty under influence quantities. Therefore:

- If compliance to class  $C$  is granted as described above for both the intrinsic uncertainty tests and the tests with influence quantities, then compliance to class  $C$  is granted.
- Otherwise, compliance to class  $C$  is not granted, a larger class shall be considered.

This process is illustrated in Figure G.2.

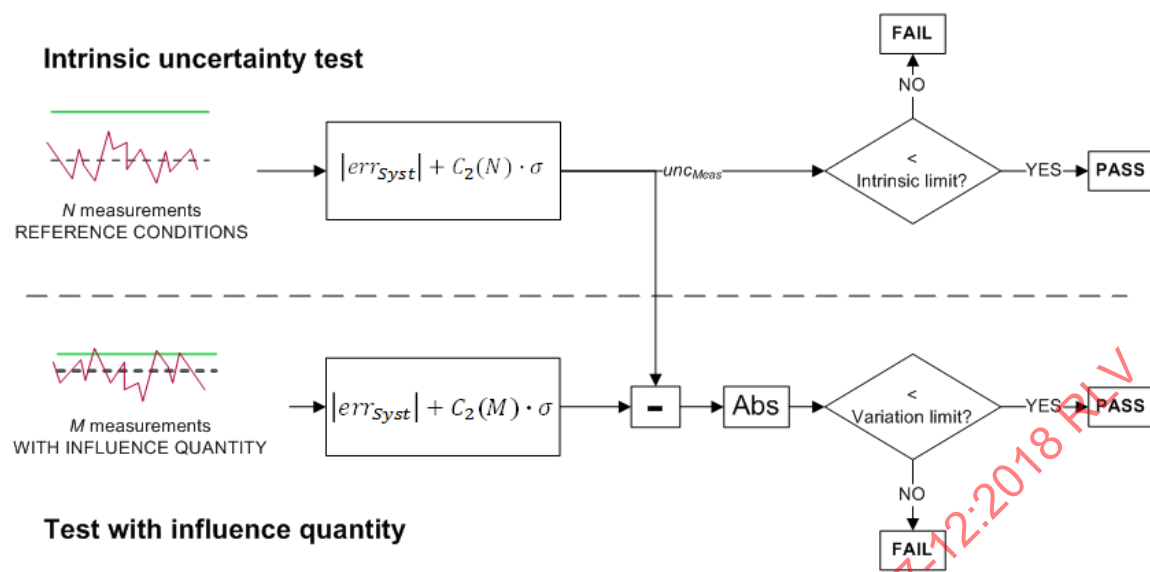


Figure G.2 – Overview of the uncertainty test procedure

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## COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

### **SÉCURITÉ ÉLECTRIQUE DANS LES RÉSEAUX DE DISTRIBUTION BASSE TENSION JUSQU'À 1 000 V c.a. ET 1 500 V c.c. – DISPOSITIFS DE CONTRÔLE, DE MESURE OU DE SURVEILLANCE DE MESURES DE PROTECTION –**

#### **Partie 12: Dispositifs de comptage et de surveillance du réseau électrique (PMD)**

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La Norme internationale IEC 61557-12 a été établie par le comité d'études 85 de l'IEC: Équipement de mesure des grandeurs électriques et électromagnétiques.

Cette deuxième édition annule et remplace la première édition parue en 2007. Cette édition constitue une révision technique.

Cette édition inclut les modifications techniques majeures suivantes par rapport à l'édition précédente:

- a) Suppression des PMD-A du fait que ces dispositifs sont à présent largement couverts par la série de normes IEC 62586.
- b) Création de trois catégories de PMD accompagnées d'une liste des fonctions minimales exigées pour chacune des catégories.
- c) Ajout d'une nouvelle Annexe A décrivant les différentes applications associées aux normes et dispositifs correspondants et d'une autre nouvelle Annexe C portant sur les conventions du facteur de puissance.

Le texte de cette Norme internationale est issu des documents suivants:

| FDIS        | Rapport de vote |
|-------------|-----------------|
| 85/644/FDIS | 85/649/RVD      |

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette Norme internationale.

Ce document a été rédigé selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série IEC 61557, publiées sous le titre général *Sécurité électrique dans les réseaux de distribution basse tension jusqu'à 1 000 V c.a. et 1 500 V c.c. – Dispositifs de contrôle, de mesure ou de surveillance de mesures de protection*, peut être consultée sur le site web de l'IEC.

Le comité a décidé que le contenu de ce document ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous «<http://webstore.iec.ch>» dans les données relatives au document recherché. À cette date, le document sera

- reconduit,
- supprimé,
- remplacé par une édition révisée, ou
- amendé.

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## INTRODUCTION

Les réseaux de distribution d'énergie ont besoin de garantir l'efficacité énergétique, la disponibilité en énergie et les performances de réseau afin de faire face aux défis suivants:

- exigences de développement durable pour lesquelles le mesurage de l'énergie, par exemple, est reconnu comme un élément essentiel de la gestion énergétique, faisant partie de l'effort global pour réduire les émissions de gaz carbonique et pour améliorer le rendement commercial des organismes de fabrication, des organisations commerciales et des services publics;
- évolutions technologiques (charges électroniques, méthodes de mesure électroniques, etc.);
- besoins des utilisateurs finaux (économies de coûts, conformité aux aspects de la réglementation des constructions, etc.) par rapport à la gestion de l'énergie électrique ainsi que d'autres énergies, ou fluides. D'autres fonctionnalités impliquant plusieurs paramètres non électriques sont souvent nécessaires parallèlement;
- sécurité et continuité du service;
- évolutions des normes d'installation, par exemple la détection des surintensités est à présent une nouvelle exigence pour le conducteur de neutre en raison du contenu harmonique.

La surveillance des grandeurs électriques dans les réseaux internes permet de relever ces défis.

Les dispositifs sur le marché actuel ont différentes caractéristiques, qui nécessitent un système de références commun. Par conséquent, l'élaboration du présent document est nécessaire afin de faciliter les choix des utilisateurs finaux en matière de performances, de sécurité, d'interprétation des indications, etc. Le présent document fournit une base à la spécification et à la description de tels dispositifs ainsi qu'à l'évaluation de leurs performances.

Pour répondre aux exigences du projet d'efficacité énergétique, un bon nombre de dispositifs de comptage et de surveillance du réseau électrique (PMD<sup>1</sup>) chargés de mesurer les paramètres électriques peuvent aussi collecter des données (eau, air, gaz, température...) à partir d'autres capteurs ou compteurs situés à l'intérieur des bâtiments ou des zones d'implantation d'usines. Il est nécessaire d'équiper les PMD d'un bus de communication pour qu'ils soient en mesure de transmettre l'ensemble de ces données à un logiciel de surveillance. Le logiciel de surveillance traite toutes les données collectées en vue de les surveiller et de générer des rapports utiles à l'analyse de l'utilisation et de la consommation d'énergie.

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<sup>1</sup> PMD = power metering and monitoring device,

# **SÉCURITÉ ÉLECTRIQUE DANS LES RÉSEAUX DE DISTRIBUTION BASSE TENSION JUSQU'À 1 000 V c.a. ET 1 500 V c.c. – DISPOSITIFS DE CONTRÔLE, DE MESURE OU DE SURVEILLANCE DE MESURES DE PROTECTION –**

## **Partie 12: Dispositifs de comptage et de surveillance du réseau électrique (PMD)**

### **1 Domaine d'application**

La présente partie de l'IEC 61557 spécifie des exigences relatives aux dispositifs de comptage et de surveillance du réseau électrique (PMD) qui mesurent et surveillent les grandeurs électriques dans les réseaux de distribution électrique et, facultativement, d'autres signaux externes. Ces exigences définissent également les performances dans les réseaux alternatifs ou continus monophasés et triphasés ayant des tensions assignées inférieures ou égales à 1 000 V en courant alternatif ou inférieures ou égales à 1 500 V en courant continu.

Ces dispositifs sont fixes ou portables. Ils sont destinés à être utilisés à l'intérieur et/ou à l'extérieur.

Les dispositifs de comptage et de surveillance du réseau électrique (PMD) tels que définis dans le présent document donnent des informations supplémentaires sur la sécurité, ce qui facilite la vérification de l'installation et augmente les performances des réseaux de distribution.

Les dispositifs de comptage et de surveillance du réseau électrique (PMD) relatifs aux paramètres électriques décrits dans le présent document sont utilisés pour des applications industrielles et commerciales générales.

Le présent document ne traite pas des aspects liés à la sécurité fonctionnelle et à la cybersécurité.

Le présent document n'est pas applicable:

- aux appareils de comptage d'électricité conformes à l'IEC 62053-21, à l'IEC 62053-22, à l'IEC 62053-23 et à l'IEC 62053-24. Néanmoins, les incertitudes définies dans le présent document pour le mesurage de l'énergie active et réactive sont tirées de celles définies dans l'IEC 62053 (toutes les parties);
- au mesurage et à la surveillance des paramètres électriques définis dans l'IEC 61557-2 à l'IEC 61557-9 et dans l'IEC 61557-13 ou dans l'IEC 62020;
- aux instruments de qualité de l'alimentation (PQI – *power quality instrument*) conformes à l'IEC 62586 (toutes les parties);
- aux dispositifs relevant des domaines d'application de l'IEC 60051 (toutes les parties) (appareils de mesure électriques analogique à action directe).

NOTE 1 Ces types de dispositifs sont généralement utilisés dans les applications ou pour les besoins généraux suivants:

- gestion énergétique à l'intérieur de l'installation, y compris la facilitation de la mise en œuvre des documents tels que l'ISO 50001 et l'IEC 60364-8-1;
- surveillance et/ou mesurage des paramètres électriques;
- mesurage et/ou surveillance de la qualité de l'énergie à l'intérieur des installations commerciales ou industrielles.

NOTE 2 Un dispositif de mesure et de surveillance des paramètres électriques se compose généralement de plusieurs modules fonctionnels. Tous les modules fonctionnels ou une partie de ces modules sont combinés en un dispositif. Exemples de modules fonctionnels:

- mesurage et surveillance de plusieurs paramètres électriques simultanément;
- mesurage et/ou surveillance de l'énergie ainsi que, parfois, conformité à la réglementation des constructions;
- fonctions d'alarmes;
- qualité du côté consommation d'énergie (harmoniques de courant et de tension, surtensions/sous-tensions, creux de tension et surtensions temporaires, etc.).

NOTE 3 Les PMD sont traditionnellement appelés wattmètres, contrôleurs de puissance, dispositifs de contrôle de la puissance, dispositifs de surveillance de l'énergie électrique, analyseurs de puissance, compteurs multifonctions, équipements de mesure multifonctions, compteurs d'énergie.

NOTE 4 Les applications de comptage, de mesure et de surveillance sont expliquées à l'Annexe A.

## 2 Références normatives

Les documents suivants cités dans le texte constituent, pour tout ou partie de leur contenu, des exigences du présent document. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

IEC 60068-2-1, *Essais d'environnement – Partie 2-1: Essais – Essai A: Froid*

IEC 60068-2-2, *Essais d'environnement – Partie 2-2: Essais – Essai B: Chaleur sèche*

IEC 60068-2-30, *Essais d'environnement – Partie 2-30: Essais – Essai Db: Essai cyclique de chaleur humide (cycle de 12 h + 12 h)*

IEC 60529, *Degrés de protection procurés par les enveloppes (Code IP)*

IEC 61000-4-30:2015, *Compatibilité électromagnétique (CEM) – Partie 4-30: Techniques d'essai et de mesure – Méthodes de mesure de la qualité de l'alimentation*

IEC 61010-1:2010, *Règles de sécurité pour appareils électriques de mesurage, de régulation et de laboratoire – Partie 1: Exigences générales*

IEC 61010-1:2010/AMD1:2016

IEC 61010-2-030:2017, *Exigences de sécurité pour appareils électriques de mesurage, de régulation et de laboratoire – Partie 2-030: Exigences particulières pour les appareils équipés de circuits d'essai ou de mesure*

IEC 61326-1:2012, *Matériel électrique de mesure, de commande et de laboratoire – Exigences relatives à la CEM – Partie 1: Exigences générales*

IEC 62053-31:1998, *Équipement de comptage de l'électricité (c.a.) – Prescriptions particulières – Partie 31: Dispositifs de sortie d'impulsions pour compteurs électromécaniques et électroniques (seulement deux fils)*

## 3 Termes, définitions et notations

Pour les besoins du présent document, les termes, définitions et notations suivants s'appliquent.

L'ISO et l'IEC tiennent à jour des bases de données terminologiques destinées à être utilisées en normalisation, consultables aux adresses suivantes:

- IEC Electropedia: disponible à l'adresse <http://www.electropedia.org/>
- ISO Online browsing platform: disponible à l'adresse <http://www.iso.org/obp>

### 3.1 Définitions générales

#### 3.1.1

##### **dispositif de comptage et de surveillance du réseau électrique**

###### **PMD**

combinaison en un ou plusieurs dispositifs de plusieurs modules fonctionnels destinés à mesurer et à surveiller les paramètres électriques dans les réseaux de distribution d'énergie ou les installations électriques, utilisés pour des applications telles que l'efficacité énergétique, la surveillance de l'alimentation et les performances du réseau

Note 1 à l'article: Le terme générique «surveillance» englobe également les fonctions d'enregistrement, de gestion d'alarme, etc.

Note 2 à l'article: Ces dispositifs peuvent inclure des fonctions de qualité du côté consommation d'énergie pour la surveillance à l'intérieur des installations commerciales ou industrielles.

Note 3 à l'article: L'abréviation «PMD» est dérivée du terme anglais développé correspondant «*power metering and monitoring device*».

#### 3.1.2

##### **fonctions d'évaluation de la qualité de l'alimentation**

fonctions d'évaluation de la qualité de l'alimentation dont les méthodes de mesure sont définies dans l'IEC 61000-4-30

#### 3.1.3

##### **côté génération d'énergie**

partie du réseau où l'énergie électrique est produite, transmise et distribuée aux consommateurs finaux par le biais du réseau de distribution public

Note 1 à l'article: Cette définition englobe les microréseaux, les générateurs décentralisés ou les générateurs d'énergie renouvelable.

#### 3.1.4

##### **côté consommation d'énergie**

partie du réseau où l'énergie électrique est utilisée par les consommateurs finaux dans leur système de distribution électrique

#### 3.1.5

##### **point de couplage commun**

###### **PCC**

point d'un réseau d'alimentation électrique, le plus proche électriquement d'une charge particulière, auquel d'autres charges sont ou peuvent être connectées

Note 1 à l'article: Ces charges peuvent être soit des dispositifs, appareils ou systèmes, soit des installations distinctes de clients.

Note 2 à l'article: Pour certaines applications, le terme «point de couplage commun» s'applique uniquement aux réseaux publics.

[SOURCE: IEC 60050-161:1990, 161-07-15]

#### 3.1.6

##### **qualité de l'alimentation**

caractéristiques du courant, de la tension électrique et de la fréquence en un point donné d'un système d'énergie électrique évaluée selon un ensemble de paramètres techniques de référence

Note 1 à l'article: Ces paramètres pourraient, dans certains cas, se rapporter à la compatibilité entre l'électricité fournie sur un réseau d'énergie électrique et les charges raccordées à ce réseau d'énergie électrique.

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

### 3.1.7

#### **capteur externe dédié**

capteur propriétaire externe capable de fonctionner seulement avec une gamme de PMD spécifiés par le fabricant

### 3.1.8

#### **capteur de courant**

##### **CS**

dispositif électrique, magnétique, optique ou autre dispositif destiné à transmettre un signal correspondant au courant circulant à travers le circuit primaire de ce dispositif

Note 1 à l'article: Un transformateur de courant (CT – *current transformer*) est en général un capteur de courant magnétique.

Note 2 à l'article: L'abréviation «CS» est dérivée du terme anglais développé correspondant «current sensor».

### 3.1.9

#### **tension disponible**

valeur de la tension pouvant être développée à la sortie analogique de courant, tout en étant conforme à l'exigence de la spécification d'incertitude pour cette sortie

Note 1 à l'article: Cette définition s'applique aux signaux de sortie analogiques de courant.

### 3.1.10

#### **capteur de tension**

##### **VS**

dispositif électrique, magnétique, optique ou autre dispositif destiné à transmettre un signal correspondant à la tension à travers les bornes primaires de ce dispositif

Note 1 à l'article: Un transformateur de tension (VT – *voltage transformer*) est en général un capteur de tension magnétique.

Note 2 à l'article: L'abréviation «VS» est dérivée du terme anglais développé correspondant «voltage sensor».

### 3.1.11

#### **PMD autoalimenté**

équipement dont les bornes de mesure servent également de bornes pour son alimentation

### 3.1.12

#### **alimentation auxiliaire**

circuit d'alimentation externe, en courant alternatif ou courant continu, qui alimente le PMD par des bornes dédiées, séparées des entrées de mesure du PMD

### 3.1.13

#### **PMD alimenté par transformateur**

PMD destiné à être connecté au(x) circuit(s) mesuré(s) par un ou plusieurs transformateurs externes de mesure

Note 1 à l'article: Le PMD alimenté par transformateur correspond au PMD Sx ou PMD xS dans le présent document.

### 3.1.14

#### **élément indicateur primaire**

élément indicateur d'un compteur qui tient compte des rapports de transformation de tous les transformateurs de mesure (tension et courant) alimentant le compteur

Note 1 à l'article: La valeur de l'énergie du côté primaire des transformateurs est obtenue par la lecture directe de l'élément indicateur.

[SOURCE IEC 62053-52:2005, 3.4]

### 3.1.15

#### **élément indicateur semi-primaire**

élément indicateur d'un compteur qui tient compte du (des) rapport(s) de transformation du (des) transformateur(s), soit de courant, soit de tension alimentant le compteur

Note 1 à l'article: La valeur de l'énergie du côté primaire du (des) transformateur(s) est obtenue en multipliant par un facteur approprié la lecture de l'élément indicateur.

[SOURCE IEC 62053-52:2005, 3.5]

## 3.2 Définitions relatives à l'incertitude et à la performance

### 3.2.1

#### **conditions de référence**

ensemble approprié de valeurs et/ou de domaines de valeurs spécifiés des grandeurs d'influence pour lequel les plus petites incertitudes permises d'un appareil de mesure sont spécifiées

Note 1 à l'article: Les domaines de valeurs spécifiés pour les conditions de référence, appelées domaines de référence, ne sont pas plus larges, et sont généralement plus étroits, que ceux spécifiés pour les conditions de fonctionnement assignées.

[SOURCE: IEC 60359:2001, 3.3.10]

### 3.2.2

#### **mesurande (grandeur mesurée)**

grandeur faisant l'objet de la mesure, évaluée dans l'état où se trouve le système mesuré pendant la mesure elle-même

[SOURCE: IEC 60359:2001, 3.1.1, modifiée – les notes ont été enlevées.]

### 3.2.3

#### **incertitude**

paramètre, associé à une mesure, qui caractérise la dispersion des valeurs qui peut être attribuée au mesurande

Note 1 à l'article: Dans le présent document, l'incertitude de mesure inclut les composantes issues d'effets systématiques et d'effets aléatoires.

### 3.2.4

#### **incertitude intrinsèque**

incertitude d'un appareil de mesure lorsqu'on l'utilise dans les conditions de référence

Note 1 à l'article: Dans le présent document, il s'agit d'un pourcentage de la valeur mesurée définie dans sa plage assignée et avec les autres grandeurs d'influence dans les conditions de référence, sauf indication contraire.

[SOURCE: IEC 60359:2001, 3.2.10, modifiée – une note a été ajoutée]

### 3.2.5

#### **grandeur d'influence**

grandeur qui n'est pas l'objet de la mesure, et dont la variation affecte la relation entre l'indication et la mesure

Note 1 à l'article: Les grandeurs d'influence peuvent provenir du système de mesure, de l'appareil de mesure ou de l'environnement [VEI].

Note 2 à l'article: Comme le diagramme d'étalonnage dépend des grandeurs d'influence, pour assigner la mesure, il est nécessaire de savoir si les grandeurs d'influence applicables sont dans la plage spécifiée [VEI].

[SOURCE: IEC 60359:2001, 3.1.14, modifiée – la note 3 a été enlevée.]

### 3.2.6

#### **variation**

<d'une seule grandeur d'influence> différence entre la valeur mesurée dans les conditions de référence et toute valeur mesurée comprise dans la plage d'influence

Note 1 à l'article: Il convient que les autres caractéristiques de performance et les autres grandeurs d'influence restent dans les plages spécifiées pour les conditions de référence.

### 3.2.7

#### **conditions de fonctionnement nominales**

ensemble de conditions devant être remplies pendant la mesure pour qu'un diagramme d'étalonnage soit valable

Note 1 à l'article: Outre l'étendue de mesure spécifiée et les domaines de fonctionnement assignés pour les grandeurs d'influence, les conditions peuvent comprendre des domaines spécifiés d'autres caractéristiques de performances de fonctionnement et d'autres indications qu'il est impossible d'exprimer sous forme de domaines de grandeurs.

[SOURCE: IEC 60359:2001, 3.3.13]

### 3.2.8

#### **incertitude de fonctionnement**

incertitude calculée en tenant compte de l'incertitude intrinsèque et des incertitudes supplémentaires occasionnées par les grandeurs d'influence définies

Note 1 à l'article: L'incertitude de fonctionnement, comme l'incertitude intrinsèque, n'est pas évaluée par l'utilisateur de l'appareil, mais déclarée par son fabricant ou son étalonneur. Cette mention peut revêtir la forme d'une relation algébrique impliquant l'incertitude intrinsèque et les valeurs d'une ou plusieurs grandeurs d'influence, mais une telle relation est seulement un moyen commode d'exprimer un ensemble d'incertitudes de fonctionnement dans différentes conditions d'utilisation, et non pas une relation fonctionnelle pouvant servir à évaluer la propagation de l'incertitude à l'intérieur de l'appareil.

Note 2 à l'article: Une incertitude de fonctionnement reflète la qualité de la conception d'un appareil, et n'est pas de même nature qu'une classe de performance ou une incertitude intrinsèque.

Note 3 à l'article: L'incertitude de fonctionnement peut être supérieure à l'incertitude intrinsèque et à la classe de performance.

Note 4 à l'article: Le concept de l'incertitude de fonctionnement est lié au concept d'erreur maximale admissible développé par d'autres documents, qui est calculé à partir de trois grandeurs d'influence uniquement.

### 3.2.9

#### **incertitude globale**

incertitude constituée de l'incertitude de plusieurs appareils distincts (capteur de tension, capteur de courant et PMD)

### 3.2.10

#### **classe de performance de fonctionnement**

nombre justifiant la performance d'une seule fonction, dépendant de l'incertitude intrinsèque de la fonction, prenant en compte une étendue de mesure spécifiée et des limites de variations dues aux grandeurs d'influence spécifiées

Note 1 à l'article: Dans le présent document,  $C$  représente la valeur numérique de la classe de performance de fonctionnement (par exemple,  $C = 0,2$ ).

### 3.2.11

#### **fréquence assignée**

$f_n$

valeur de la fréquence pour laquelle la spécification du PMD est formulée

**3.2.12****courant assigné** $I_n$ 

valeur du courant pour laquelle la spécification d'un PMD comprenant un capteur de courant externe (PMD Sx) est formulée

**3.2.13****courant de base** $I_b$ 

valeur du courant pour laquelle la spécification d'un PMD à branchement direct (PMD Dx) est formulée

**3.2.14****courant de démarrage** $I_{st}$ 

valeur la plus basse du courant pour laquelle le PMD démarre et enregistre continûment

[SOURCE: IEC 62052-11:2003, 3.5.1.1, modifiée – «compteur» a été remplacé par «PMD».]

**3.2.15****courant maximal** $I_{max}$ 

valeur la plus grande de courant pour laquelle le PMD satisfait aux exigences d'incertitude du présent document

**3.2.16****tension assignée** $U_n$ 

valeur de la tension en fonction de laquelle certaines des caractéristiques du PMD sont fixées

Note 1 à l'article: En fonction du réseau de distribution et de sa connexion au PMD, cette tension peut être soit la tension entre phases, soit la tension phase-neutre.

**3.2.17****tension nominale** $U_{nom}$ 

valeur arrondie appropriée de la tension utilisée pour dénommer ou identifier un réseau

[SOURCE: IEC 60050-601:1985, 601-01-21]

**3.2.18****tension minimale** $U_{min}$ 

valeur de tension la plus basse pour laquelle le PMD satisfait aux exigences d'incertitude du présent document

**3.2.19****tension maximale** $U_{max}$ 

valeur de tension la plus grande pour laquelle le PMD satisfait aux exigences d'incertitude du présent document

**3.2.20****tension résiduelle** $U_{res}$ 

valeur minimale de  $U$  enregistrée au cours d'un creux ou d'une coupure de tension

Note 1 à l'article: La tension résiduelle est exprimée sous la forme d'une valeur, exprimée en volts, ou d'un pourcentage ou d'une fraction de la tension assignée.

### 3.2.21

#### **tension d'entrée déclarée**

$U_{din}$

valeur obtenue à partir de la tension d'alimentation déclarée d'un rapport de transformation

[SOURCE: IEC 61000-4-30:2015, 3.2]

### 3.2.22

#### **tension de référence glissante**

$U_{sr}$

valeur de tension moyennée sur une minute, représentant la tension précédant un creux de tension ou une surtension temporaire

### 3.2.23

#### **valeur moyenne**

valeur moyenne d'une grandeur pendant une durée de temps spécifiée

### 3.2.24

#### **valeur moyenne crête**

valeur moyenne la plus élevée (positive ou négative) depuis le début du mesurage ou depuis la dernière réinitialisation

### 3.2.25

#### **moyenne thermique**

résultat obtenu par un mesureur de moyenne thermique qui fournit une moyenne thermique avec un temps de réponse exponentiel, pour une charge constante donnée, l'indication donnée représentant 90 % de la moyenne actuelle sur un temps spécifié

Note 1 à l'article: Le temps est spécifié par le fabricant, habituellement 15 min.

### 3.2.26

#### **valeur moyenne en triphasé**

dans un réseau à trois ou quatre fils, moyenne arithmétique de toutes les valeurs de phase

### 3.2.27

#### **valeur maximale**

valeur la plus élevée mesurée ou calculée depuis le début du mesurage ou depuis la dernière réinitialisation

### 3.2.28

#### **valeur minimale**

valeur la plus basse mesurée ou calculée depuis le début du mesurage ou depuis la dernière réinitialisation

### 3.2.29

#### **intervalle**

laps de temps utilisé par le PMD pour intégrer des valeurs efficaces ou instantanées, afin de calculer les valeurs moyennes

## **3.3 Définitions relatives aux phénomènes électriques**

### 3.3.1

#### **courant de phase**

$I$

valeur du courant circulant dans chaque phase d'un réseau de distribution électrique

**3.3.2****courant de neutre** $I_N$ 

valeur du courant de neutre d'un réseau de distribution électrique

**3.3.3****tension entre phases****tension composée** $U$ 

tension entre conducteurs de phase

[SOURCE: IEC 60050-601:1985, 601-01-29]

**3.3.4****tension phase-neutre****tension simple** $V$ 

tension entre un conducteur de phase d'un réseau polyphasé et le point neutre

[SOURCE: IEC 60050-601:1985, 601-01-30]

**3.3.5****fréquence** $f$ 

valeur de la fréquence mesurée d'un réseau de distribution électrique

**3.3.6****facteur de puissance** $PF$ 

en régime périodique, rapport de la valeur de la puissance active à la puissance apparente

Note 1 à l'article: Ce facteur de puissance n'est pas le facteur de puissance de déplacement. Les deux types de facteurs de puissance sont différents en termes d'harmoniques.

Note 2 à l'article: L'abréviation « $PF$ » est dérivée du terme anglais développé correspondant «*power factor*».

[SOURCE: IEC 60050-131:2002 131-11-46, modifiée – la formule dans la définition n'a pas été incluse, la note 1 a été modifiée et une note 2 a été ajoutée.]

**3.3.7****amplitude du courant harmonique** $I_h$ 

valeur de l'amplitude du courant aux fréquences harmoniques dans le spectre obtenu à partir de la transformée de Fourier d'une fonction temporelle

**3.3.8****amplitude de la tension harmonique** $U_h$ 

valeur de l'amplitude de la tension aux fréquences harmoniques dans le spectre obtenu à partir de la transformée de Fourier d'une fonction temporelle

**3.3.9****harmoniques stationnaires**

<tension et courant> contenu harmonique du signal, la variation d'amplitude de chaque composante harmonique restant constante à  $\pm 0,1$  % de l'amplitude de la composante fondamentale

### 3.3.10

#### harmoniques quasi-stationnaires

<tension et courant> contenu harmonique du signal dans lequel la variation d'amplitude de chaque harmonique pour 10 cycles (réseaux de 50 Hz) ou 12 cycles (réseaux de 60 Hz) contigus reste constante à  $\pm 0,1$  % de l'amplitude de la composante fondamentale

### 3.3.11

#### sous-harmoniques

<tension et courant> composante interharmonique dont le rang est inférieur à un

Note 1 à l'article: Dans le présent document, les composantes sous-harmoniques sont limitées aux rangs inverses d'un entier.

[SOURCE: IEC 60050-551:2001, 551-20-10, modifiée – le terme a été changé de «composante sous-harmonique» à «sous-harmoniques» et le domaine a été indiqué.]

### 3.3.12

#### papillotement

impression d'instabilité de la sensation visuelle due à un stimulus lumineux dont la luminance ou la répartition spectrale fluctuent dans le temps

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

### 3.3.13

#### creux de tension

baisse temporaire de la tension en un point du réseau de distribution d'énergie électrique en dessous d'un seuil donné

Note 1 à l'article: Les interruptions sont un cas particulier des creux de tension. Des traitements ultérieurs peuvent être utilisés pour faire la distinction entre creux de tension et interruption.

Note 2 à l'article: Dans certaines parties du monde, un creux de tension est appelé «sag» en anglais. Les deux termes sont considérés comme interchangeables; cependant, le présent document n'utilisera que le terme creux de tension.

### 3.3.14

#### surtensions temporaires

augmentation temporaire de la tension en un point du réseau de distribution d'énergie électrique au-dessus d'un seuil donné

### 3.3.15

#### tension efficace rafraîchie à chaque demi-cycle

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

valeur de la tension efficace mesurée sur 1 cycle, commençant à un passage par zéro de la composante fondamentale, et rafraîchie à chaque demi-cycle

Note 1 à l'article: Cette technique est indépendante sur chaque chaîne de mesure et produit des valeurs efficaces à des instants successifs sur chaque chaîne en cas de réseaux polyphasés.

Note 2 à l'article: Cette valeur efficace de la tension peut être une valeur entre phases ou entre phase et neutre.

### 3.3.16

#### tension efficace rafraîchie à chaque cycle

$U_{rms(1)}$

valeur de la tension efficace mesurée sur 1 cycle et rafraîchie à chaque cycle

Note 1 à l'article: Au contraire de l' $U_{rms(\frac{1}{2})}$ , cette technique ne définit pas l'instant de début de cycle.

Note 2 à l'article: Cette valeur efficace de la tension peut être une valeur entre phases ou entre phase et neutre.

**3.3.17****coupure de tension**

baisse de la tension en un point du réseau de distribution d'énergie électrique en dessous d'un seuil de coupure donné

**3.3.18****déséquilibre de tension en amplitude et en phase**

dans un réseau triphasé, état dans lequel les valeurs efficaces des tensions entre conducteurs (composante fondamentale), ou les différences de phase entre conducteurs ne sont pas toutes égales

Note 1 à l'article: Le taux de déséquilibre s'exprime habituellement par le rapport de la composante inverse ou homopolaire à la composante directe.

Note 2 à l'article: Dans le présent document, le déséquilibre de tension est relatif aux réseaux triphasés.

**3.3.19****déséquilibre de tension en amplitude**

dans un réseau triphasé, état dans lequel les valeurs efficaces des tensions entre conducteurs (composante fondamentale) ne sont pas toutes égales.

Note 1 à l'article: La phase relative entre les tensions entre conducteurs n'est pas prise en compte.

Note 2 à l'article: Dans le présent document, le déséquilibre de tension est relatif aux réseaux triphasés.

**3.3.20****surtension transitoire**

surtension de courte durée, ne dépassant pas quelques millisecondes, oscillatoire ou non, généralement fortement amortie

Note 1 à l'article: Les surtensions transitoires peuvent être suivies immédiatement par des surtensions temporaires. Dans ce cas, les deux types de surtensions sont considérés comme des événements séparés.

Note 2 à l'article: L'IEC 60071-1 définit trois types de surtensions transitoires, appelées surtensions à front lent, surtensions à front rapide et surtensions à front très rapide en fonction de leur durée jusqu'à la valeur de crête, durée de queue ou durée totale, et de la possibilité d'oscillations superposées.

[SOURCE: IEC 60050-604:2016, 604-03-14]

**3.3.21****facteur de crête**

rapport de la valeur de crête à la valeur efficace

**3.4 Définitions relatives aux techniques de mesure****3.4.1****fenêtre de mesure**

intervalle de temps pendant lequel un seul mesurage est effectué, exprimé en secondes ou en nombre de cycles fondamentaux

Note 1 à l'article: La durée de la fenêtre de mesure peut être fixe ou variable en fonction de la technique de mesure.

**3.4.2****mesurage sans discontinuité**

technique de mesure dans laquelle le mesurage est effectué de manière continue sans discontinuité, c'est-à-dire en utilisant des fenêtres de mesure contigües

Note 1 à l'article: Pour les techniques numériques et pour une fréquence d'échantillonnage donnée, aucun échantillon n'est absent du traitement de mesure.

Note 2 à l'article: Lorsque des techniques de mesure sans discontinuité sont utilisées, aucune hypothèse n'est émise concernant la stabilité du signal, par opposition aux techniques de mesure avec interruption, dans lesquelles le signal est considéré comme stable pendant la durée où aucun mesurage n'est effectué.

### 3.5 Notations

#### 3.5.1 Fonctions

| Symbole             | Fonction                                                                                               |
|---------------------|--------------------------------------------------------------------------------------------------------|
| $P$                 | puissance active totale                                                                                |
| $E_a$               | énergie active totale                                                                                  |
| $Q_A / Q_V$         | puissance réactive totale arithmétique / puissance réactive totale vectorielle                         |
| $E_{rA} / E_{rV}$   | énergie réactive totale arithmétique / énergie réactive totale vectorielle                             |
| $S_A / S_V$         | puissance apparente totale arithmétique / puissance apparente totale vectorielle                       |
| $E_{apA} / E_{apV}$ | énergie apparente totale arithmétique / énergie apparente totale vectorielle                           |
| $f$                 | fréquence                                                                                              |
| $I$                 | courant de phase ( $I_p$ : courant sur la phase $p$ )                                                  |
| $I_N / I_{Nc}$      | courant de neutre mesuré / courant de neutre calculé                                                   |
| $U$                 | tension entre phases ( $U_{pg}$ : tension phase $p$ à phase $g$ )                                      |
| $V$                 | tension phase-neutre ( $V_p$ : tension phase $p$ à neutre)                                             |
| $PF_A / PF_V$       | facteur de puissance arithmétique / facteur de puissance vectoriel                                     |
|                     | NOTE $PF_V = \cos(\varphi)$ lorsqu'aucune harmonique n'est présente.                                   |
| $P_{st} / P_{lt}$   | papillotement de courte durée / papillotement de longue durée                                          |
| $U_{dip}$           | creux de tension entre phases ( $U_{pgdip}$ : creux phase $p$ à phase $g$ )                            |
| $V_{dip}$           | creux de tension phase-neutre ( $V_{pdip}$ : creux de tension phase $p$ à neutre)                      |
| $U_{swl}$           | surtensions temporaires entre phases ( $U_{pgswl}$ : surtensions temporaires phase $p$ à phase $g$ )   |
| $V_{swl}$           | surtensions temporaires phase-neutre ( $V_{p swl}$ : surtensions temporaires phase $p$ à neutre)       |
| $U_{tr}$            | surtensions transitoires entre phases ( $U_{pg tr}$ : surtensions transitoires phase $p$ à phase $g$ ) |
| $V_{tr}$            | surtensions transitoires phase-neutre ( $V_{p tr}$ : surtensions transitoires phase $p$ à neutre)      |
| $U_{int}$           | coups de tension entre phases ( $U_{pgint}$ : coups de tension phase $p$ à phase $g$ )                 |
| $V_{int}$           | coups de tension phase-neutre ( $V_{p int}$ : coups de tension phase $p$ à neutre)                     |
| $U_{nb}$            | déséquilibre de tension en amplitude et en phase entre phases ( $U_{pg nb}$ : phase $p$ à phase $g$ )  |
| $V_{nb}$            | déséquilibre de tension en amplitude et en phase phase-neutre ( $V_{p nb}$ : phase $p$ à neutre)       |
| $I_{nb}$            | phase et amplitude du déséquilibre de courant                                                          |
| $U_{nba}$           | déséquilibre de tension en amplitude entre phases ( $U_{pgnba}$ : phase $p$ à phase $g$ )              |
| $V_{nba}$           | déséquilibre de tension en amplitude phase-neutre ( $V_{p nba}$ : phase $p$ à neutre)                  |
| $I_{nba}$           | amplitude du déséquilibre de courant                                                                   |
| $U_h$               | harmoniques de tension entre phases ( $U_{pg h}$ : phase $p$ à phase $g$ )                             |
| $V_h$               | harmoniques de tension phase-neutre ( $V_{p h}$ : phase $p$ à neutre)                                  |
| $THD_u$             | taux de distorsion harmonique total de la tension entre phases par rapport à la fondamentale           |
| $THD-R_u$           | taux de distorsion harmonique total de la tension entre phases par rapport à la valeur efficace        |
| $THD_v$             | taux de distorsion harmonique total de la tension phase-neutre par rapport à la fondamentale           |
| $THD-R_v$           | taux de distorsion harmonique total de la tension phase-neutre par rapport à la valeur efficace        |
| $THD-R$             | taux de distorsion harmonique total du courant par rapport à la valeur efficace                        |

#### 3.5.2 Symboles et abréviations

|         |                      |
|---------|----------------------|
| $\%U_n$ | pourcentage de $U_n$ |
| $\%I_n$ | pourcentage de $I_n$ |
| $\%I_b$ | pourcentage de $I_b$ |

### 3.5.3 Indices

|      |                                                 |
|------|-------------------------------------------------|
| a    | actif                                           |
| r    | réactif                                         |
| ap   | apparent                                        |
| n    | assigné                                         |
| b    | de base                                         |
| nom  | nominal                                         |
| N    | neutre                                          |
| c    | calculé                                         |
| h    | harmonique                                      |
| i    | courant                                         |
| u    | tension                                         |
| dip  | creux                                           |
| swl  | swells (surtensions temporaires)                |
| tr   | transitoire                                     |
| int  | interruption (coupure)                          |
| nb   | unbalance (déséquilibre)                        |
| nba  | amplitude unbalance (déséquilibre en amplitude) |
| A    | arithmétique                                    |
| V    | vectorel                                        |
| min  | valeur minimale                                 |
| max  | valeur maximale                                 |
| avg  | average value (valeur moyenne)                  |
| peak | peak value (valeur crête)                       |
| res  | résiduel                                        |

## 4 Exigences

### 4.1 Exigences générales

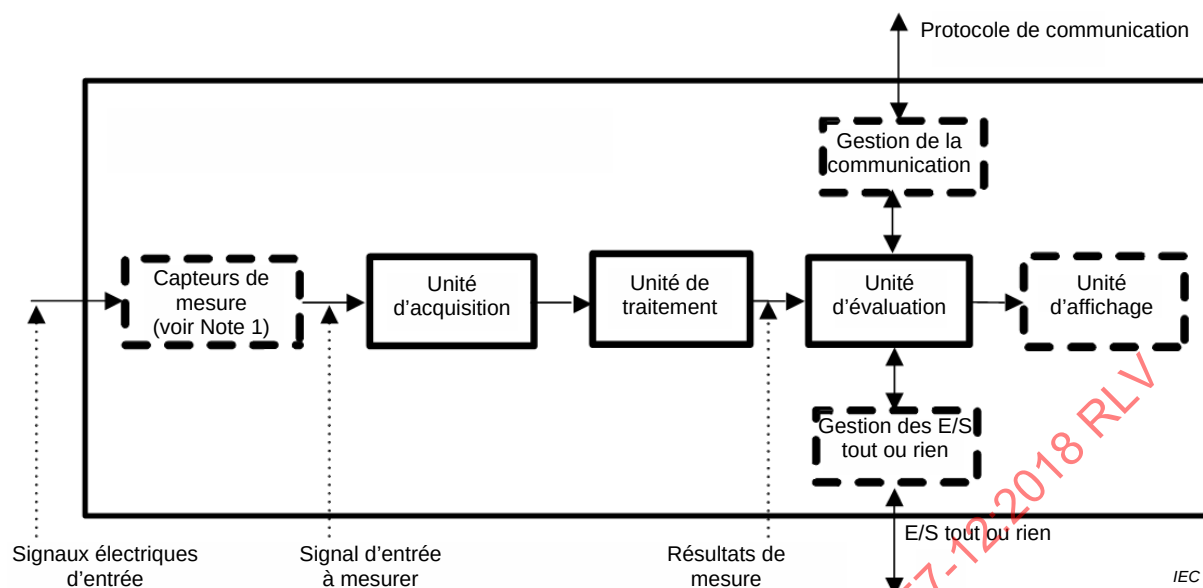
Les exigences suivantes doivent s'appliquer sauf spécification contraire dans la suite du texte.

### 4.2 Architecture générale d'un PMD

Architecture de la chaîne de mesure: la grandeur électrique à mesurer peut être soit directement accessible, comme c'est généralement le cas dans les réseaux basse tension, soit accessible par l'intermédiaire d'un capteur de mesure, par exemple les capteurs de tension (VS) ou les capteurs de courant (CS).

La Figure 1 représente l'architecture courante d'un PMD.

Dans certains cas, quand un PMD n'inclut pas les capteurs, leurs incertitudes associées ne sont pas prises en compte. Lorsqu'un PMD inclut les capteurs, leurs incertitudes associées sont prises en compte.



NOTE 1 Il n'est pas nécessaire d'inclure dans le PMD les éléments représentés dans les cases en pointillé.

NOTE 2 Les E/S sont des signaux analogiques et/ou numériques avec alarmes.

**Figure 1 – Chaîne de mesure générique d'un PMD**

### 4.3 Classification des PMD

Les PMD sont classés selon les applications définies dans le Tableau 1.

**Tableau 1 – Classification fonctionnelle des PMD avec des fonctions minimales exigées**

| Symbole des fonctionnalités <sup>a</sup>                                                                                                                                                  | Type de PMD <sup>b</sup>        |                                                  |                                                                         |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|--------------------------------------------------|-------------------------------------------------------------------------|
|                                                                                                                                                                                           | PMD-I<br>Efficacité énergétique | PMD-II<br>Surveillance de base de l'installation | PMD-III<br>Surveillance avancée de l'installation/performance du réseau |
| $P$                                                                                                                                                                                       |                                 | ■                                                | ■                                                                       |
| $Q$                                                                                                                                                                                       |                                 | ■                                                | ■                                                                       |
| $S$                                                                                                                                                                                       |                                 | ■                                                | ■                                                                       |
| $E_a$                                                                                                                                                                                     | ■                               | ■                                                | ■                                                                       |
| $E_r$                                                                                                                                                                                     |                                 | ■                                                | ■                                                                       |
| $E_{ap}$                                                                                                                                                                                  |                                 |                                                  | ■                                                                       |
| $f$                                                                                                                                                                                       |                                 | ■                                                | ■                                                                       |
| $I$                                                                                                                                                                                       |                                 | ■                                                | ■                                                                       |
| $I_N$                                                                                                                                                                                     |                                 |                                                  | ■                                                                       |
| $U$ et/ou $V$                                                                                                                                                                             |                                 | ■                                                | ■                                                                       |
| $PF$                                                                                                                                                                                      |                                 | ■                                                | ■                                                                       |
| $THD_U$ et/ou $THD_V$ et/ou $THD-R_U$ et/ou $THD-R_V$                                                                                                                                     |                                 |                                                  | ■                                                                       |
| $THD_I$ et/ou $THD-R_I$                                                                                                                                                                   |                                 |                                                  | ■                                                                       |
| <sup>a</sup> Seules les grandeurs totales sont obligatoires.                                                                                                                              |                                 |                                                  |                                                                         |
| <sup>b</sup> Pour les PMD autres que PMD-I, PMD-II et PMD-III et qui sont dénommés PMD-x, d'autres combinaisons de fonctions sont autorisées et doivent être spécifiées par le fabricant. |                                 |                                                  |                                                                         |

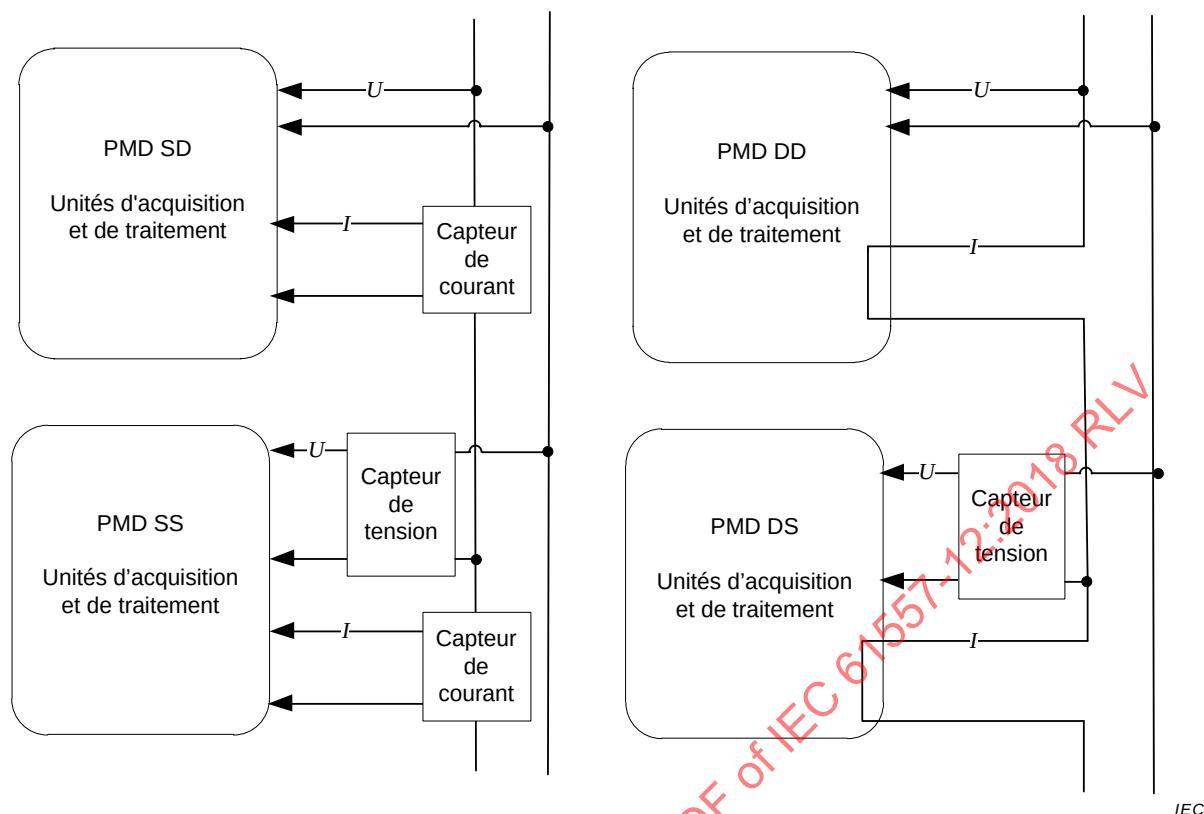
#### 4.4 Structure des PMD

##### 4.4.1 Structure des PMD avec capteurs

Les PMD peuvent inclure des capteurs internes, ou nécessiter des capteurs externes, comme représenté à la Figure 2. Selon ces caractéristiques, ils peuvent ainsi être classés en quatre catégories comme défini dans le Tableau 2.

**Tableau 2 – Structure des PMD**

|                        |                                                                                    | Mesurage du courant                                                                |                                                                                    |
|------------------------|------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|
|                        |                                                                                    | PMD avec capteur externe<br>(capteurs de courant à l'extérieur du PMD)<br>→ PMD Sx | PMD à branchement direct<br>(capteurs de courant à l'intérieur du PMD)<br>→ PMD Dx |
| Mesurage de la tension | PMD à branchement direct<br>(capteurs de tension à l'intérieur du PMD)<br>→ PMD xD | PMD SD<br>(Insertion semi-directe)                                                 | PMD DD<br>(Insertion directe)                                                      |
|                        | PMD avec capteur externe<br>(capteurs de tension à l'extérieur du PMD)<br>→ PMD xS | PMD SS<br>(Insertion indirecte)                                                    | PMD DS<br>(Insertion semi-directe)                                                 |



NOTE Un PMD spécifié comme un PMD Dx (respectivement PMD xD) peut parfois, dans certaines conditions, être utilisé comme un PMD Sx (respectivement PMD xS) lorsqu'il est utilisé avec des capteurs externes, à condition qu'il soit conforme aux exigences des PMD Sx et Dx (respectivement PMD xS et xD).

**Figure 2 – Description des différents types de PMD**

#### 4.4.2 Exigences relatives au PMD autoalimenté

Un PMD autoalimenté triphasé doit effectuer le mesurage dans les limites d'exactitude spécifiées, même lorsqu'une ou deux des trois phases sont déconnectées.

#### 4.5 Liste des classes de performance applicables

Le Tableau 3 spécifie les classes de performance applicables.

**Tableau 3 – Liste des classes de performance applicables**

|                                                                                             |      |      |     |     |     |   |   |     |   |   |
|---------------------------------------------------------------------------------------------|------|------|-----|-----|-----|---|---|-----|---|---|
| Énergie active                                                                              |      |      |     | 0,2 | 0,5 | 1 | 2 |     |   |   |
| Puissance active                                                                            |      |      | 0,1 | 0,2 | 0,5 | 1 | 2 | 2,5 |   |   |
| Énergie réactive                                                                            |      |      |     |     |     |   | 2 |     | 3 |   |
| Puissance réactive                                                                          |      |      |     |     |     | 1 | 2 |     | 3 |   |
| Énergie apparente                                                                           |      |      |     | 0,2 | 0,5 | 1 | 2 |     |   |   |
| Puissance apparente                                                                         |      |      |     | 0,2 | 0,5 | 1 | 2 |     |   |   |
| Fréquence                                                                                   | 0,02 | 0,05 | 0,1 | 0,2 | 0,5 |   |   |     |   |   |
| Courant de phase                                                                            |      | 0,05 | 0,1 | 0,2 | 0,5 | 1 | 2 |     |   |   |
| Courant de neutre mesuré                                                                    |      |      |     | 0,2 | 0,5 | 1 | 2 |     |   |   |
| Courant de neutre calculé                                                                   |      |      | 0,1 | 0,2 | 0,5 | 1 | 2 |     |   |   |
| Tension                                                                                     |      | 0,05 | 0,1 | 0,2 | 0,5 | 1 | 2 |     |   |   |
| Facteur de puissance                                                                        |      |      |     |     | 0,5 | 1 | 2 |     |   | 5 |
| Papillotement                                                                               |      |      |     |     |     |   |   |     |   | 5 |
| Mesurage de creux de tension et de surtensions temporaires                                  |      |      |     |     | 0,5 | 1 | 2 |     |   |   |
| Surtensions transitoires                                                                    |      |      |     |     | 0,5 | 1 | 2 |     |   |   |
| Déséquilibre de tension                                                                     |      |      |     | 0,2 | 0,5 | 1 |   |     |   |   |
| Harmoniques de tension                                                                      |      |      |     |     |     | 1 | 2 |     | 3 | 5 |
| Taux de distorsion harmonique total (THD – <i>total harmonic distortion</i> ) de la tension |      |      |     |     |     | 1 | 2 |     | 3 | 5 |
| Déséquilibre de courant                                                                     |      |      |     | 0,2 | 0,5 | 1 |   |     |   |   |
| Harmoniques de courant                                                                      |      |      |     |     |     | 1 | 2 |     | 3 | 5 |
| Taux de distorsion harmonique total (THD – <i>total harmonic distortion</i> ) du courant    |      |      |     |     |     | 1 | 2 |     | 3 | 5 |

Les exigences relatives aux performances d'un PMD associé à un capteur externe dédié sont les mêmes que pour un PMD à branchement direct. Chaque combinaison d'un PMD associé à un capteur externe dédié doit être considérée comme un PMD DD qui doit satisfaire aux exigences de performance du présent document.

**EXEMPLE** Si un fabricant fournit trois différents types de capteurs dédiés (par exemple, un CT (transformateur de courant) dédié de 100 A, un CT dédié de 500 A et un CT dédié de 1 000 A), ce fabricant fournira trois différents rapports d'essais de type de performance (un pour les essais liés au PMD associé au capteur dédié de 100 A, un pour les essais liés au PMD associé au capteur dédié de 500 A et un troisième pour les essais liés au PMD associé au capteur dédié de 1 000 A). Le fabricant doit fournir une justification appropriée (par exemple, des résultats de simulation, des résultats d'essai existants, des notes de calcul, des schémas...) pour l'extrapolation des performances si certains essais physiques ne sont pas réalisés.

**NOTE** L'Annexe E et l'Annexe F fournissent des recommandations relatives à l'association d'un PMD avec un capteur Annexe F.

## 4.6 Conditions de référence et de fonctionnement pour les PMD

### 4.6.1 Conditions de référence

Le Tableau 4 spécifie les conditions de référence pour les essais:

**Tableau 4 – Conditions de référence pour les essais**

| Conditions                                                                                                                                                                                                                                                                                                                          | Conditions de référence                                                 |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------|
| Température de fonctionnement                                                                                                                                                                                                                                                                                                       | 23 °C ± 2 °C, sauf spécification contraire par le fabricant             |
| Humidité relative                                                                                                                                                                                                                                                                                                                   | 40 % à 60 % RH                                                          |
| Tension d'alimentation auxiliaire                                                                                                                                                                                                                                                                                                   | Tension d'alimentation assignée ± 1 %                                   |
| Phases                                                                                                                                                                                                                                                                                                                              | Trois phases disponibles <sup>a</sup>                                   |
| Déséquilibre de tensions                                                                                                                                                                                                                                                                                                            | ≤ 0,1 % <sup>a</sup>                                                    |
| Champ magnétique continu externe                                                                                                                                                                                                                                                                                                    | ≤ 40 A/m en courant continu<br>≤ 3 A/m en courant alternatif à 50/60 Hz |
| Composante continue sur la tension et le courant                                                                                                                                                                                                                                                                                    | Aucune                                                                  |
| Forme d'onde                                                                                                                                                                                                                                                                                                                        | Sinusoïdale                                                             |
| Fréquence                                                                                                                                                                                                                                                                                                                           | Fréquence assignée (50 Hz ou 60 Hz) ± 0,2 % <sup>b</sup>                |
| <sup>a</sup> Exigé uniquement dans le cas de réseaux triphasés.<br><sup>b</sup> Il convient que les PMD utilisent les fréquences assignées normalisées de 50 Hz ou 60 Hz, si possible, bien que d'autres fréquences assignées, ou plages de fréquences assignées, y compris le fonctionnement en continu, puissent être spécifiées. |                                                                         |

#### 4.6.2 Conditions de fonctionnement assignées

##### 4.6.2.1 Généralités

Les Tableaux 5 à 7 donnent les conditions dans lesquelles les fonctions doivent être conformes à leurs spécifications.

##### 4.6.2.2 Conditions de fonctionnement en température assignées pour les appareils portables

Le Tableau 5 donne les températures assignées de fonctionnement pour les PMD portables:

**Tableau 5 – Températures assignées de fonctionnement pour les appareils portables**

|                                                                   | Classe de température K40 des PMD |
|-------------------------------------------------------------------|-----------------------------------|
| Plage de fonctionnement assignée (avec une incertitude spécifiée) | 0 °C à +40 °C                     |
| Plage limite de fonctionnement (pas de défaillances de matériels) | –10 °C à +55 °C                   |
| Plage limite pour le stockage et le transport                     | –25 °C à +70 °C                   |

##### 4.6.2.3 Conditions de fonctionnement en température assignées pour les équipements installés de manière fixe

Le Tableau 6 donne les températures assignées de fonctionnement pour les PMD installés de manière fixe:

**Tableau 6 – Températures assignées de fonctionnement  
pour les équipements installés de manière fixe**

|                                                                                                                                                                                                                                                                                 | Classe de température K55 des PMD | Classe de température K70 des PMD | Classe de température Kx <sup>b</sup> des PMD              |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------|-----------------------------------|------------------------------------------------------------|
| Plage de fonctionnement assignée (avec incertitude spécifiée)                                                                                                                                                                                                                   | –5 °C à +55 °C                    | –25 °C à +70 °C                   | Supérieure à +70 °C et/ou inférieure à –25 °C <sup>a</sup> |
| Plage limite de fonctionnement (pas de défaillance de matériels)                                                                                                                                                                                                                | –5 °C à +55 °C                    | –25 °C à +70 °C                   | Supérieure à +70 °C et/ou inférieure à –25 °C <sup>a</sup> |
| Plage limite pour le stockage et le transport                                                                                                                                                                                                                                   | –25 °C à +70 °C                   | –40 °C à +85 °C                   | Selon la spécification du fabricant <sup>a</sup>           |
| <sup>a</sup> Les limites doivent être définies par le fabricant, conformément à l'application.<br><sup>b</sup> Kx représente les conditions étendues.<br><sup>c</sup> La température de fonctionnement est la température la plus élevée de l'air à proximité immédiate du PMD. |                                   |                                   |                                                            |

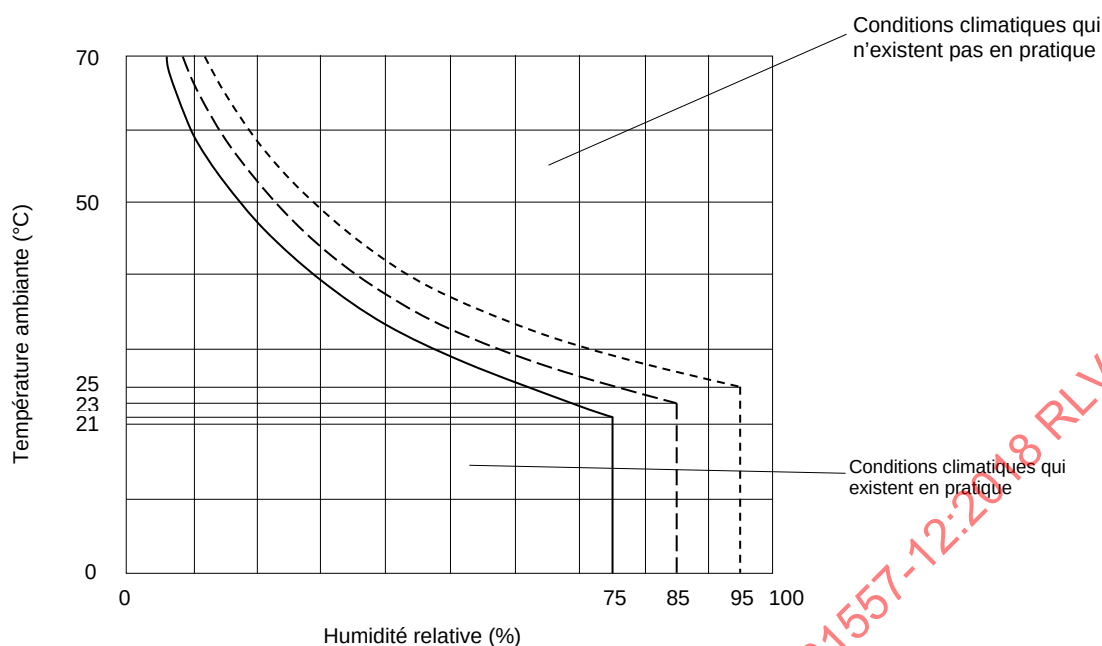
#### 4.6.2.4 Conditions assignées de fonctionnement en humidité et altitude

Le Tableau 7 donne les conditions assignées de fonctionnement en humidité et en altitude pour les PMD portables et installés de manière fixe:

**Tableau 7 – Conditions de fonctionnement en humidité et en altitude**

|                                                                                                                                                                                   | Conditions normalisées     | Conditions étendues                 |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------|-------------------------------------|
| Plage de fonctionnement assignée (avec incertitude spécifiée)                                                                                                                     | 0 % à 75 % HR <sup>b</sup> | 0 % à plus de 75 % HR <sup>ab</sup> |
| Plage limite de fonctionnement pendant 30 jours/an                                                                                                                                | 0 % à 90 % HR <sup>b</sup> | 0 % à plus de 90 % HR <sup>ab</sup> |
| Plage limite pour le stockage et le transport                                                                                                                                     | 0 % à 90 % HR <sup>b</sup> | 0 % à plus de 90 % HR <sup>ab</sup> |
| Altitude                                                                                                                                                                          | 0 m à 2 000 m              | 0 m à plus de 2 000 m <sup>a</sup>  |
| <sup>a</sup> Les limites doivent être définies par le fabricant, conformément à l'application.<br><sup>b</sup> Les valeurs d'humidité relative sont spécifiées sans condensation. |                            |                                     |

Les limites d'humidité relative en fonction de la température de l'air ambiant sont représentées à la Figure 3.



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**Figure 3 – Relation entre la température de l'air ambiant et l'humidité relative**

#### **4.7 Conditions de démarrage**

Les relevés de mesure doivent être disponibles par l'intermédiaire d'une interface de communication ou d'une interface utilisateur locale 15 s après l'application de l'alimentation. Si la durée du démarrage est supérieure à 15 s, les fabricants doivent spécifier le temps maximal à partir duquel les grandeurs de mesure sont disponibles par l'intermédiaire d'une interface de communication ou d'une interface utilisateur locale après l'application de l'alimentation.

Lorsqu'aucune interface utilisateur locale ou de communication n'est disponible, cette exigence doit être vérifiée selon la procédure d'essai décrite en 6.2.17.

#### **4.8 Exigences relatives aux fonctions des PMD**

##### **4.8.1 Exigences générales**

##### **4.8.1.1 Exigences de couverture**

Le 4.8 indique une liste de fonctions. En fonction du type de mesurage, l'ensemble ou une partie des fonctions énumérées doit être mesuré.

Toutes les fonctions mises en œuvre dans le produit et spécifiées dans le présent document doivent satisfaire aux exigences du présent document.

##### **4.8.1.2 Exigences relatives à la fenêtre de mesure**

Sauf spécification contraire, la fenêtre de mesure d'une grandeur mesurée ne doit pas dépasser 3 s ou 150/180 cycles à la fréquence assignée.

Cette exigence peut ne pas être satisfaite pour le THD et les harmoniques. Dans ce cas, la fenêtre de mesure du THD et des harmoniques doit être déclarée par le fabricant.

Cette exigence ne s'applique pas aux énergies ainsi qu'aux grandeurs de pointe, qui sont obtenues par intégration ou moyennage des grandeurs de base mesurées dans la fenêtre de mesure.

#### 4.8.1.3 Exigences relatives aux grandeurs de tension phase-neutre

Sauf spécification contraire, les fonctions de tension phase-neutre doivent satisfaire aux mêmes exigences que les fonctions de tension entre phases, si les fonctions de tension phase-neutre sont mises en œuvre.

#### 4.8.1.4 Exigences en matière de limites de variation due aux grandeurs d'influence

Pour des raisons pratiques, si la limite de variation calculée exigée est inférieure à 0,02 %, l'exigence doit donc être fixée à 0,02 %.

#### 4.8.1.5 Courant maximal

Lorsque le PMD est mis en fonctionnement sur un ou plusieurs transformateurs de courant, l'attention est attirée sur la nécessité d'adapter la plage de courants du PMD à celle du secondaire du ou des transformateurs de courant. Le courant maximal du PMD doit être de 120 %  $I_n$  au moins.

### 4.8.2 Mesurages de la puissance active ( $P$ ) et de l'énergie active ( $E_a$ )

#### 4.8.2.1 Techniques

Voir Annexe B.

Un mesurage sans discontinuité est exigé.

#### 4.8.2.2 Plage assignée de fonctionnement

Les exigences de l'incertitude intrinsèque doivent s'appliquer dans la plage suivante:

$$80 \% U_n < U < 120 \% U_n$$

#### 4.8.2.3 Tableau d'incertitude intrinsèque

L'incertitude intrinsèque, dans les conditions de référence, ne doit pas dépasser les limites données dans le Tableau 8:

**Tableau 8 – Tableau d'incertitude intrinsèque pour le mesurage de la puissance active et de l'énergie active**

| Étendue de mesure spécifiée                            |                                                        | Facteur de puissance <sup>c</sup> | Limites de l'incertitude intrinsèque pour les PMD de classe de performance de fonctionnement <sup>C<sup>a</sup> b</sup> |                   | Unité |
|--------------------------------------------------------|--------------------------------------------------------|-----------------------------------|-------------------------------------------------------------------------------------------------------------------------|-------------------|-------|
| Valeur du courant pour les PMD Dx à branchement direct | Valeur du courant pour les PMD Sx avec capteur externe |                                   | pour C < 1                                                                                                              | pour C ≥ 1        |       |
|                                                        |                                                        |                                   |                                                                                                                         |                   |       |
| 2 % $I_b \leq I < 10 \%$ $I_b$                         | 1 % $I_n \leq I < 5 \%$ $I_n$                          | 1                                 | ± 2,0 × C                                                                                                               | Aucune exigence   | %     |
| 5 % $I_b \leq I < 10 \%$ $I_b$                         | 2 % $I_n \leq I < 5 \%$ $I_n$                          | 1                                 | Aucune exigence                                                                                                         | ± (1,0 × C + 0,5) | %     |
| 10 % $I_b \leq I \leq I_{\max}$                        | 5 % $I_n \leq I \leq I_{\max}$                         | 1                                 | ± 1,0 × C                                                                                                               | ± 1,0 × C         | %     |
| 5 % $I_b \leq I < 20 \%$ $I_b$                         | 2 % $I_n \leq I < 10 \%$ $I_n$                         | 0,5 inductif                      | ± (1,7 × C + 0,15)                                                                                                      | Aucune exigence   | %     |
|                                                        |                                                        | 0,8 capacitif                     | ± (1,7 × C + 0,15)                                                                                                      | Aucune exigence   |       |
| 10 % $I_b \leq I < 20 \%$ $I_b$                        | 5 % $I_n \leq I < 10 \%$ $I_n$                         | 0,5 inductif                      | Aucune exigence                                                                                                         | ± (1,0 × C + 0,5) | %     |
|                                                        |                                                        | 0,8 capacitif                     | Aucune exigence                                                                                                         | ± (1,0 × C + 0,5) |       |
| 20 % $I_b \leq I \leq I_{\max}$                        | 10 % $I_n \leq I \leq I_{\max}$                        | 0,5 inductif                      | ± (1,0 × C + 0,1)                                                                                                       | ± 1,0 × C         | %     |
|                                                        |                                                        | 0,8 capacitif                     | ± (1,0 × C + 0,1)                                                                                                       | ± 1,0 × C         |       |

<sup>a</sup> Les classes de performance applicables sont énumérées dans le Tableau 3.

<sup>b</sup> Pour les classes 1 et 2 de mesure de l'énergie active du présent document, les limites d'incertitude des classes 1 et 2 définies dans le Tableau 6 de l'IEC 62053-21:2003 peuvent être utilisées ainsi que les limites d'incertitude données dans ce tableau. Pour les classes 0,2 et 0,5 de mesure de l'énergie active du présent document, les limites d'incertitude des classes 0,2S et 0,5S définies dans le Tableau 4 de l'IEC 62053-22:2003 peuvent être utilisées ainsi que les limites d'incertitude données dans ce tableau.

<sup>c</sup> Dans les conditions de référence, les signaux sont sinusoïdaux; ainsi, dans ce cas, le facteur de puissance = cos φ.

#### 4.8.2.4 Limites de variation due aux grandeurs d'influence

Les variations supplémentaires dues aux grandeurs d'influence par rapport aux conditions de référence données en 4.6.1 ne doivent pas dépasser les limites pour la classe de performance correspondante données dans le Tableau 9:

Tableau 9 – Grandeurs d'influence pour le mesurage de la puissance active et de l'énergie active (1 de 3)

| Grandeurs d'influence                                              |                                                                                      | Étendue de mesure spécifiée <sup>e</sup>                         |                                                                 | Facteur de puissance <sub>j</sub> | Coefficient de température pour les PMD de classe de performance de fonctionnement $C^{a,b}$ |                                | Unité          |
|--------------------------------------------------------------------|--------------------------------------------------------------------------------------|------------------------------------------------------------------|-----------------------------------------------------------------|-----------------------------------|----------------------------------------------------------------------------------------------|--------------------------------|----------------|
| Type d'influence                                                   | Plage d'influence                                                                    | Valeur du courant pour les PMD Dx à branchement direct           | Valeur du courant pour les PMD Sx avec capteur externe          |                                   | pour $C < 1$                                                                                 | pour $C \geq 1$                |                |
| Température ambiante                                               | conformément à la plage de fonctionnement assignée du Tableau 5 et Tableau 6         | 10 % $I_b \leq I \leq I_{max}$<br>20 % $I_b \leq I \leq I_{max}$ | 5 % $I_n \leq I \leq I_{max}$<br>10 % $I_n \leq I \leq I_{max}$ | 1<br>0,5 inductif                 | 0,05 × C<br>0,1 × C                                                                          | 0,05 × C<br>0,07 × C           | % / K<br>% / K |
|                                                                    |                                                                                      |                                                                  |                                                                 |                                   | Limites de variation pour les PMD de classe de performance de fonctionnement $C^{a,b}$       |                                |                |
|                                                                    |                                                                                      |                                                                  |                                                                 |                                   | pour $C < 1$                                                                                 | pour $C \geq 1$                |                |
| Tension d'alimentation auxiliaire <sup>l</sup>                     | tension assignée ± 15 %                                                              | 10 % $I_b$                                                       | 10 % $I_n$                                                      | 1                                 | 0,1 × C                                                                                      | 0,1 × C                        | %              |
| Tension                                                            | 80 % $U_n < U < 120 \% U_n$                                                          | 5 % $I_b \leq I \leq I_{max}$<br>10 % $I_b \leq I \leq I_{max}$  | 2 % $I_n \leq I \leq I_{max}$<br>5 % $I_n \leq I \leq I_{max}$  | 1<br>0,5 inductif                 | 0,3 × C + 0,04<br>0,6 × C + 0,08                                                             | 0,3 × C + 0,4<br>0,5 × C + 0,5 | %              |
| Fréquence                                                          | fréquence assignée ± 2 %                                                             | 5 % $I_b \leq I \leq I_{max}$<br>10 % $I_b \leq I \leq I_{max}$  | 2 % $I_n \leq I \leq I_{max}$<br>5 % $I_n \leq I \leq I_{max}$  | 1<br>0,5 inductif                 | 0,3 × C + 0,04<br>0,3 × C + 0,04                                                             | 0,3 × C + 0,2<br>0,3 × C + 0,4 | %              |
| Séquence de phase inversée                                         | ---                                                                                  | 10 % $I_b$                                                       | 10 % $I_n$                                                      | 1                                 | 0,15 × C + 0,02                                                                              | 1,5                            | %              |
| Déséquilibre de tension                                            | 0 % à 10 %                                                                           | $I_b$                                                            | $I_n$                                                           | 1                                 | 1,5 × C + 0,2                                                                                | 2,0 × C                        | %              |
| Phase manquante <sup>f</sup>                                       | une ou deux phases manquantes                                                        | $I$                                                              | $I_n$                                                           | 1                                 | 2,0 × C                                                                                      | 2,0 × C                        | %              |
| Composantes harmoniques dans les circuits de courant et de tension | tension, 5 <sup>e</sup> harmonique: 10 %<br>courant, 5 <sup>e</sup> harmonique: 40 % | 50 % $I_{max}$                                                   | 50 % $I_{max}$                                                  | 1                                 | 0,4 × C + 0,3                                                                                | 0,2 × C + 0,6                  | %              |

Tableau 9 (2 de 3)

| Grandeurs d'influence                                                                           |                                                                                         | Étendue de mesure spécifiée <sup>e</sup>                            |                                                                     | Facteur de puissance <sup>j</sup> | Limites de variation pour les PMD de classe de performance de fonctionnement C <sup>a b</sup> |                      | Unité |
|-------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------|---------------------------------------------------------------------|---------------------------------------------------------------------|-----------------------------------|-----------------------------------------------------------------------------------------------|----------------------|-------|
| Type d'influence                                                                                | Plage d'influence                                                                       | Valeur du courant pour les PMD Dx à branchement direct <sup>f</sup> | Valeur du courant pour les PMD Sx avec capteur externe <sup>f</sup> |                                   |                                                                                               |                      |       |
| Harmoniques impairs dans le circuit de courant alternatif                                       | voir <sup>g</sup>                                                                       | 50 % $I_b$                                                          | 50 % $I_n$                                                          | 1                                 | $3,0 \times C$                                                                                | $3,0 \times C$       | %     |
| Sous-harmoniques dans le circuit de courant alternatif                                          | voir <sup>g</sup>                                                                       | 50 % $I_b$                                                          | 50 % $I_n$                                                          | 1                                 | $3,0 \times C$                                                                                | $3,0 \times C$       | %     |
| Réjection de la tension de mode commun sur les entrées de courant isolées <sup>k</sup>          | 0 à tension maximale par rapport à la terre (selon la catégorie de mesure) <sup>i</sup> | 10 % $I_b$                                                          | 5 % $I_n$                                                           | 1                                 | $1,0 \times C$                                                                                | $0,5 \times C$       | %     |
| Induction magnétique permanente en courant alternatif d'origine externe 0,5 mT <sup>c d h</sup> | voir <sup>c</sup> et <sup>d</sup>                                                       | $I_b$                                                               | $I_n$                                                               | 1                                 | 2,0                                                                                           | $1,0 \times C + 1,0$ | %     |
| Champs électromagnétiques RF <sup>c d</sup>                                                     | voir <sup>c</sup> et <sup>d</sup>                                                       | $I_b$                                                               | $I_n$                                                               | 1                                 | $3,4 \times C + 0,3$                                                                          | $1,0 \times C + 1,0$ | %     |
| Perturbations conduites, induites par des champs radioélectriques <sup>c d</sup>                | voir <sup>c</sup> et <sup>d</sup>                                                       | $I_b$                                                               | $I_n$                                                               | 1                                 | $3,4 \times C + 0,3$                                                                          | $1,0 \times C + 1,0$ | %     |

Tableau 9 (3 de 3)

|   |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|---|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| a | Les classes de performance applicables sont énumérées dans le Tableau 3.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
| b | Pour les classes 1 et 2 de mesure de l'énergie active du présent document, les limites de variation des classes 1 et 2 définies dans le Tableau 8 de l'IEC 62053-21:2003 peuvent être utilisées ainsi que les limites d'incertitude données dans ce tableau. Pour les classes 0,2 et 0,5 de mesure de l'énergie active du présent document, les limites de variation des classes 0,2S et 0,5S définies dans le Tableau 6 de l'IEC 62053-22:2003 peuvent être utilisées ainsi que les limites d'incertitude données dans ce tableau.                                                                                                                                                                                                                                                                                                         |
| c | Les niveaux de CEM et les conditions d'essai sont définis dans l'IEC 61326-1 relative aux sites industriels.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| d | Les grandeurs d'influence de CEM ne sont applicables que pour les mesurages d'énergie.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| e | Les courants sont équilibrés, sauf spécification contraire.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| f | Les PMD polyphasés avec trois éléments de mesure doivent effectuer des mesurages et des enregistrements, dans les limites de variation du pourcentage d'erreur indiquées dans le présent tableau, en cas de coupure des phases suivantes: <ul style="list-style-type: none"> <li>– une ou deux des phases, dans un réseau triphasé à quatre fils;</li> <li>– une des trois phases, dans un réseau triphasé à trois fils (si le PMD est conçu pour un tel service).</li> </ul> Cette exigence ne couvre que les coupures de phase et ne prend pas en compte des événements tels que les défaillances de fusibles de transformateur.         Pour les PMD polyphasés avec deux éléments de mesure, l'essai ne s'applique pas.         Pour les PMD à alimentation auxiliaire, l'alimentation auxiliaire n'est pas coupée au cours de l'essai. |
| g | Voir l'Article 6.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| h | Une induction magnétique d'origine externe de 0,5 mT produite par un courant à la même fréquence que celle de la tension appliquée au PMD et dans les conditions les plus défavorables de phase et de direction ne doit pas provoquer une variation dépassant les valeurs représentées dans ce tableau.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| i | Une catégorie de mesure est définie dans l'IEC 61010-2-030, par exemple une tension de mode commun de 300 V pour 300 V cat. III                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| j | Dans les conditions de référence, les signaux sont sinusoïdaux; ainsi, dans ce cas, le facteur de puissance = $\cos \varphi$ .                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| k | Si les entrées de courant sont connectées de façon interne ou externe à la terre, cette exigence n'est pas applicable.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| l | Ces limites sont établies pour un PMD alimenté par la tension réseau. Dans le cas d'une plage plus large de la tension d'alimentation alternative ou continue, les essais doivent être effectués au moins aux valeurs extrêmes de cette plage. Dans tous les cas, le PMD doit répondre aux exigences dans la plage spécifiée de tensions d'alimentation.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

#### 4.8.2.5 Conditions de démarrage et à vide

##### 4.8.2.5.1 Démarrage du PMD

Voir 4.7.

##### 4.8.2.5.2 Condition à vide (uniquement pour le mesurage d'énergie)

Lorsque la tension est appliquée sans courant circulant dans le circuit de courant, la sortie d'essai du PMD ne doit pas produire plus d'une impulsion.

Pour cet essai, le circuit de courant doit être en circuit ouvert et une tension de 115 % de la tension assignée doit être appliquée au circuit de tension.

Dans le cas d'un shunt extérieur, seul le circuit d'entrée du PMD doit être mis en circuit ouvert.

La période d'essai minimale  $\Delta t$  doit être celle décrite dans le Tableau 10:

**Tableau 10 – Période d'essai minimale**

| Types de PMD | Durée d'essai minimale $\Delta t$ (min) pour la condition à vide                         |                                                                                          |
|--------------|------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
|              | pour $C < 1$                                                                             | pour $C \geq 1$                                                                          |
| PMD          | $\Delta t = \frac{((100 / C) + 400) \times 10^6}{k \times m \times U_n \times I_{\max}}$ | $\Delta t = \frac{((240 / C) + 360) \times 10^6}{k \times m \times U_n \times I_{\max}}$ |

où

$C$  est la classe de performance de fonctionnement;

$k$  est le nombre d'impulsions émises par le dispositif de sortie du PMD par kilowattheure (impulsion/kWh);

$m$  est le nombre d'éléments de mesure;

NOTE Un élément de mesure est un composant du dispositif de mesure qui génère une sortie proportionnelle à l'énergie.

$U_n$  est la tension assignée en volts;

$I_{\max}$  est le courant maximal en ampères.

Pour les PMD fonctionnant sur transformateurs avec des caractéristiques primaires ou semi-primaires, la constante  $k$  doit correspondre aux valeurs secondaires (tension et courant).

##### 4.8.2.5.3 Courant de démarrage

Le PMD doit démarrer et enregistrer continûment aux valeurs de courant de démarrage (et, dans le cas de dispositifs de mesure triphasés, avec des charges équilibrées) présentées dans le Tableau 11.

Lorsque les conditions de démarrage sont satisfaites (conformément au Tableau 11), l'incertitude intrinsèque doit se situer entre –40 % et +90 % des valeurs mesurées.

Si le PMD est conçu pour le mesurage de l'énergie dans les deux directions, cet essai doit alors être appliqué avec un flux d'énergie dans chaque direction.

**Tableau 11 – Courant de démarrage pour le mesurage de la puissance active et de l'énergie active**

| Types de PMD | Facteur de puissance <sup>a</sup> | Courant de démarrage pour les PMD de classe de performance de fonctionnement C |                                     |
|--------------|-----------------------------------|--------------------------------------------------------------------------------|-------------------------------------|
|              |                                   | pour C < 1                                                                     | pour C ≥ 1                          |
| PMD Dx       | 1                                 | $2 \times 10^{-3} \times I_b$                                                  | $(C + 3) \times 10^{-3} \times I_b$ |
| PMD Sx       | 1                                 | $1 \times 10^{-3} \times I_n$                                                  | $(C + 1) \times 10^{-3} \times I_n$ |

<sup>a</sup> Dans les conditions de référence, les signaux sont sinusoïdaux; ainsi, dans ce cas, le facteur de puissance =  $\cos \varphi$ .

**4.8.3 Mesurages de la puissance réactive ( $Q_A$ ,  $Q_V$ ) et de l'énergie réactive ( $E_{rA}$ ,  $E_{rV}$ )****4.8.3.1 Techniques**

Voir Annexe B.

Un mesurage sans discontinuité est exigé.

**4.8.3.2 Plage assignée de fonctionnement**

Les exigences de l'incertitude intrinsèque doivent s'appliquer à l'intérieur de la plage assignée suivante:

$$80 \% U_n < U < 120 \% U_n$$

**4.8.3.3 Tableau d'incertitude intrinsèque**

L'incertitude intrinsèque, dans les conditions de référence, ne doit pas dépasser les limites données dans le Tableau 12:

**Tableau 12 – Tableau d'incertitude intrinsèque pour le mesurage de la puissance réactive et de l'énergie réactive**

| Étendue de mesure spécifiée                            |                                                        | sin $\varphi$ (inductif ou capacitif) | Limites de l'incertitude intrinsèque pour les PMD de classe de performance de fonctionnement C <sup>a b</sup> |                     | Unité |
|--------------------------------------------------------|--------------------------------------------------------|---------------------------------------|---------------------------------------------------------------------------------------------------------------|---------------------|-------|
| valeur du courant pour les PMD Dx à branchement direct | valeur du courant pour les PMD Sx avec capteur externe |                                       | pour C < 3                                                                                                    | pour C ≥ 3          |       |
| $5 \% I_b \leq I < 10 \% I_b$                          | $2 \% I_n \leq I < 5 \% I_n$                           | 1                                     | $\pm 1,25 \times C$                                                                                           | $\pm 1,33 \times C$ | %     |
| $10 \% I_b \leq I \leq I_{\max}$                       | $5 \% I_n \leq I \leq I_{\max}$                        | 1                                     | $\pm 1,0 \times C$                                                                                            | $\pm 1,0 \times C$  | %     |
| $10 \% I_b \leq I < 20 \% I_b$                         | $5 \% I_n \leq I < 10 \% I_n$                          | 0,5                                   | $\pm 1,25 \times C$                                                                                           | $\pm 1,33 \times C$ | %     |
| $20 \% I_b \leq I \leq I_{\max}$                       | $10 \% I_n \leq I \leq I_{\max}$                       | 0,5                                   | $\pm 1,0 \times C$                                                                                            | $\pm 1,0 \times C$  | %     |
| $20 \% I_b \leq I \leq I_{\max}$                       | $10 \% I_n \leq I \leq I_{\max}$                       | 0,25                                  | $\pm 1,25 \times C$                                                                                           | $\pm 1,33 \times C$ | %     |

<sup>a</sup> Les classes de performance applicables sont énumérées dans le Tableau 3.

<sup>b</sup> Pour les classes 2 et 3 de mesure de l'énergie réactive du présent document, les limites d'incertitude des classes 2 et 3 définies dans le Tableau 6 de l'IEC 62053-23:2003 peuvent être utilisées ainsi que les limites d'incertitude données dans ce tableau.

#### **4.8.3.4 Limites de variation due aux grandeurs d'influence**

Les variations supplémentaires dues aux modifications des grandeurs d'influence par rapport aux conditions de référence données en 4.6.1 ne doivent pas dépasser les limites pour la classe de performance correspondante données dans le Tableau 13:

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Tableau 13 – Grandeurs d'influence pour le mesurage de la puissance réactive et de l'énergie réactive

| Type d'influence                                                                 | Grandeurs d'influence | Plage d'influence                                                            | Étendue de mesure spécifiée <sup>d</sup>                         |                                                                 | sin $\phi$<br>(inductif ou capacitif) | Coefficient de température pour les PMD de classe de performance de fonctionnement $C^{a e}$ |                                    | Unité          |
|----------------------------------------------------------------------------------|-----------------------|------------------------------------------------------------------------------|------------------------------------------------------------------|-----------------------------------------------------------------|---------------------------------------|----------------------------------------------------------------------------------------------|------------------------------------|----------------|
|                                                                                  |                       |                                                                              | Valeur du courant pour les PMD Dx à branchement direct           | Valeur du courant pour les PMD Sx avec capteur externe          |                                       | pour $C < 3$                                                                                 | pour $C \geq 3$                    |                |
| Température ambiante                                                             |                       | conformément à la plage de fonctionnement assignée du Tableau 5 et Tableau 6 | 10 % $I_b \leq I \leq I_{max}$<br>20 % $I_b \leq I \leq I_{max}$ | 5 % $I_n \leq I \leq I_{max}$<br>10 % $I_n \leq I \leq I_{max}$ | 1<br>0,5                              | 0,05 $\times C$<br>0,075 $\times C$                                                          | 0,05 $\times C$<br>0,08 $\times C$ | % / K<br>% / K |
|                                                                                  |                       |                                                                              |                                                                  |                                                                 |                                       | Limites de variation pour les PMD de classe de performance de fonctionnement $C^{a b}$       |                                    |                |
| Tension d'alimentation auxiliaire <sup>f</sup>                                   |                       | tension assignée $\pm 15$ %                                                  | 10 % $I_b$                                                       | 10 % $I_n$                                                      | 1                                     | 0,1 $\times C$                                                                               | 0,1 $\times C$                     | %              |
| Tension                                                                          |                       | 80 % $U_n < U < 120$ % $U_n$                                                 | 5 % $I_b \leq I \leq I_{max}$<br>10 % $I_b \leq I \leq I_{max}$  | 2 % $I_n \leq I \leq I_{max}$<br>5 % $I_n \leq I \leq I_{max}$  | 1<br>0,5 inductif                     | 0,5 $\times C$<br>0,75 $\times C$                                                            | 0,66 $\times C$<br>1,0 $\times C$  | %<br>%         |
| Fréquence                                                                        |                       | fréquence assignée $\pm 2$ %                                                 | 5 % $I_b \leq I \leq I_{max}$<br>10 % $I_b \leq I \leq I_{max}$  | 2 % $I_n \leq I \leq I_{max}$<br>5 % $I_n \leq I \leq I_{max}$  | 1<br>0,5 inductif                     | 1,25 $\times C$<br>1,25 $\times C$                                                           | 2,5<br>2,5                         | %              |
| Induction magnétique continue d'origine externe de 0,5 mT <sup>b c</sup>         |                       | voir <sup>b</sup> et <sup>c</sup>                                            | $I_b$                                                            | $I_n$                                                           | 1                                     | 1,5 $\times C$                                                                               | 3,0                                | %              |
| Champs électromagnétiques RF <sup>b c</sup>                                      |                       | voir <sup>b</sup> et <sup>c</sup>                                            | $I_b$                                                            | $I_n$                                                           | 1                                     | 1,5 $\times C$                                                                               | 3,0                                | %              |
| Perturbations conduites, induites par des champs radioélectriques <sup>b c</sup> |                       | voir <sup>b</sup> et <sup>c</sup>                                            | $I_b$                                                            | $I_n$                                                           | 1                                     | 1,5 $\times C$                                                                               | 3,0                                | %              |

- a Les classes de performance applicables sont énumérées dans le Tableau 3.
- b Les niveaux de CEM et les conditions d'essai sont définis dans l'IEC 61326-1 relative aux sites industriels.
- c Les grandeurs d'influence de CEM ne sont applicables que pour les mesurages d'énergie.
- d Les courants sont équilibrés, sauf spécification contraire.
- e Pour les classes 2 et 3 de mesure de l'énergie réactive du présent document, les limites de variation des classes 2 et 3 définies dans le Tableau 8 de l'IEC 62053-23:2003 peuvent être utilisées ainsi que les limites d'incertitude données dans ce tableau.
- f Ces limites sont établies pour un PMD alimenté par la tension réseau. Dans le cas d'une plage plus large de la tension d'alimentation alternative ou continue, les essais doivent être effectués au moins aux valeurs extrêmes de cette plage. Dans tous les cas, le PMD doit répondre aux exigences dans la plage spécifiée de tensions d'alimentation.

### 4.8.3.5 Conditions de démarrage et à vide

#### 4.8.3.5.1 Démarrage du PMD

Voir 4.7.

#### 4.8.3.5.2 Condition à vide

Lorsque la tension est appliquée sans courant circulant dans le circuit de courant, la sortie d'essai du PMD ne doit pas produire plus d'une impulsion.

Pour cet essai, le circuit de courant doit être en circuit ouvert et une tension de 115 % de la tension assignée doit être appliquée au circuit de tension.

Dans le cas d'un shunt extérieur, seul le circuit d'entrée doit être mis en circuit ouvert.

La période d'essai minimale  $\Delta t$  doit être celle décrite dans le Tableau 14:

**Tableau 14 – Période d'essai minimale**

| Types de PMD | Période d'essai minimale $\Delta t$ (min) pour la condition à vide                       |                                                                                          |
|--------------|------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------|
|              | pour $C < 3$                                                                             | pour $C \geq 3$                                                                          |
| PMD          | $\Delta t = \frac{((240 / C) + 360) \times 10^6}{k \times m \times U_n \times I_{\max}}$ | $\Delta t = \frac{((1080 / C) - 60) \times 10^6}{k \times m \times U_n \times I_{\max}}$ |

où

$C$  est la classe de performance de fonctionnement;

$k$  est le nombre d'impulsions émises par le dispositif de sortie du PMD par kilovarheure (impulsion/kvarh);

$m$  est le nombre d'éléments de mesure;

$U_n$  est la tension assignée en volts;

$I_{\max}$  est le courant maximal en ampères.

Pour les PMD fonctionnant sur transformateurs avec des caractéristiques primaires ou semi-primaires, la constante  $k$  doit correspondre aux valeurs secondaires (tension et courant).

#### 4.8.3.5.3 Courant de démarrage

Le PMD doit démarrer et enregistrer continûment aux valeurs de courant de démarrage (et, dans le cas de dispositifs de mesure triphasés, avec une charge équilibrée) présentées dans le Tableau 15.

Lorsque les conditions de démarrage sont satisfaites (conformément au Tableau 15), l'incertitude intrinsèque doit se situer entre –40 % et +90 % des valeurs mesurées.

Si le PMD est conçu pour le mesurage de l'énergie dans les deux directions, cet essai doit alors être appliqué avec un flux d'énergie dans chaque direction.

**Tableau 15 – Courant de démarrage pour le mesurage de l'énergie réactive**

| Types de PMD | sin φ (inductif ou capacitif) | Courant de démarrage pour les PMD de classe de performance de fonctionnement C |                                              |
|--------------|-------------------------------|--------------------------------------------------------------------------------|----------------------------------------------|
|              |                               | pour C < 3                                                                     | pour C ≥ 3                                   |
| PMD Dx       | 1                             | $(C + 3) \times 10^{-3} \times I_b$                                            | $(5 \times C - 5) \times 10^{-3} \times I_b$ |
| PMD Sx       | 1                             | $(C + 1) \times 10^{-3} \times I_n$                                            | $(2 \times C - 1) \times 10^{-3} \times I_n$ |

#### 4.8.4 Mesurages de la puissance apparente ( $S_A$ , $S_V$ ) et de l'énergie apparente ( $E_{apA}$ , $E_{apV}$ )

##### 4.8.4.1 Techniques

Voir Annexe B.

Un mesurage sans discontinuité est exigé.

##### 4.8.4.2 Plage assignée de fonctionnement

Les exigences de l'incertitude intrinsèque doivent s'appliquer dans la plage suivante:

$$80 \% U_n < U < 120 \% U_n$$

##### 4.8.4.3 Tableau d'incertitude intrinsèque

L'incertitude intrinsèque dans les conditions de référence ne doit pas dépasser les limites indiquées dans le Tableau 16:

**Tableau 16 – Tableau d'incertitude intrinsèque pour le mesurage de la puissance apparente et de l'énergie apparente**

| Étendue de mesure spécifiée                            |                                                        | Limites de l'incertitude intrinsèque pour les PMD de classe de performance de fonctionnement C <sup>a</sup> |                            | Unité |
|--------------------------------------------------------|--------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|----------------------------|-------|
| Valeur du courant pour les PMD Dx à branchement direct | Valeur du courant pour les PMD Sx avec capteur externe | pour C < 1                                                                                                  | pour C ≥ 1                 |       |
| $5 \% I_b < I \leq 10 \% I_b$                          | $2 \% I_n < I \leq 5 \% I_n$                           | $\pm 2,0 \times C$                                                                                          | $\pm (1,0 \times C + 0,5)$ | %     |
| $10 \% I_b < I \leq I_{max}$                           | $5 \% I_n < I \leq I_{max}$                            | $\pm 1,0 \times C$                                                                                          | $\pm 1,0 \times C$         | %     |

<sup>a</sup> Les classes de performance applicables sont énumérées dans le Tableau 3.

##### 4.8.4.4 Limites de variation due aux grandeurs d'influence

Les variations supplémentaires dues aux modifications des grandeurs d'influence par rapport aux conditions de référence données en 4.6.1 ne doivent pas dépasser les limites pour la classe de performance correspondante données dans le Tableau 17: