

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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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: ~~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- a) PMD-A has been withdrawn due the fact these devices are now mainly covered by the IEC 62586 series of standards.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.

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

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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_{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_{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_{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_{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

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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~~

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

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.~~

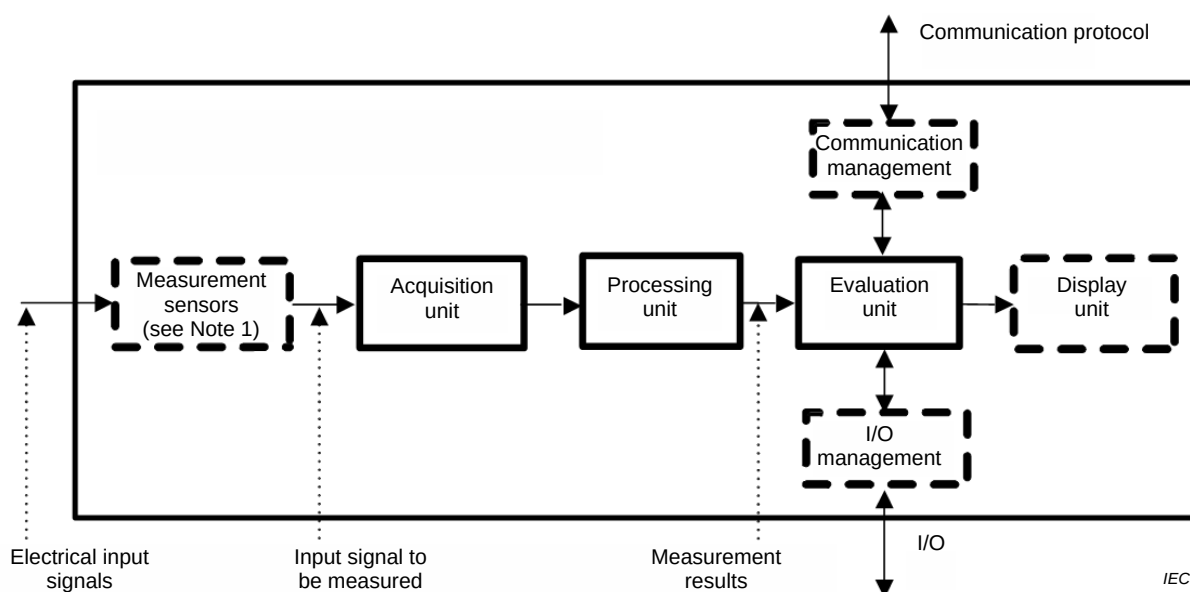
~~NOTE Guidance for requirements applicable to PMD-A or/and PMD is given in Annex E.~~

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 symbol ^a	PMD type ^b		
	PMD-I Energy efficiency	PMD-II Basic power monitoring	PMD-III Advanced power monitoring /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 and/or $THD-R_u$ and/or $THD-R_v$			■
THD_i and/or $THD-R_i$			■
^a Only total quantities are mandatory			
^b 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.			

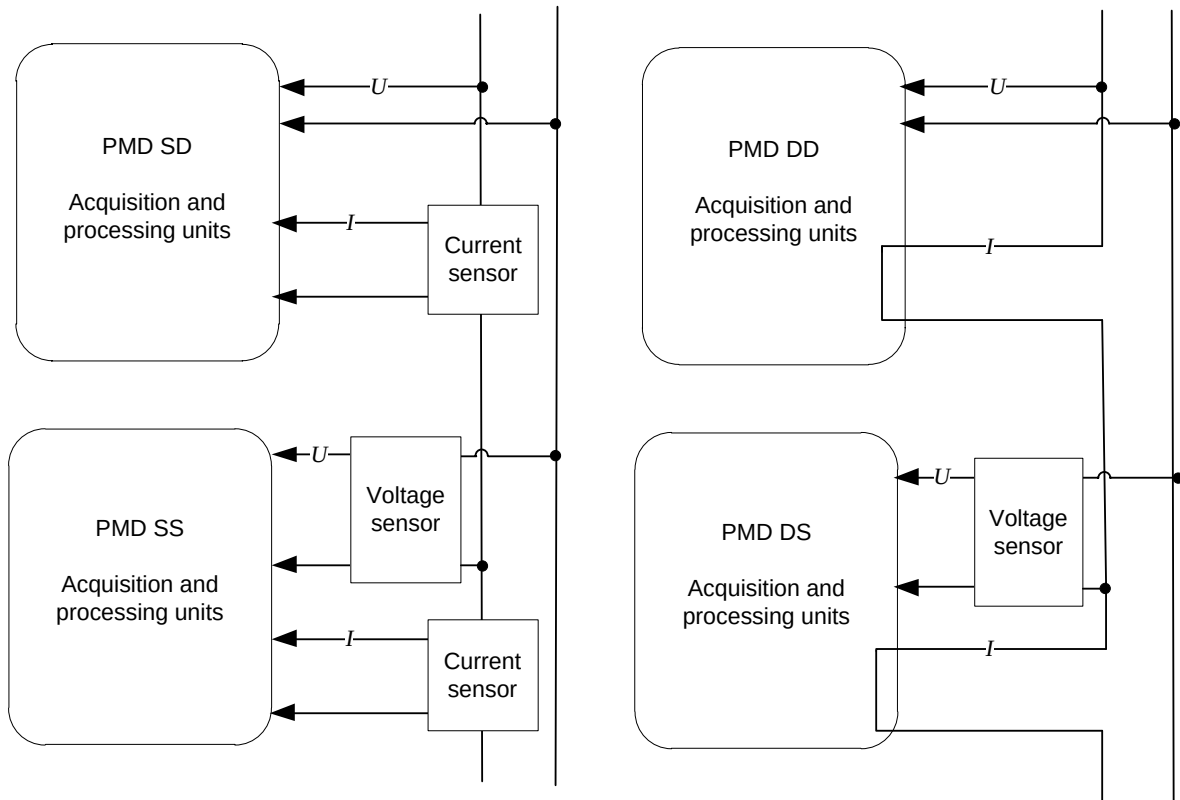
4.4 Structure of PMD

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



IEC

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
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~~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 ^a
Voltages unbalance	≤ 0,1 % ^a
External continuous magnetic field	≤ 40 A/m DC ≤ 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 % ^b
^a Required only in the case of three-phase systems.	
^b 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

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

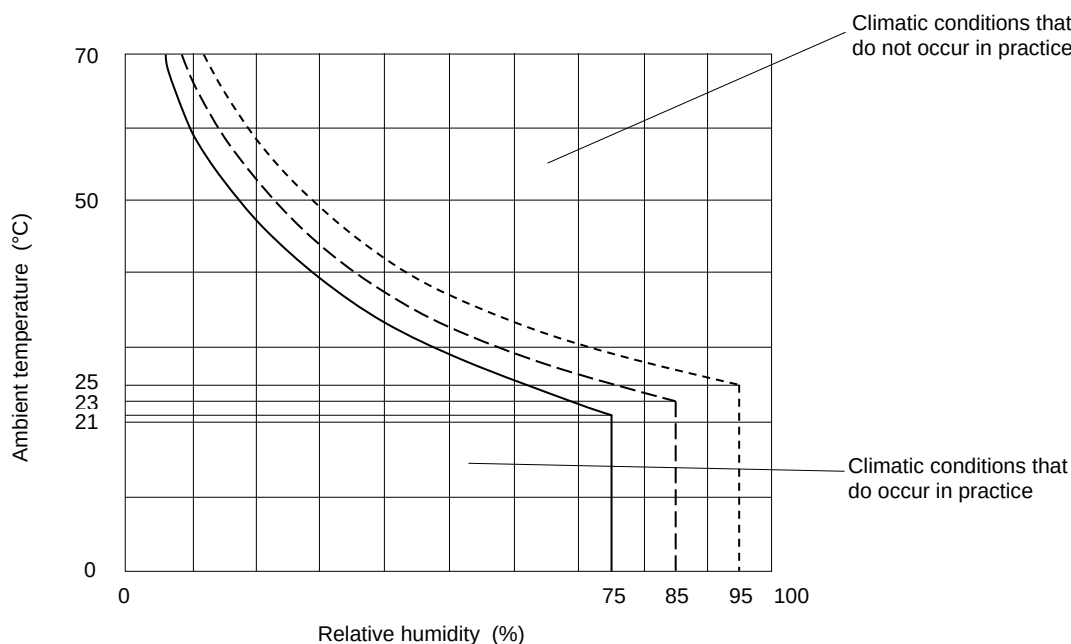
4.6.2.4 Rated humidity and altitude operating conditions

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

Table 7 – Humidity and altitude operating conditions

	Standard conditions	Extended conditions
Rated operating range (with specified uncertainty)	0 % to 75 % RH ^b	0 % to above 75 % RH ^{a b}
Limit range of operation for 30 days/year	0 % to 90 % RH ^b	0 % to above 90 % RH ^{a b}
Limit range for storage and shipping	0 % to 90 % RH ^b	0 % to above 90 % RH ^{a b}
Altitude	0 m to 2 000 m	0 m to above 2 000 m ^a
^a Limits are to be defined by manufacturer according to the application. ^b 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 ^c	Intrinsic uncertainty limits for PMD of function performance class C ^{a b e}		Unit
Value of current for direct connected PMD Dx	Value of current for sensor operated PMD Sx		for C < 1	for C ≥ 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 0,8 capacitive	$\pm (1,7 \times C + 0,15)$ $\pm (1,7 \times C + 0,15)$	No requirement No requirement	%
10 % $I_b \leq I < 20 \% I_b$	5 % $I_n \leq I < 10 \% I_n$	0,5 inductive 0,8 capacitive	No requirement No requirement	$\pm (1,0 \times C + 0,5)$ $\pm (1,0 \times C + 0,5)$	%
20 % $I_b \leq I \leq I_{max}$	10 % $I_n \leq I \leq I_{max}$	0,5 inductive 0,8 capacitive	$\pm (1,0 \times C + 0,1)$ $\pm (1,0 \times C + 0,1)$	$\pm 1,0 \times C$ $\pm 1,0 \times C$	%
~~^a 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.~~ ~~^b 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.~~ ^a Applicable performance classes are listed in Table 3. ^b 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. ^c In reference conditions, signals are sinusoidal, so in this case the power factor = cos φ.					

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 range	Specified measuring range ^e		Power factor ^j	Temperature coefficient for PMD of function performance class C ^{a b}		Unit
		Value of current for direct connected PMD Dx ^f	Value of current for sensor operated PMD Sx ^f		for C < 1	for C ≥ 1	
Ambient temperature	according to rated operating range of Table 5 and Table 6	10 % $I_b \leq I \leq I_{max}$ 20 % $I_b \leq I \leq I_{max}$	5 % $I_n \leq I \leq I_{max}$ 10 % $I_n \leq I \leq I_{max}$	1 0,5 inductive	0,05 x C 0,1 x C	0,05 x C 0,07 x C	% / K % / K
					Limits of variation for PMD of function performance class C ^{a b}		
					for C < 1	for C ≥ 1	
Auxiliary power supply voltage ⁱ	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 % $I_b \leq I \leq I_{max}$ 10 % $I_b \leq I \leq I_{max}$	2 % $I_n \leq I \leq I_{max}$ 5 % $I_n \leq I \leq I_{max}$	1 0,5 inductive	0,3 x C + 0,04 0,6 x C + 0,08	0,3 x C + 0,4 0,5 x C + 0,5	%
Frequency	rated frequency ± 2 %	5 % $I_b \leq I \leq I_{max}$ 10 % $I_b \leq I \leq I_{max}$	2 % $I_n \leq I \leq I_{max}$ 5 % $I_n \leq I \leq I_{max}$	1 0,5 inductive	0,3 x C + 0,04 0,3 x C + 0,04	0,3 x C + 0,2 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 ^f	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, 5th harmonic: 10 % current, 5th 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		Influence range	Specified measuring range ^e		Power factor ^j	~~Temperature coefficient~~ Limits of variation for PMD of function performance class C ^{a b}		Unit
Influence type			Value of current for direct connected PMD D _{x f} ^f	Value of current for sensor operated PMD S _{x f} ^f				
Odd harmonics in the AC current circuit		see ^g	50 % I_b	50 % I_n	1	3,0 x C	3,0 x C	%
Sub-harmonics in the AC current circuit		see ^g	50 % I_b	50 % I_n	1	3,0 x C	3,0 x C	%
Common mode voltage rejection on isolated current inputs ^k		0 to maximum voltage to earth (depending on measuring category) ⁱ	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 ^{c d h}		see ^c and ^d	I_b	I_n	1	2,0	1,0 x C + 1,0	%
Electromagnetic RF fields ^{c d}		see ^c and ^d	I_b	I_n	1	3,4 x C + 0,3	1,0 x C + 1,0	%
Conducted disturbances, induced by radio frequency fields ^{c d}		see ^c and ^d	I_b	I_n	1	3,4 x C + 0,3	1,0 x C + 1,0	%

Table 9 (3 of 3)

~~a~~	~~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~~
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~~	~~Not applicable to self-powered PMD.~~
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: – in a three-phase, four-wire network one or two phases; – in a three-phase, three-wire network (if the PMD is designed for this service) one of the three phases. This only covers phase interruptions and does not cover events such as transformer fuse failures. In case of polyphase PMD with two measuring elements the test does not apply. For PMD with auxiliary power supply, the auxiliary power supply is not interrupted during the test.
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 = $\cos \varphi$.
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.

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

The minimum test period Δt shall be as described in Table 10:

Table 10 – Minimum test period

PMD types	Minimum test period Δt (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 ^a	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	$1 \times 10^{-3} \times I_n$	$(C + 1) \times 10^{-3} \times I_n$

^a 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 ϕ (inductive or capacitive)	Intrinsic uncertainty limits for PMD of function performance class C ^{a b-e}		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	$\pm 1,25 \times C$	$\pm 1,33 \times C$	%
~~^a 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.~~ ~~^b 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.~~ ^a Applicable performance classes are listed in Table 3. ^b 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 type	Influence range	Specified measuring range ^d		$\sin \varphi$ (inductive or capacitive)	Temperature coefficient for PMD of function performance class $C^{a e}$		Unit
		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 % $I_b \leq I \leq I_{max}$ 20 % $I_b \leq I \leq I_{max}$	5 % $I_n \leq I \leq I_{max}$ 10 % $I_n \leq I \leq I_{max}$	1 0,5	0,05 × C 0,075 × C	0,05 × C 0,08 × C	% / K % / K
					Limits of variation for PMD of function performance class $C^{a b}$		
					for $C < 3$	for $C \geq 3$	
Auxiliary power supply voltage ^f	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 % $I_b \leq I \leq I_{max}$ 10 % $I_b \leq I \leq I_{max}$	2 % $I_n \leq I \leq I_{max}$ 5 % $I_n \leq I \leq I_{max}$	1 0,5 inductive	0,5 × C 0,75 × C	0,66 × C 1,0 × C	% %
Frequency	Rated frequency ± 2 %	5 % $I_b \leq I \leq I_{max}$ 10 % $I_b \leq I \leq I_{max}$	2 % $I_n \leq I \leq I_{max}$ 5 % $I_n \leq I \leq I_{max}$	1 0,5 inductive	1,25 × C 1,25 × C	2,5 2,5	%
Permanent AC magnetic induction of external origin 0,5 mT ^{b c}	see ^b and ^c	I_b	I_n	1	1,5 × C	3,0	%
Electromagnetic RF fields ^{b c}	see ^b and ^c	I_b	I_n	1	1,5 × C	3,0	%
Conducted disturbances, induced by radio frequency fields ^{b c}	see ^b and ^c	I_b	I_H	1	1,5 × C	3,0	%

~~^a 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.~~

^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 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.

^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, 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 Δt shall be as described in Table 14:

Table 14 – Minimum test period

PMD types	Minimum test period Δt (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 ^{a-b}		Unit
Value of current for direct connected PMD Dx	Value of current for sensor operated PMD Sx	for C < 1	for C ≥ 1	
$5 \% I_b < I \leq 10 \% I_b$	$2 \% I_n < I \leq 5 \% I_n$	$\pm 2,0 \times C$	$\pm (1,0 \times C + 0,5)$	%
$10 \% I_b < I \leq I_{\max}$	$5 \% I_n < I \leq I_{\max}$	$\pm 1,0 \times C$	$\pm 1,0 \times C$	%

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

~~^b 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.~~

^a 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 ^d		Power factor ^e	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 ^f	Rated voltage $\pm 15 \%$	$10 \% I_b$	$10 \% I_n$	1	$0,1 \times C$	$0,1 \times C$	%
Voltage	$80 \% U_n < U < 120 \% U_n$	$5 \% I_b \leq I \leq I_{max}$ $10 \% I_b \leq I \leq I_{max}$	$2 \% I_n \leq I \leq I_{max}$ $5 \% I_n \leq I \leq I_{max}$	1 0,5 inductive	$0,3 \times C + 0,04$ $0,6 \times C + 0,08$	$0,3 \times C + 0,4$ $0,5 \times C + 0,5$	%
Continuous magnetic induction of external origin 0,5 mT ^{c,d}	see ^c and ^d	I_b	I_n	1	2,0	$1,0 \times C + 1,0$	%
Electromagnetic RF fields ^{c,d}	see ^c and ^d	I_b	I_n	1	$3,4 \times C + 0,3$	$1,0 \times C + 1,0$	%
Conducted disturbances, induced by radio frequency fields ^{c,d}	see ^c and ^d	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 for PMD of function performance class C ^{a-b}	Unit
45 Hz to 55 Hz or 55 Hz to 65 Hz	$\pm 1,0 \times C$	%
^a ~~The permitted values for function performance class C are: 0,02 – 0,05 – 0,1 – 0,2 – 0,5.~~ ^b ~~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.~~ ^a 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 ^a	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
		Limits of variation for PMD of function performance class C^a	
Voltage	50 % U_n to U_{max}	$0,2 \times C$	%
Harmonics in the voltage circuits ^b	3 rd harmonic 10 % 5 th harmonic 12 % 7 th harmonic 10 % 9 th harmonic 3 % 11 th harmonic 7 % 13 th harmonic 6 % 15 th harmonic 1 %	$0,2 \times C$	%
~~^a The permitted values for function performance class C are: 0,02 — 0,05 — 0,1 — 0,2 — 0,5~~ ~~^b All harmonics components have the same relative phase, but in opposite phase referred to the fundamental.~~ ^a Applicable performance classes are listed in Table 3. ^b All harmonics components should have zero phase referred to the fundamental. 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 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 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 ^a	Minimum bandwidth (harmonic)	Crest factor
PMD Sx	10 % I_n to 120 % I_n	45 Hz to 15 times rated frequency or 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 DC and 45 Hz to 15 times rated frequency	2
NOTE ^a 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 ^{a-b}	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 % $I_n \leq I \leq I_{max}$	$\pm 1,0 \times C$	%
^a ~~The permitted values for function performance class C are: 0,05 0,1 0,2 0,5 1 2.~~ ^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.~~ ^a 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 ^{a-b}	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 % $I_n \leq I_N \leq I_{max}$	$\pm 1,0 \times C$	%
^a ~~The permitted values for function performance class C are: 0,2 0,5 1 2.~~ ^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.~~ ^a 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 for PMD of function performance class C ^{a b c}	Unit
value of current for direct connected PMD Dx	value of current for sensor operated PMD Sx		
$20 \% I_b \leq I_p^c \leq I_{\max}$	$10 \% I_n \leq I_p^c \leq I_{\max}$	$\pm 1,0 \times C$	$\% I^b$
~~a The permitted values for function performance class C are: 0,1 0,2 0,5 1 2.~~ ~~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.~~ a Applicable performance classes are listed in Table 3. b Uncertainty shall be expressed as a percentage of the phase current, whose current is the largest. c 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: