



BSI Standards Publication

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)

National foreword

This British Standard is the UK implementation of EN IEC 61557-12:2022+A1:2022. It is identical to IEC 61557-12:2018 incorporating amendment 1:2021. It supersedes BS EN IEC 61557-12:2022, which will be withdrawn on 14 December 2021.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by **A1** **A1**.

The UK participation in its preparation was entrusted to Technical Committee PEL/85, Measuring equipment for electrical and electromagnetic quantities.

A list of organizations represented on this committee can be obtained on request to its committee manager.

Contractual and legal considerations

This publication has been prepared in good faith, however no representation, warranty, assurance or undertaking (express or implied) is or will be made, and no responsibility or liability is or will be accepted by BSI in relation to the adequacy, accuracy, completeness or reasonableness of this publication. All and any such responsibility and liability is expressly disclaimed to the full extent permitted by the law.

This publication is provided as is, and is to be used at the recipient's own risk.

The recipient is advised to consider seeking professional guidance with respect to its use of this publication.

This publication is not intended to constitute a contract. Users are responsible for its correct application.

This publication has been prepared under a mandate given to the European Standards Organizations by the European Commission and the European Free Trade Association. It is intended to support requirements of the EU legislation detailed in the European Foreword. A European Annex, usually Annex ZA or ZZ, describes how this publication relates to that EU legislation.

For the Great Britain market (England, Scotland and Wales), if UK Government has designated this publication for conformity with UKCA marking (or similar) legislation, it may contain an additional National Annex. Where such a National Annex exists, it shows the correlation between this publication and the relevant UK legislation. If there is no National Annex of this kind, the relevant Annex ZA or ZZ in the body of the European text will indicate the relationship to UK regulation applicable in Great Britain. References to EU legislation may need to be read in accordance with the UK designation and the applicable UK law. Further information on designated standards can be found at www.bsigroup.com/standardsandregulation.

For the Northern Ireland market, UK law will continue to implement relevant EU law subject to periodic confirmation. Therefore Annex ZA/ZZ in the European text, and references to EU legislation, are still valid for this market.

UK Government is responsible for legislation. For information on legislation and policies relating to that legislation, consult the relevant pages of www.gov.uk.

© The British Standards Institution 2022
Published by BSI Standards Limited 2022

ISBN 978 0 539 05924 3

ICS 17.220.20; 29.080.01; 29.240.01

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 March 2022.

Amendments/corrigenda issued since publication

Date	Text affected
30 June 2022	Implementation of IEC amendment 1:2021 with CENELEC endorsement A1:2022

English Version

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)
(IEC 61557-12:2018)

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)
(IEC 61557-12:2018)

Elektrische Sicherheit in Niederspannungsnetzen bis AC 1
000 V und DC 1 500 V - Geräte zum Prüfen, Messen oder
Überwachen von Schutzmaßnahmen - Teil 12: Geräte zur
Energiesmessung und -überwachung (PMD)
(IEC 61557-12:2018)

This European Standard was approved by CENELEC on 2021-11-10. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN-CENELEC Management Centre or to any CENELEC member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.



European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

European foreword

The text of document 85/644/FDIS, future edition 2 of IEC 61557-12, prepared by IEC/TC 85 "Measuring equipment for electrical and electromagnetic quantities" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 61557-12:2022.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2022-08-10
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2026-11-10

This document supersedes EN 61557-12:2008 and all of its amendments and corrigenda (if any).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a Standardization Request given to CENELEC by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive(s) / Regulation(s).

For the relationship with EU Directive(s) / Regulation(s), see informative Annex ZZ, which is an integral part of this document.

Any feedback and questions on this document should be directed to the users' national committee. A complete listing of these bodies can be found on the CENELEC website.

Endorsement notice

The text of the International Standard IEC 61557-12:2018 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60044-7:1999	NOTE	Harmonized as EN 60044-7:2000 (not modified)
IEC 60044-8:2002	NOTE	Harmonized as EN 60044-8:2002 (not modified)
IEC 60051 (series)	NOTE	Harmonized as EN IEC 60051 (series)
IEC 60071-1:2006	NOTE	Harmonized as EN 60071-1:2006 (not modified)
IEC 60359:2001	NOTE	Harmonized as EN 60359:2002 (not modified)
IEC 60364-6	NOTE	Harmonized as HD 60364-6
IEC 60364-8-1	NOTE	Harmonized as HD 60364-8-1
IEC 61000-4-5	NOTE	Harmonized as EN 61000-4-5
IEC 61000-4-7:2002	NOTE	Harmonized as EN 61000-4-7:2002 (not modified)

IEC 61000-4-15	NOTE	Harmonized as EN 61000-4-15
IEC 61010-2-030	NOTE	Harmonized as EN IEC 61010-2-030
IEC 61010-2-031	NOTE	Harmonized as EN 61010-2-031
IEC 61010-2-032	NOTE	Harmonized as EN IEC 61010-2-032
IEC 61140:2001	NOTE	Harmonized as EN 61140:2002 (not modified)
IEC 61557-2:2007	NOTE	Harmonized as EN 61557-2:2007 (not modified)
IEC 61557-3:2007	NOTE	Harmonized as EN 61557-3:2007 (not modified)
IEC 61557-4:2007	NOTE	Harmonized as EN 61557-4:2007 (not modified)
IEC 61557-5:2007	NOTE	Harmonized as EN 61557-5:2007 (not modified)
IEC 61557-7:2007	NOTE	Harmonized as EN 61557-7:2007 (not modified)
IEC 61557-8:2014	NOTE	Harmonized as EN 61557-8:2015 (not modified)
IEC 61557-9:2014	NOTE	Harmonized as EN 61557-9:2015 (not modified)
IEC 61557-13:2011	NOTE	Harmonized as EN 61557-13:2011 (not modified)
IEC 61869-2:2012	NOTE	Harmonized as EN 61869-2:2012 (not modified)
IEC 61869-3:2011	NOTE	Harmonized as EN 61869-3:2011 (not modified)
IEC 62020	NOTE	Harmonized as EN 62020
IEC 62052-11:2003	NOTE	Harmonized as EN 62052-11:2003 (not modified)
IEC 62053 (series)	NOTE	Harmonized as EN 62053 (series)
IEC 62053-21:2003	NOTE	Harmonized as EN 62053-21:2003 (not modified)
IEC 62053-22:2003	NOTE	Harmonized as EN 62053-22:2003 (not modified)
IEC 62053-23:2003	NOTE	Harmonized as EN 62053-23:2003 (not modified)
IEC 62053-24:2014	NOTE	Harmonized as EN 62053-24:2015 (not modified)
IEC 62586 (series)	NOTE	Harmonized as EN 62586-2:2017/A1 (series)
IEC 62586-1	NOTE	Harmonized as EN 62586-1
ISO 50001	NOTE	Harmonized as EN ISO 50001

European foreword to amendment A1

The text of document 85/755/FDIS, future IEC 61557-12/A1, prepared by IEC/TC 85 "Measuring equipment for electrical and electromagnetic quantities" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN IEC 61557-12:2022/A1:2022.

The following dates are fixed:

- latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2022-07-07
- latest date by which the national standards conflicting with the document have to be withdrawn (dow) 2026-11-10

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC shall not be held responsible for identifying any or all such patent rights.

This document has been prepared under a Standardization Request given to CENELEC by the European Commission and the European Free Trade Association.

Any feedback and questions on this document should be directed to the users' national committee. A complete listing of these bodies can be found on the CENELEC website.

Endorsement notice

The text of the International Standard IEC 61557-12:2018/A1:2021 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

IEC 60688 NOTE Harmonized as EN 60688

IEC 61869 (series) NOTE Harmonized as EN IEC 61869 (series)

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

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.

NOTE 1 Where an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60068-2-1	-	Environmental testing - Part 2-1: Tests - Test A: Cold	EN 60068-2-1	-
IEC 60068-2-2	-	Environmental testing - Part 2-2: Tests - Test B: Dry heat	EN 60068-2-2	-
IEC 60068-2-30	-	Environmental testing - Part 2-30: Tests - Test Db: Damp heat, cyclic (12 h + 12 h cycle)	EN 60068-2-30	-
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	EN 61000-4-30	2015
IEC 61010-1	2010	Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 1: General requirements	EN 61010-1	2010
+ A1 (mod)	2016		+ A1	2019
IEC 61010-2-030	2017	Safety requirements for electrical equipment for measurement, control, and laboratory use - Part 2-030: Particular requirements for equipment having testing or measuring circuits	EN IEC 61010-2-030	2021
-	-		+ A11	2021
IEC 61326-1	2012	Electrical equipment for measurement, control and laboratory use - EMC requirements - Part 1: General requirements	EN 61326-1	2013
IEC 62053-31	1998	Electricity metering equipment (a.c.) - Particular requirements - Part 31: Pulse output devices for electromechanical and electronic meters (two wires only)	EN 62053-31	1998

Annex ZZ (informative)

Relationship between this European standard and the safety objectives of Directive 2014/35/EU [2014 OJ L96] aimed to be covered

This European Standard has been prepared under a Commission's standardization request relating to harmonized standards in the field of the Low Voltage Directive, M/511, to provide one voluntary means of conforming to safety objectives of Directive 2014/35/EU of the European Parliament and of the Council of 26 February 2014 on the harmonization of the laws of the Member States relating to the making available on the market of electrical equipment designed for use within certain voltage limits [2014 OJ L96].

Once this standard is cited in the Official Journal of the European Union under that Directive, compliance with the normative clauses of this standard given in Table ZZ.1 confers, within the limits of the scope of this standard, a presumption of conformity with the corresponding safety objectives of that Directive, and associated EFTA regulations.

Table ZZ.1 — Correspondence between this European standard and Annex I of Directive 2014/35/EU [2014 OJ L96]

Safety objectives of Directive 2014/35/EU (Annex I)	Clause(s) / subclause(s) of this EN	Remarks / Notes
1. General conditions		
1 (a) the essential characteristics, the recognition and observance of which will ensure that electrical equipment will be used safely and in applications for which it was made, shall be marked on the electrical equipment, or, if this is not possible, on an accompanying document	1; 2; 3; 4; 5; 6	
1 (b) the electrical equipment, together with its component parts, shall be made in such a way as to ensure that it can be safely and properly assembled and connected	1; 2; 3; 4; 5; 6	
1 (c) the electrical equipment shall be so designed and manufactured as to ensure that protection against the hazards set out in points 2 and 3 is assured, providing that the equipment is used in applications for which it was made and is adequately maintained	Same as those covering safety objectives 2 a) to 2 d) and 3 a) to 3 c) in addition to the clauses 1; 3; 4	
2. Protection against hazards arising from the electrical equipment		
Measures of a technical nature shall be laid down in accordance with point 1, in order to ensure that:		
2 (a) persons and domestic animals are adequately protected against the danger of physical injury or other harm which might be caused by direct or indirect contact	4.9; 4.10; 6.1; 6.2; 6.3	

2 (b) temperatures, arcs or radiation which would cause a danger, are not produced	4.9; 4.10; 6.1; 6.2; 6.3	
2 (c) persons, domestic animals and property are adequately protected against non-electrical dangers caused by the electrical equipment which are revealed by experience	4.9; 4.10; 6.1; 6.2; 6.3	
2 (d) the insulation is suitable for foreseeable conditions	4.9; 4.10; 6.1; 6.2; 6.3	
3. Protection against hazards which may be caused by external influences on the electrical equipment Technical measures shall be laid down in accordance with point 1, in order to ensure that the electrical equipment:		
3 (a) meets the expected mechanical requirements in such a way that persons, domestic animals and property are not endangered	4.9; 4.10; 6.1; 6.2; 6.3	
3 (b) is resistant to non-mechanical influences in expected environmental conditions, in such a way that persons, domestic animals and property are not endangered	4.9; 4.10; 6.1; 6.2; 6.3	
3 (c) does not endanger persons, domestic animals and property in foreseeable conditions of overload	4.10; 5.2; 5.3; 6.1; 6.2; 6.3	

WARNING 1 — Presumption of conformity stays valid only as long as a reference to this European standard is maintained in the list published in the Official Journal of the European Union. Users of this standard should consult frequently the latest list published in the Official Journal of the European Union.

WARNING 2 — Other Union legislation may be applicable to the product(s) falling within the scope of this standard.

CONTENTS

FOREWORD	9
INTRODUCTION	11
1 Scope	12
2 Normative references	13
3 Terms, definitions and notations	13
3.1 General definitions	14
3.2 Definitions related to uncertainty and performance	16
3.3 Definitions related to electric phenomena	19
3.4 Definitions related to measurement techniques	22
3.5 Notations	23
3.5.1 Functions	23
3.5.2 Symbols and abbreviations	23
3.5.3 Indices	24
4 Requirements	24
4.1 General requirements	24
4.2 PMD general architecture	24
4.3 Classification of PMD	25
4.4 Structure of PMD	26
4.4.1 Structure of PMD related to sensors	26
4.4.2 Requirements for self-powered PMD	26
4.5 List of applicable performance classes	27
4.6 Operating and reference conditions for PMD	27
4.6.1 Reference conditions	27
4.6.2 Rated operating conditions	28
4.7 Start-up conditions	30
4.8 Requirements for PMD functions	30
4.8.1 General requirements	30
4.8.2 Active power (P) and active energy (E_a) measurements	31
4.8.3 Reactive power (Q_A , Q_V) and reactive energy (E_{rA} , E_{rV}) measurements	37
4.8.4 Apparent power (S_A , S_V) and apparent energy (E_{apA} , E_{apV}) measurements	40
4.8.5 Frequency (f) measurements	42
4.8.6 RMS phase current (I) and neutral current (I_N , I_{NC}) measurements	43
4.8.7 RMS voltage (U) measurements	47
4.8.8 Power factor (PF_A , PF_V) measurements	49
4.8.9 Short term flicker (P_{St}) and long term flicker (P_{Lt}) measurements	49
4.8.10 Voltage dip (U_{dip}) and voltage swell (U_{SwI}) measurements	50
4.8.11 Voltage interruption (U_{int}) measurements	55
4.8.12 Transient overvoltage (U_{tr}) measurements	56
4.8.13 Voltage unbalance (U_{nb} , U_{nba}) measurements	56
4.8.14 Voltage harmonics (U_h) and voltage THD (THD_U and $THD-R_U$) measurements	57
4.8.15 Current unbalance (I_{nb} , I_{nba}) measurements	58
4.8.16 Current harmonics (I_h) and current THD (THD_i and $THD-R_i$) measurements	59

4.8.17	Minimum, maximum, peak, three-phases average and demand measurements	60
4.9	General mechanical requirements	60
4.9.1	Vibration requirements	60
4.9.2	IP requirements	60
4.10	Safety requirements	61
4.10.1	Protection against electrical hazards	61
4.10.2	Protection against mechanical hazards	62
4.10.3	Protection against other hazards	62
4.11	EMC requirements	62
4.11.1	Immunity	62
4.11.2	Emission	62
4.12	Inputs and/or outputs	62
4.12.1	General	62
4.12.2	Analog outputs	62
4.12.3	Pulse outputs	63
4.12.4	Control outputs	63
4.12.5	Analog inputs	63
4.12.6	Pulse and control inputs	63
5	Marking and operating instructions	63
5.1	General	63
5.2	Marking	63
5.3	Operating, installation and maintenance instructions	64
5.3.1	General	64
5.3.2	General characteristics	64
5.3.3	Essential characteristics	64
6	Tests	66
6.1	General	66
6.2	Type tests of PMD	67
6.2.1	General	67
6.2.2	Tests of intrinsic uncertainty	67
6.2.3	Tests of variation of uncertainty with influence quantities	67
6.2.4	Test of temperature influence	67
6.2.5	Active power	68
6.2.6	Apparent power	70
6.2.7	Power factor	71
6.2.8	Common mode voltage rejection test	71
6.2.9	Frequency	71
6.2.10	Measurement of voltage harmonics and THD_U	72
6.2.11	Measurement of current harmonics and THD_I	72
6.2.12	Dips and swells	73
6.2.13	Voltage interruptions	73
6.2.14	Outputs tests	73
6.2.15	Climatic tests	74
6.2.16	EMC tests	75
6.2.17	Start-up tests	75
6.2.18	Gapless measurement test	75
6.2.19	Safety tests	75
6.3	Routine tests	75

6.3.1	Protective bonding test	75
6.3.2	Dielectric strength test	76
6.3.3	Uncertainty test	76
Annex A	(informative) Metering, measuring and monitoring applications	77
A.1	Applications on demand side and supply side	77
A.2	Link between applications, devices and standards	77
Annex B	(informative) Definitions of electrical parameters	79
B.1	General	79
B.2	Definitions in the presence of a neutral	79
B.3	Power measurement in three-phase three-wire systems using the two-wattmeter method	83
B.3.1	General	83
B.3.2	Total active power	84
B.3.3	Total vector reactive power using quadrature phase shift definition	84
B.3.4	Total vector reactive power using Budeanu's definition	85
B.4	Additional relationships in case of sinusoidal voltage	85
Annex C	(informative) Convention about the sign of the power factor	86
C.1	General	86
C.2	Convention for power factor (consumer perspective)	86
C.3	Convention for power factor (producer reference frame)	87
Annex D	(normative) Definitions of minimum, maximum, peak and demand values	89
D.1	Demand quantities	89
D.1.1	General	89
D.1.2	Power demand	89
D.1.3	Current demand	89
D.1.4	Thermal current demand (or bi-metal current demand)	89
D.1.5	Specified intervals for demand calculation	89
D.2	Peak demand quantities	90
D.3	Three-phase average quantities	90
D.4	Maximum and minimum quantities	90
Annex E	(informative) Intrinsic uncertainty and operating uncertainty	91
E.1	General	91
E.2	Operating uncertainty calculation	91
Annex F	(informative) Recommended sensor classes for the different kinds of PMD	93
F.1	General considerations	93
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	93
F.3	List of functions affected by uncertainty of external sensors	93
Annex G	(informative) Notion of measurement uncertainty	95
G.1	General considerations	95
G.2	Computing the expanded uncertainty	95
G.2.1	General	95
G.2.2	Estimated standard deviation	95
G.2.3	Expanded uncertainty	96
G.3	Determining the measurement uncertainty	97
G.3.1	Systematic error	97
G.3.2	Measurement uncertainty	97
G.4	Using the measurement uncertainty as a pass/fail criterion	98

G.4.1	Intrinsic uncertainty tests	98
G.4.2	Tests with influence quantities	98
G.4.3	Overall pass/fail criterion	98
A1	Annex H (normative) Requirements for power metering and monitoring function (PMF) and additional requirements for equipment embedding power metering and monitoring function (EPMF)	100
H.1	Scope	100
H.2	Normative references	100
H.3	Terms, definitions and notations	101
H.4	Requirements for PMF and additional requirements for EPMF	101
H.4.1	General requirements	101
H.4.2	EPMF general architecture	102
H.4.3	Classification of PMF	102
H.4.4	Structure of EPMF	103
H.4.5	List of applicable performance classes for PMF	103
H.4.6	Operating and reference conditions	103
H.4.7	Start-up conditions for EPMF	104
H.4.8	Requirements for PMF	104
H.4.9	General mechanical requirements	104
H.4.10	Safety requirements	104
H.4.11	EMC requirements	104
H.4.12	Inputs and/or outputs	104
H.5	Marking and operating instructions	105
H.5.1	General	105
H.5.2	Marking	105
H.5.3	Operating, installation and maintenance instructions	105
H.6	Tests	106
H.6.1	General	106
H.6.2	Type tests of EPMF	106
H.6.3	Routine tests of EPMF	108 A1
A1	Annex I (informative) Potential new requirements derived from IEC 62053-2x series of standards	109
I.1	Scope	109
I.2	Future requirements for active power (P) and active energy (E_a) measurements	110
I.2.1	Future intrinsic uncertainty tables	110
I.2.2	Future limits of variations due to influence quantities	111
I.3	Future requirements for reactive power (Q) and reactive energy (E_r) measurements	116
I.3.1	Future intrinsic uncertainty tables	116
I.3.2	Limits of variation in percentage error due to influence quantities	116 A1
	Bibliography	119
	Figure 1 – PMD generic measurement chain	25
	Figure 2 – Description of different types of PMD	26
	Figure 3 – Relationship between ambient air temperature and relative humidity	30
	Figure 4 – Waveform for odd harmonics influence test on active power measurement	68
	Figure 5 – Spectral content for odd harmonics influence test on active power measurement	69

Figure 6 – Waveform for sub-harmonics influence test on active power measurement.....	70
Figure 7 – Spectral content for sub-harmonics influence test on active power measurement.....	70
Figure 8 – Common mode voltage influence testing	71
Figure 9 – Waveform for harmonics influence test on frequency measurement.....	72
Figure A.1 – Simplified overview of measurement applications on supply side and demand side	77
Figure B.1 – Arithmetic and vector apparent powers in sinusoidal situation.....	83
Figure B.2 – Three-phase circuit without neutral	84
Figure C.1 – Formatting of power factor with a consumer perspective	86
Figure C.2 – Convention for power factor with a producer perspective	87
Figure D.1 – Thermal current demand.....	89
Figure D.2 – Fixed block interval.....	90
Figure D.3 – Sliding block interval.....	90
Figure E.1 – Different kinds of uncertainties.....	91
Figure E.2 – Flowchart for the determination of the operating uncertainty	92
Figure G.1 – Illustration of the notion of measurement uncertainty	97
Figure G.2 – Overview of the uncertainty test procedure	99
Figure H.1 – Example of architecture of EPMF.....	102
Table 1 – Functional classification of PMD with minimal required functions.....	25
Table 2 – Structure of PMD.....	26
Table 3 – List of applicable performance classes	27
Table 4 – Reference conditions for testing	28
Table 5 – Rated operating temperatures for portable equipment	28
Table 6 – Rated operating temperatures for fixed installed equipment	29
Table 7 – Humidity and altitude operating conditions	29
Table 8 – Intrinsic uncertainty table for active power and active energy measurement	32
Table 9 – Influence quantities for active power and active energy measurement (1 of 3).....	33
Table 10 – Minimum test period	36
Table 11 – Starting current for active power and active energy measurement	37
Table 12 – Intrinsic uncertainty table for reactive power and reactive energy measurement.....	37
Table 13 – Influence quantities for reactive power and reactive energy measurement.....	38
Table 14 – Minimum test period	39
Table 15 – Starting current for reactive energy measurement	40
Table 16 – Intrinsic uncertainty table for apparent power and apparent energy measurement.....	40
Table 17 – Influence quantities for apparent power and apparent energy measurement.....	41
Table 18 – Intrinsic uncertainty table for frequency measurement	42
Table 19 – Influence quantities for frequency measurement.....	43
Table 20 – Rated range of operation for phase current measurement	43
Table 21 – Rated range of operation for neutral current (calculated or measured).....	44
Table 22 – Intrinsic uncertainty table for phase current	44

Table 23 – Intrinsic uncertainty table for neutral current measurement.....	44
Table 24 – Intrinsic uncertainty table for neutral current calculation	45
Table 25 – Influence quantities for phase current and neutral current measurement	46
Table 26 – Rated range of operation for RMS voltage measurement	47
Table 27 – Intrinsic uncertainty table for RMS voltage measurement.....	47
Table 28 – Influence quantities for RMS voltage measurement	48
Table 29 – Intrinsic uncertainty table for power factor measurement	49
Table 30 – Intrinsic uncertainty table for flicker measurement	50
Table 31 – Rated range of operation for voltage dips and swells measurement.....	52
Table 32 – Intrinsic uncertainty table for voltage dips and swells measurement	53
Table 33 – Influence quantities for dips and swells measurement	54
Table 34 – Intrinsic uncertainty table for voltage interruption measurement	56
Table 35 – Intrinsic uncertainty table for transient overvoltage measurement.....	56
Table 36 – Intrinsic uncertainty table for voltage unbalance measurement	57
Table 37 – Rated range of operation for voltage harmonics measurement	57
Table 38 – Intrinsic uncertainty table for voltage harmonics measurement	57
Table 39 – Intrinsic uncertainty table for voltage THD_U or $THD-R_U$ measurement	58
Table 40 – Intrinsic uncertainty table for current unbalance measurement	58
Table 41 – Rated range of operation for current harmonics measurement.....	59
Table 42 – Intrinsic uncertainty table for current harmonics measurement	59
Table 43 – Intrinsic uncertainty table for current THD_i and $THD-R_i$ measurement	59
Table 44 – Minimum IP requirements for PMD	60
Table 45 – PMD specification form.....	65
Table 46 – Characteristics specification template.....	66
Table A.1 – Main measurement applications	78
Table B.1 – Definition of symbols.....	79
Table B.2 – Calculation definitions for electrical parameters	80
Table C.1 – Conventions for the sign of Power factor with a Consumer perspective	87
Table C.2 – Conventions for the sign of power factor with a producer perspective	88
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	93
Table F.2 – List of functions affected by uncertainty of external sensors	94
Table G.1 – Correction factor $C(N)$ for sample size N	96
A1 Table H.1 – List of equipment that may embed EPMF	101
Table H.2 – Functional classification of PMF with minimal required functions.....	102
Table H.3 – Structure of EPMF	103
Table H.4 – Value of current according to the type of EPMF	104
Table H.5 – EPMF specification form	105
Table I.1 – Future intrinsic uncertainty table for active power and active energy measurement for classes $> 0,5$	110
Table I.2 – Future intrinsic uncertainty table for active power and active energy measurement for classes $\leq 0,5$	110
Table I.3 – Limits of variation in percentage error due to influence quantities for classes $> 0,5$	111

A1	Table I.4 – Limits of variation in percentage error due to influence quantities for classes $\leq 0,5$	113
	Table I.5 – Future intrinsic uncertainty table for reactive power and reactive energy measurement	116
	Table I.6 – Limits of variation in percentage error due to influence quantities.....	116 A1

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**ELECTRICAL SAFETY IN LOW VOLTAGE DISTRIBUTION SYSTEMS
UP TO 1 000 V a.c. AND 1 500 V d.c. –
EQUIPMENT FOR TESTING, MEASURING OR MONITORING
OF PROTECTIVE MEASURES –****Part 12: Performance measuring and monitoring devices (PMD)**

FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

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

The text of this standard is based on the following documents:

FDIS	Report on voting
85/311/FDIS	85/312/RVD

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

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

This standard is to be used in conjunction with IEC 61557-1 (unless otherwise specified).

A list of all parts of the IEC 61557 series, published under the general title *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*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

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

A1 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 of PMD 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.

Additionally, this document specifies requirements for measurement functions dedicated to metering and monitoring of electrical parameters called power metering and monitoring function (PMF) which can be embedded in equipment (EPMF) that is not classified as PMD and for which the main function is not power metering and monitoring.

Requirements for power metering and monitoring function (PMF) and additional requirements for equipment embedding power metering and monitoring function (EPMF) are described in Annex H.

The power metering and monitoring devices (PMD) for electrical parameters described in this document are used for general industrial and commercial applications.

The power metering and monitoring devices (PMD) can be associated with sensing devices such as but not limited to instruments transformers compliant to IEC 61869 series of standards or with transducers compliant to IEC 60688.

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

This document is not applicable to:

- 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]



3.1.16

power metering and monitoring function

PMF

measurement function dedicated to metering and monitoring electrical parameters within electrical distribution systems embedded in an equipment that is not a PMD and complies to another IEC product standard

3.1.17

equipment embedding PMF

EPMF

equipment or arrangement of equipment embedding PMF whose main function is not metering and monitoring of electrical parameters

Note 1 to entry: Such equipment are uninterruptible power systems (UPS), static transfer systems (STS), circuit breakers, transfer switching equipment (TSE), switches, disconnectors, switch-disconnectors, fuse-combination units, programmable controllers (PLC), inverter for use in photovoltaic power systems, adjustable speed electrical power drive systems, protection relay, residual current devices (RCDs, RCBOS), residual current monitoring devices (RCM), load-shedding equipment (LSE), bi-directional grid connected power converters.

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.

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

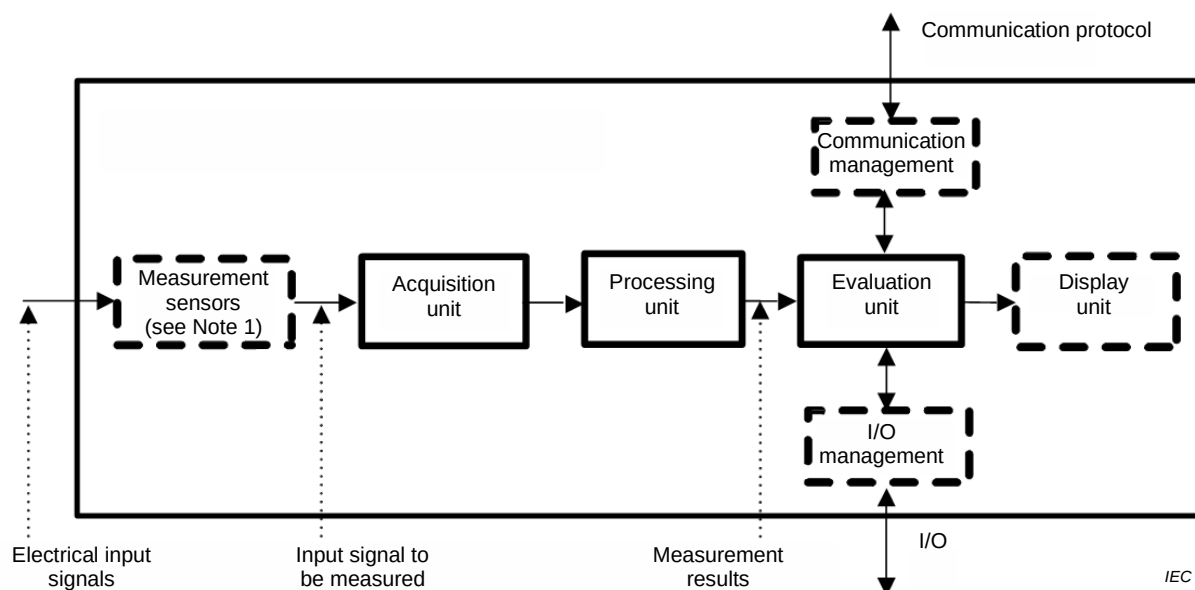
The following requirements shall apply unless otherwise specified hereafter.

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 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.

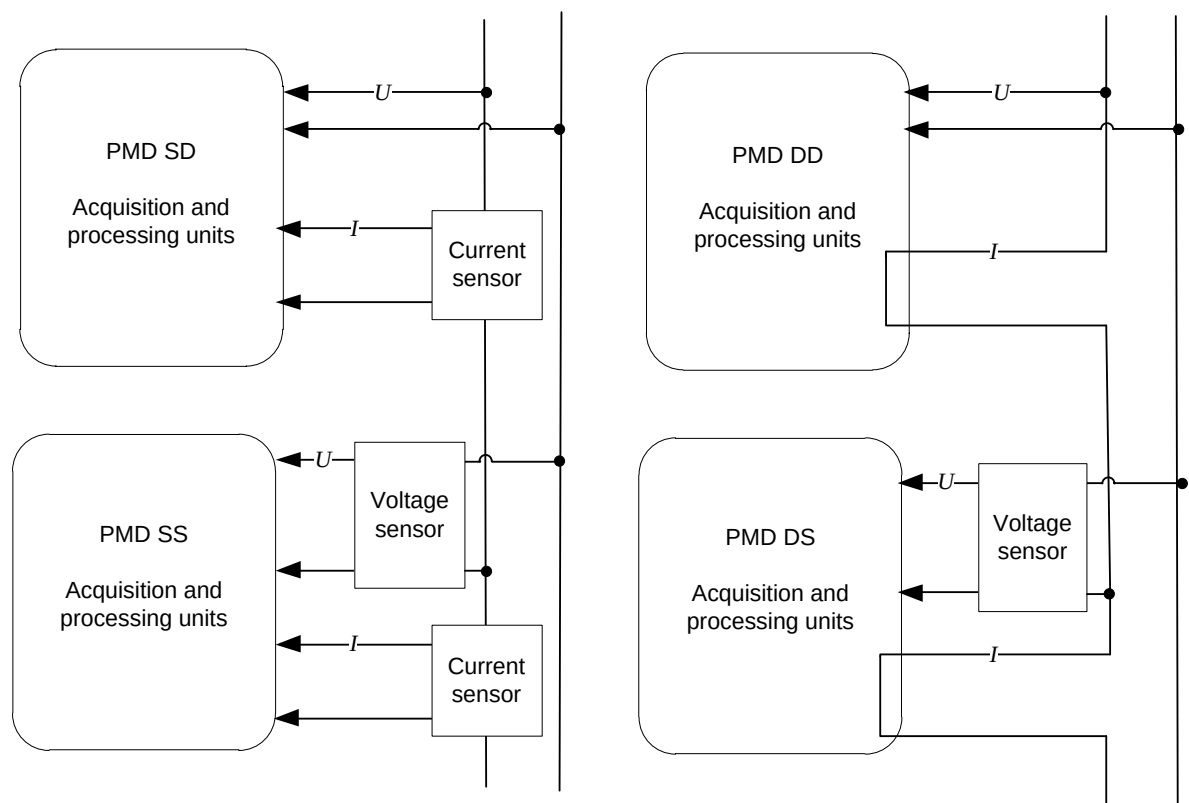
4.4 Structure of PMD

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 – 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

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.			

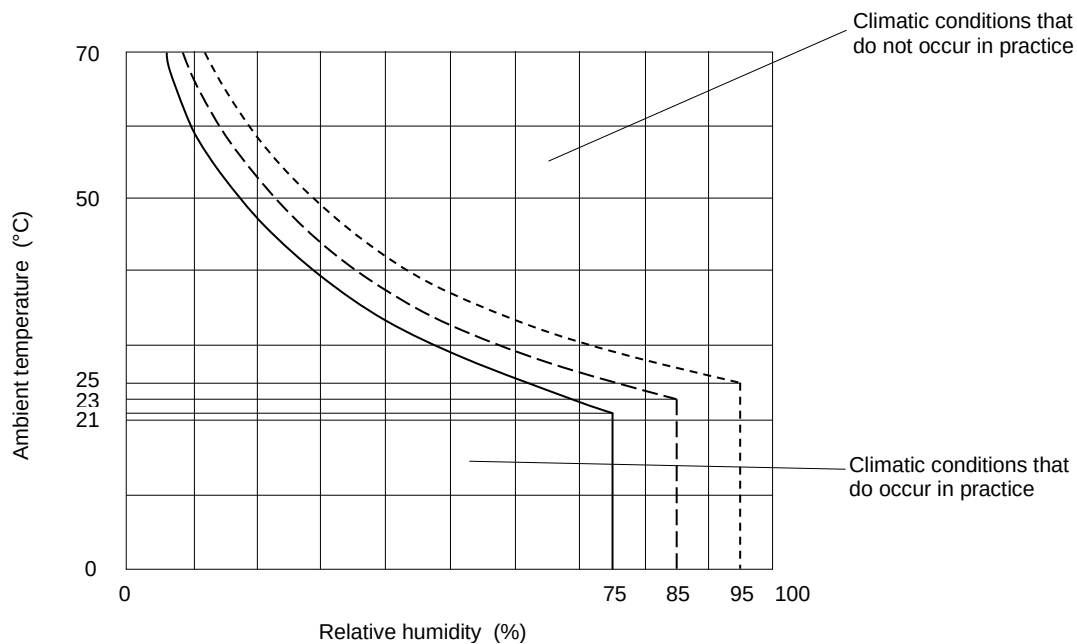
4.6.2.4 Rated humidity and altitude operating conditions

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.



IEC

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.