BS EN 62053-24:2015

BSI Standards Publication

Electricity metering equipment (a.c.) — Particular requirements

Part 24: Static meters for reactive energy at fundamental frequency (classes 0,5 S, 1 S and 1)

National foreword

This British Standard is the UK implementation of EN 62053-24:2015. It is identical to IEC 62053-24:2014.

The UK participation in its preparation was entrusted to Technical Committee PEL/13, Electricity Meters.

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

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Published by BSI Standards Limited 2015

ISBN 978 0 580 71816 8
ICS 17.220.20; 91.140.50

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 January 2015.

Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 62053-24

January 2015

ICS 17.220.20; 91.140.50

English Version

Electricity metering equipment (a.c.) - Particular requirements - Part 24: Static meters for reactive energy at fundamental frequency (classes 0,5 S, 1 S and 1) (IEC 62053-24:2014)

Équipement de comptage de l'électricité (c.a.) - Exigences particulières - Partie 24: Compteurs statiques d'énergie réactive à la fréquence fondamentale (classes 0,5 S, 1 S et 1) (IEC 62053-24:2014)

Wechselstrom-Elektrizitätszähler - Besondere Anforderungen - Teil 24: Elektronische Grundschwingungs-Blindverbrauchszähler der Genauigkeitsklassen 0,5 S, 1 S und 1 (IEC 62053-24:2014)

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

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Foreword

The text of document 13/1569/FDIS, future edition 1 of IEC 62053-24, prepared by IEC/TC 13 "Electrical energy measurement and control" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 62053-24:2015.

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)	2015-07-16
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2017-07-24

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

This document has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association, and supports essential requirements of EU Directive.

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

Endorsement notice

The text of the International Standard IEC 62053-24:2014 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 61869-2:2012	NOTE	Harmonized as EN 61869-2:2012 (not modified).
IEC 62053-21:2003	NOTE	Harmonized as EN 62053-21:2003 (not modified).
IEC 62053-23:2003	NOTE	Harmonized as EN 62053-23:2003 (not modified).
IEC 62053-61:1998	NOTE	Harmonized as EN 62053-61:1998 (not modified).

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE 1 When 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

Publication	Year	Title	EN/HD	Year
IEC 62052-11	2003	Electricity metering equipment (AC) - General requirements, tests and test conditions - Part 11: Metering equipment	EN 62052-11	2003

Annex ZZ
(informative)

Coverage of Essential Requirements of EU Directives

This European Standard has been prepared under a mandate given to CENELEC by the European Commission and the European Free Trade Association and within its scope this standard covers all relevant essential requirements as given in Annex I of the EU Directive 2004/108/EC.

Compliance with this standard provides one means of conformity with the specified essential requirements of the Directive concerned.

WARNING: Other requirements and other EU Directives can be applied to the products falling within the scope of this standard.

CONTENTS

INTRODUCTION

This part of IEC 62053 is to be used with the following relevant parts of the IEC 62052, IEC 62053 and IEC 62059 series, *Electricity metering equipment*:

IEC 62052-11:2003, *Electricity metering equipment (a.c.) – General requirements, tests and test conditions – Part 11: Metering equipment*

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

IEC 62053-52:2005, *Electricity metering equipment (a.c.) – Particular requirements – Part 52: Symbols*

IEC 62053-61:1998, *Electricity metering equipment (a.c.) – Particular requirements – Part 61: Power consumption and voltage requirements*

IEC 62059-11:2002, *Electricity metering equipment (a.c.) – Dependability – Part 11: General concepts*

IEC 62059-21:2002, *Electricity metering equipment (a.c.) – Dependability – Part 21: Collection of meter dependability data from the field*

IEC 62059-31-1:2008, *Electricity metering equipment – Dependability –Part 31-1: Accelerated reliability testing – Elevated temperature and humidity*

IEC 62059-32-1:2011, *Electricity metering equipment – Dependability – Part 32-1: Durability – Testing of the stability of metrological characteristics by applying elevated temperature*

IEC 62059-41:2006, *Electricity metering equipment – Dependability – Part 41: Reliability prediction*

This part is a standard for type testing electricity meters. It covers the particular requirements for meters, used indoors and outdoors. It does not deal with special implementations (such as metering-part and/or displays in separate housings).

This standard is intended to be used in conjunction with IEC 62052-11. When any requirement in this standard concerns an item already covered in IEC 62052-11, the requirements of this standard take precedence over the requirements of IEC 62052-11.

This standard distinguishes:

- between transformer operated meters of accuracy class index 0,5 S and 1 S and direct connected meters of accuracy class index 1;
- between protective class I and protective class II meters;
- between meters for use in networks equipped with or without earth fault neutralizers.

The test levels are regarded as minimum values that provide for the proper functioning of the meter under normal working conditions. For special application, other test levels might be necessary and should be agreed on between the user and the manufacturer.

ELECTRICITY METERING EQUIPMENT (a.c.) – PARTICULAR REQUIREMENTS –

Part 24: Static meters for reactive energy at fundamental frequency (classes 0,5 S, 1 S and 1)

1 Scope

This part of IEC 62053 applies only to newly manufactured transformer operated static var-hour meters of accuracy classes 0,5 S, and 1 S as well as direct connected static var-hour meters of accuracy class 1, for the measurement of alternating current electrical reactive energy in 50 Hz or 60 Hz networks and it applies to their type tests only.

This standard uses a conventional definition of reactive energy where the reactive power and energy is calculated from the fundamental frequency components of the currents and voltages only. See Clause 3.

NOTE 1 This differs from the approach of IEC 62053-23, where reactive power and energy is defined only for sinusoidal signals. In this standard reactive power and energy is defined for all periodic signals. Reactive power and energy is defined in this way to achieve proper reproducibility of measurements with meters of different designs. With this definition, reactive power and energy reflects the generally unnecessary current possible to compensate with capacitors rather than the total unnecessary current.

It applies only to static var-hour meters for indoor and outdoor application consisting of a measuring element and register(s) enclosed together in a meter case. It also applies to operation indicator(s) and test output(s). If the meter has a measuring element for more than one type of energy (multi-energy meters), or when other functional elements, like maximum demand indicators, electronic tariff registers, time switches, ripple control receivers, data communication interfaces, etc., are enclosed in the meter case, then the relevant standards for these elements also apply.

NOTE 2 IEC 61869-2:2012 describes transformers having a measuring range of 0,05 I_n to I_{max} for accuracy classes 0,2, 0,5, 1 and 2, and transformers having a measuring range of 0,01 I_n to I_{max} for accuracy classes 0,2 S and 0,5 S. As the measuring range of a meter and its associated transformers have to be matched and as only transformers of classes 0,2 S / 0,5 S have the current error and phase displacement characteristics suitable to operate a class 0,5 S / 1 S meter respectively as specified in this standard, the measuring range of the transformer operated meters will be 0,01 I_n to I_{max}. Reactive meters intended to be used together with non-S transformers are, therefore, not covered by this standard.

It does not apply to:

- var-hour meters where the voltage across the connection terminals exceeds 600 V (line-to-line voltage for meters for polyphase systems);
- portable meters;
- data interfaces to the register of the meter;
- reference meters.

The dependability aspect is covered by the standards of the IEC 62059 series.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC 62052-11:2003, *Electricity metering equipment (a.c.) – General requirements, tests and test conditions – Part 11: Metering equipment*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 62052-11 apply with the following exception:

3.1
reactive power
Q
reactive power Q in a single phase system is defined for steady-state and periodic signals as

$$Q = U_1 * I_1 * \sin\varphi_1$$

where U_1 and I_1 are the r.m.s. values of the fundamental frequency components of the voltage and the current respectively, and

φ_1 is the phase angle between them. The reactive power in poly-phase system is the algebraic sum of the per-phase reactive powers:

$$Q = U_{L1} * I_{L1} * \sin\varphi_{L1} + U_{L2} * I_{L2} * \sin\varphi_{L2} + ...$$

where

L1 and L2 are the first and second phase of the system.

Note 1 to entry: For direction of flow and sign of reactive power, see Annex C.

Note 2 to entry: The actual algorithm used for the calculation of reactive power is not of importance as long as the meter meets requirements of this standard. See also Annex E.

Note 3 to entry: While meters for active energy have to measure active energy including harmonic components, reactive energy meters according to this standard have to measure fundamental component reactive energy, with minimum influence from harmonics.

4 Standard electrical values

The values given in IEC 62052-11 apply.

5 Mechanical requirements

The requirements of IEC 62052-11 apply.

6 Climatic conditions

The conditions given in IEC 62052-11 apply.

7 Electrical requirements

7.1 General

In addition to the electrical requirements in IEC 62052-11, meters shall fulfil the following requirements.

7.2 Power consumption

7.2.1 General

The power consumption in the voltage and current circuit shall be determined at reference values of the influence quantities given in 8.6 by any suitable method. The overall uncertainty of the measurement of the power consumption shall not exceed 5 %.

7.2.2 Voltage circuits

The active and apparent power consumption in each voltage circuit of a meter at reference voltage, reference temperature and reference frequency shall not exceed the values shown in Table 1.

Table 1 – Power consumption in voltage circuits for single-phase and polyphase meters including the power supply

Meters	Power supply connected to the voltage circuits	Power supply not connected to the voltage circuits
Voltage circuit	2 W and 10 VA	0,5 VA
Auxiliary power supply	–	10 VA
NOTE 1 In order to match voltage transformers to meters, the meter manufacturer should state whether the burden is inductive or capacitive (for transformer operated meters only). NOTE 2 The above figures are mean values. Switching power supplies with peak values in excess of these specified values are permitted, but it should be ensured that the rating of associated voltage transformers is adequate. NOTE 3 For multifunctional meters, see IEC 62053-61.		

7.2.3 Current circuits

The apparent power taken by each current circuit of a direct connected meter at basic current, reference frequency and reference temperature shall not exceed the values shown in Table 2.

The apparent power taken by each current circuit of a meter connected through a current transformer shall not exceed the value shown in Table 2, at a current value that equals the rated secondary current of the corresponding transformer, at reference temperature and reference frequency of the meter.

Table 2 – Power consumption in current circuits

Meters	Class of meter		
	0,5 S	1 S	1
Single-phase and polyphase direct connected meter	–	–	4,0 VA
Single-phase and polyphase transformer operated meters	1,0 VA	1,0 VA	–
NOTE 1 The rated secondary current is the value of the secondary current indicated on the current transformer, on which the performance of the transformer is based. Standard values of maximum secondary current are 120 %, 150 % and 200 % of the rated secondary current. NOTE 2 In order to match current transformers to meters, the meter manufacturer should state whether the burden is inductive or capacitive (for transformer operated meters only).			

7.3 Influence of short-time overcurrents

Short-time overcurrents shall not damage the meter. The meter shall perform correctly when back to its initial working condition and the variation of error shall not exceed the values shown in Table 3.

The test circuit shall be practically non-inductive and the test shall be performed for polyphase meters phase-by-phase.

After the application of the short-time overcurrent with the voltage maintained at the terminals, the meter shall be allowed to return to the initial temperature with the voltage circuit(s) energized (about 1 h).

a) Meter for direct connection

   The meter shall be able to carry a short-time overcurrent of 30 I_{max} (r.m.s.) with a relative tolerance of +0 % to –10 % for one half-cycle of a sinusoidal waveforms starting at zero volt, at rated frequency.

b) Meter for connection through current transformer

   The meter shall be able to carry for 0,5 s a sinusoidal current at rated frequency equal to 20 I_{max} with a relative tolerance of +0 % to –10 %.

This requirement does not apply to meters having a switch in the current circuits. For this case, see appropriate standards.

Table 3 – Variations due to short-time overcurrents

Meters for	Value of current	sin φ (inductive or capacitive)	Limits of variations in percentage error for meters of class		
			0,5 S	1 S	1
Direct connection	I_b	1	–	–	1,5
Connection through current transformers	I_n	1	0,1	0,1	–

7.4 Influence of self-heating

The variation of error due to self-heating shall not exceed the values given in Table 4.

Table 4 – Variations due to self-heating

Value of current	sin φ (inductive or capacitive)	Limits of variations in percentage error for meters of class	
		0,5 S	1 S or 1
I_{max}	1	0,2	0,7
	0,5	0,2	1,0

The test shall be carried out as follows: After the voltage circuits have been energized at reference voltage for at least 1 h, without any current in the current circuits, the maximum current shall be applied to the current circuits. The meter error shall be measured at sin φ = 1 immediately after the current is applied and then at intervals short enough to allow a correct drawing to be made of the curve of error variation as a function of time. The test shall be carried out for at least 1 h, and in any event until the variation of error during 20 min does not exceed 0,1 % for class 1 S and class 1 meters and 0,05 % for a class 0,5 S meter.

For this test, the percentage error of the meter shall be measured at sin φ = 1 and sin φ = 0,5 inductive or capacitive with minimum interruptions for changing the measurement point.

The cable to be used for energizing the meter shall have a length of 1 m. For meters with I_{max} > 6 A, the cable cross-section shall ensure that the current density is between 3,2 A/mm^2 and 4 A/mm^2. For meters with an $I_{max} \leq$ 6 A, a cross-section in accordance with the meter specification shall be used.

7.5 AC voltage test

The a.c. voltage test shall be carried out in accordance with Table 5.

The test voltage shall be substantially sinusoidal, having a frequency between 45 Hz and 65 Hz, and applied for 1 min. The power source shall be capable of supplying at least 500 VA.

During the tests relative to earth, the auxiliary circuits with reference voltage equal to or below 40 V shall be connected to earth.

All these tests shall be carried out with the case closed and the cover and terminal covers in place.

During this test, no flashover, disruptive discharge or puncture shall occur.

Table 5 – AC voltage tests

Test	Applicable to	Test voltage r.m.s	Points of application of the test voltage
A	Protective class I meters	2 kV	a) Between, on the one hand, all the current and voltage circuits as well as the auxiliary circuits whose reference voltage is over 40 V, connected together, and, on the other hand, earth
		2 kV	b) Between circuits not intended to be connected together in service
B	Protective class II meters	4 kV	a) Between, on the one hand, all the current and voltage circuits as well as the auxiliary circuits whose reference voltage is over 40 V, connected together, and, on the other hand, earth
		2 kV	b) Between circuits not intended to be connected together in service
		–	c) A visual inspection for compliance with the conditions of 5.7 of IEC 62052-11:2003.

8 Accuracy requirements

8.1 General

The tests and test conditions given in IEC 62052-11 apply.

8.2 Limits of error due to variation of the current

When the meter is under the reference conditions given in 8.6, the percentage errors shall not exceed the limits for the relevant accuracy class given in Table 6 and Table 7.

Table 6 – Percentage error limits (single-phase meters and polyphase meters with balanced loads)

Value of current		sin φ (inductive or capacitive)	Percentage error limits for meters of class		
for direct connected meters	for transformer operated (S) meters a)		0,5 S a)	1 S a)	1
$0,05\ I_b \le I < 0,1\ I_b$	$0,01\ I_n \le I < 0,05\ I_n$	1	±1,0	±1,5	±1,5
$0,1\ I_b \le I \le I_{max}$	$0,05\ I_n \le I \le I_{max}$	1	±0,5	±1,0	±1,0
$0,1\ I_b \le I < 0,2\ I_b$	$0,05\ I_n \le I < 0,1\ I_n$	0,5	±1,0	±1,5	±1,5
$0,2\ I_b \le I \le I_{max}$	$0,1\ I_n \le I \le I_{max}$	0,5	±0,5	±1,0	±1,0
$0,2\ I_b \le I \le I_{max}$	$0,1\ I_n \le I \le I_{max}$	0,25	±1,0	±2,0	±2,0

a) It is recommended that current transformers of accuracy class 0,2 S / 0,5 S are used with meters of accuracy class 0,5 S / 1 S respectively in order to keep the overall system error – due to the phase displacement – on a low level.

Table 7 – Percentage error limits (polyphase meters carrying a single-phase load, but with balanced polyphase voltages applied to voltage circuits)

Value of current		sin φ (inductive or capacitive)	Percentage error limits for meters of class	
for direct connected meters	for transformer operated (S) meters a)		0,5 S a)	1 or 1 S a)
$0,1\ I_b \le I \le I_{max}$	$0,05\ I_n \le I \le I_{max}$	1	± 0,7	± 1,5
$0,2\ I_b \le I \le I_{max}$	$0,1\ I_n \le I \le I_{max}$	0,5	± 1,0	± 2,0
$0,2\ I_b \le I \le I_{max}$	$0,1\ I_n \le I \le I_{max}$	0,25	± 1,5	± 3,0

a) It is recommended that current transformers of accuracy class 0,2 S / 0,5 S are used with meters of accuracy class 0,5 S / 1 S respectively in order to keep the overall system error – due to the phase displacement – on a low level.

The difference between the percentage error when the meter is carrying a single-phase load and a balanced polyphase load at basic current I_b and sin φ = 1 for direct connected meters, shall not exceed 1,5 % for meters of class 1. At rated current I_n and sin φ = 1 for transformer operated meters, the difference shall not exceed 0,7 % and 1,5 % for meters of classes 0,5 S and 1 S respectively.

When testing for compliance with Table 7, the test current should be applied to each measuring element in sequence.

8.3 Limits of error due to influence quantities

8.3.1 General

The additional percentage error due to the change of influence quantities with respect to reference conditions, as given in 8.6, shall not exceed the limits for the relevant accuracy class given in Table 8.

Table 8 – Influence quantities

Influence quantity	**Value of current (balanced unless otherwise stated)**		**sin φ (inductive or capacitive)**	**Mean temperature coefficient %/K for meters of class**	
	for direct connected meters	**for transformer-operated meters**		**0,5 S**	**1 or 1 S**
Ambient temperature variation [7]	$0,1\ I_b \le I \le I_{max}$	$0,05\ I_n \le I \le I_{max}$	1	0,03	0,05
	$0,2\ I_b \le I \le I_{max}$	$0,1\ I_n \le I \le I_{max}$	0,5	0,05	0,10
				Limits of variation in percentage error for meters of class	
				0,5 S	**1 or 1 S**
Voltage variation ±10 % [1] [2]	$0,05\ I_b \le I \le I_{max}$	$0,02\ I_n \le I \le I_{max}$	1	0,25	0,5
	$0,1\ I_b \le I \le I_{max}$	$0,05\ I_n \le I \le I_{max}$	0,5	0,5	1,0
Frequency variation±2 % [2]	$0,05\ I_b \le I \le I_{max}$	$0,02\ I_n \le I \le I_{max}$	1	0,5	1,0
	$0,1\ I_b \le I \le I_{max}$	$0,05\ I_n \le I \le I_{max}$	0,5	0,5	1,0
Harmonic components in the current and voltage circuits [9]	I_b	$I_{max}/2$	1	2,5	2,5
DC and even harmonics in the current circuit [3]	$\frac{I_{max}}{\sqrt{2}}$	–	1	–	6,0
Continuous magnetic induction of external origin [4]	I_b	I_n	1	2,0	2,0
Magnetic induction of external origin 0,5 mT [5]	I_b	I_n	1	1,0	2,0
Electromagnetic RF fields	I_b	I_n	1	2,0	2,0
Operation of accessories [6]	$0,05\ I_b$	$0,05\ I_n$	1	0,5	0,5
Conducted disturbances, induced by radio-frequency fields	I_b	I_n	1	1,5	2,5
Fast transient burst	I_b	I_n	1	2,0	3,0
Damped oscillatory waves immunity [8]	–	I_n	1	2,0	3,0

1) For the voltage ranges from –20 % to –10 % and +10 % to +15 %, the limits of variation in percentage errors are three times the values given in this Table.

Below 0,8 U_n the error of the meter may vary between +10 % and –100 %.

2) The recommended test point for voltage variation and frequency variation is I_b for direct connected meters and I_n for transformer operated meters.

3) The purpose of this test is to check for current sensor saturation only. The test conditions are specified in 8.3.2 and in Annex A. The distortion factor of the voltage shall be less than 1 %. This test is not applicable for transformer operated meters.

4) The test conditions are specified in 8.3.3.

5) 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 meter and under the most unfavourable conditions of phase and direction shall not cause a variation in the percentage error of the meter exceeding the values shown in this Table.

The magnetic induction shall be obtained by placing the meter in the centre of a circular coil, 1 m in mean diameter, of square section and of small radial thickness relative to the diameter, and having 400 At.

6) Such an accessory, when enclosed in the meter case, is energized intermittently, for example the electromagnet of a multi-rate register.

It is preferable that the connection to the auxiliary device(s) is marked to indicate the correct method of connection. If these connections are made by means of plugs and sockets, they should not be interchangeable.

7) The mean temperature coefficient shall be determined for the whole operating range. The operating temperature range shall be divided into 20 K wide ranges. The mean temperature coefficient shall then be determined for these ranges, by taking measurements10 K above and 10 K below the middle of the range. During the test, the temperature shall be in no case outside the specified operating temperature range.

8) See IEC 62052-11:2003, 7.5.7.

9) The test conditions are specified in 8.3.4.

Tests for variation caused by influence quantities should be performed independently with all other influence quantities at their reference conditions (see Table 11).

8.3.2 Tests of the influence of DC and even harmonics in the current circuit

This test applies only for direct connected meters.

The tests of the influence of DC and even harmonics in the current circuit shall be made with the circuit shown in Figure A.1 or with other equipment able to generate the required wave-forms, and the current wave-forms as shown in Figure A.2.

The variation in percentage error when the meter is subjected to the test wave-form given in Figure A.2 and when it is subjected to the reference wave-form shall not exceed the limits of variation given in Table 8.

The values given in Figure A.2 are for 50 Hz only. For other frequencies the values have to be adapted accordingly.

8.3.3 Continuous magnetic induction of external origin

The continuous magnetic induction may be obtained by using the electromagnet according to Annex B, energized with a d.c. current. This magnetic field shall be applied to all accessible surfaces of the meter when it is mounted as for normal use. The value of the magneto-motive force applied shall be 1 000 At (ampere-turns).

8.3.4 Harmonics

This test is to verify that harmonics do not influence the measurements more than what is given in Table 8.

Test conditions:

- fundamental frequency current (I_1): see Table 8;
- fundamental frequency voltage: $U_1 = U_n$;
- fundamental frequency power factor: such that sin φ_1 = 1;
- content of 5th harmonic voltage: U_5 = 10 % of U_n;
- content of 5th harmonic current: I_5 = 40 % of fundamental frequency current;
- harmonic power factor: such that sin φ_5 = 1;
- fundamental and harmonic voltages positive zero crossing coincides.

The test shall be repeated when the harmonic power factor is changed such that sin φ_5 = 0.

The variation in percentage error when the meter is subjected to the test wave-form compared to when it is subjected to the reference wave-form shall not exceed the limits of variation given in Table 8.

The reference standard meter used for these tests should be designed and evaluated to measure reactive power in accordance with the definition given in clause 3.

NOTE Harmonic power factor: such that sin φ_5 = 1; means that the phase angle of the fifth order current harmonic is lagging the fifth order voltage harmonic by 90 degrees (or 1 ms for a 50 Hz signal or 0,833 ms for a 60 Hz signal).

8.4 Test of starting and no-load condition

8.4.1 General

For these tests, the conditions and the values of the influence quantities shall be as stated in 8.6 except for any changes specified below.

8.4.2 Initial start-up of the meter

The meter shall be functional within 5 s after the reference voltage is applied to the meter terminals.

8.4.3 Test of no-load condition

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

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

The minimum test period Δt shall be

$$\Delta t \geq \frac{600 \cdot 10^6}{k \cdot m \cdot U_n \cdot I_{max}} [min]$$

for meters of class 0,5 S, 1 S and 1

where:

k is the number of pulses emitted by the output device of the meter per kilovarhour (imp/kvarh);

m is the number of measuring elements;

U_n is the reference voltage in volts;

I_{max} is the maximum current in amperes.

For transformer-operated meters with primary or half-primary registers, the constant k shall correspond to the secondary values (voltages and currents).

8.4.4 Starting

The meter shall start and continue to register at the starting current values (and in the case of polyphase meters, with balanced load) shown in Table 9.

Table 9 – Starting current

Meters for	**Class of meter**		**sin φ**
	0,5 S	**1 and 1 S**	**(inductive or capacitive)**
Direct connection	–	0,004 I_b	1
Connection through current transformers	0,001 I_n	0,002 I_n	1

8.5 Meter constant

The relation between the test output and the indication in the display shall comply with the marking on the name-plate.

8.6 Accuracy test conditions

To test the accuracy requirements, the following test conditions shall be maintained:

a) the meter shall be tested in its case with the cover in position; all parts intended to be earthed shall be earthed;

b) before any test is made, the circuits shall have been energized for a time sufficient to reach thermal stability;

c) in addition, for polyphase meters:
   - the phase sequence shall be as marked on the diagram of connections;
   - the voltages and currents shall be substantially balanced; see Table 10.

d) the reference conditions are given in Table 11.

Table 10 – Voltage and current balance

Polyphase meters	**Class of meter**	
	0,5 S	**1 and 1 S**
Each of the voltages between phase and neutral and between any two phases shall not differ from the average corresponding voltage by more than	±1 %	±1 %
Each of the currents in the phase conductors shall not differ from the average current by more than	±1 %	±1 %
The phase displacements of each of these currents from the corresponding phase-to-neutral voltage, irrespective of the phase angle, shall not differ from each other by more than	2°	2°
When testing a polyphase var-hour meter, errors may arise if the testing method used and the meter under test are differently affected by voltage and current unbalance. In such cases, the reference voltage shall be carefully adjusted to a high degree of symmetry.		

Table 11 – Reference conditions

Influence quantity	Reference value	Permissible tolerances for meters of class	
		0,5 S	**1 and 1 S**
Ambient temperature	Reference temperature or, in its absence, 23 °C [a)]	±2 °C	±2 °C
Voltage	Reference voltage	±1,0 %	±1,0 %
Frequency	Reference frequency	±0,3 %	±0,3 %
Phase sequence	L1 – L2 – L3	–	–
Voltage unbalance	All phases connected	–	–
Wave-form	Sinusoidal voltages and currents	Distortion factor less than:	
		2 %	2 %
Continuous magnetic induction of external origin	Equal to zero	–	–
Magnetic induction of external origin at the reference frequency	Magnetic induction equal to zero	Induction value which causes a variation of error not greater than:	
		±0,1 %	±0,2 %
		but should in any case be smaller than 0,05 mT [b)]	
Electromagnetic RF fields, 30 kHz to 2 GHz	Equal to zero	<1 V/m	<1 V/m
Operation of accessories	No operation of accessories	–	–
Conducted disturbances, induced by radiofrequency fields, 150 kHz to 80 MHz	Equal to zero	<1 V	<1 V

a) If the tests are made at a temperature other than the reference temperature, including permissible tolerances, the results shall be corrected by applying the appropriate temperature coefficient of the meter.

b) The test consists of:

1) for a single-phase meter, determining the errors first with the meter normally connected to the mains and then after inverting the connections to the current circuits as well as to the voltage circuits. Half of the difference between the two errors is the value of the variation of error. Because of the unknown phase of the external field, the test should be made at 0,1 I_b resp. 0,05 I_n at sin φ = 1 and 0,2 I_b resp. 0,1 I_n at sin φ = 0,5 (inductive or capacitive);

2) for a three-phase meter, making three measurements at 0,1 I_b resp. 0,05 I_n at sin φ = 1, after each of which the connection to the current circuits and to the voltage circuits are changed over 120° while the phase sequence is not altered. The greatest difference between each of the errors so determined and their average value is the value of the variation of error.

8.7 Interpretation of test results

Certain test results may fall outside the limits indicated in Table 6 and Table 7 owing to uncertainties of measurements and other parameters capable of influencing the measurements. However, if by one displacement of the zero line parallel to itself by no more than the limits indicated in Table 12, all the test results are brought within the limits indicated in Table 6 and Table 7 the meter type shall be considered acceptable.

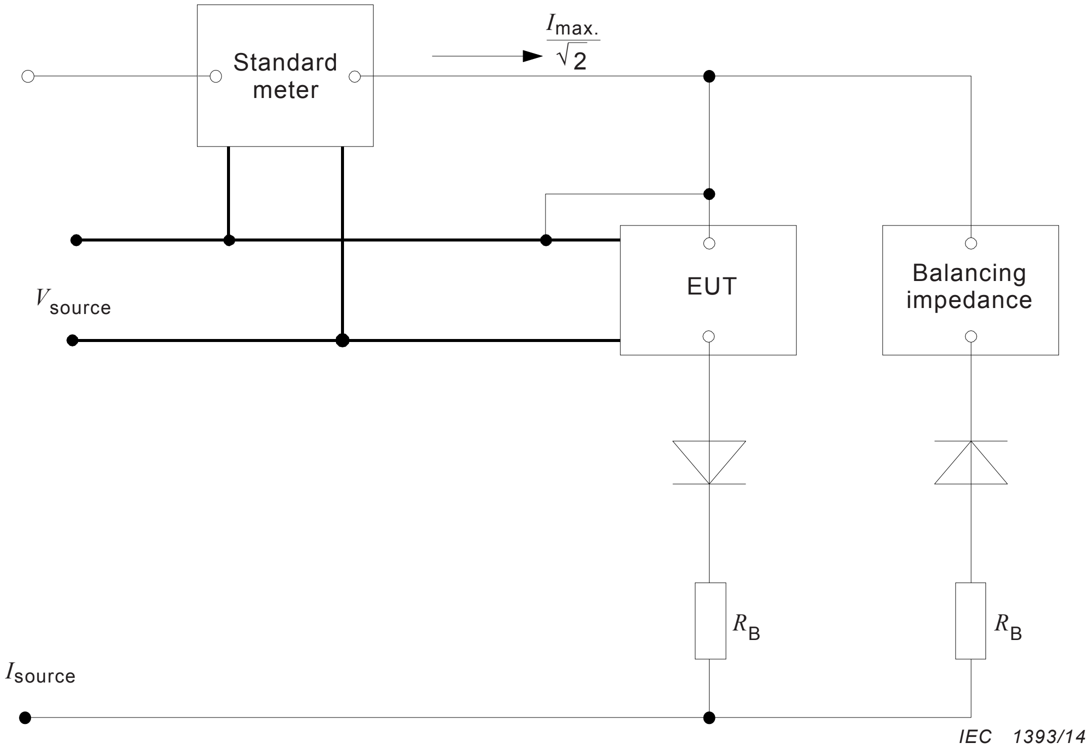
Table 12 – Interpretation of test results

	Class of meter	
	0,5 S	**1 and 1 S**
Permissible displacement of the zero line (%)	0,2	0,5

Annex A
(normative)

Test circuit diagram for DC and even harmonics

The values given in Figure A.2 are for 50 Hz only. For other frequencies the values have to be adapted accordingly.



The balancing impedance shall be equal to the impedance of the equipment under test (EUT) to ensure the measurement accuracy.

The balancing impedance could most conveniently be a meter of the same type as the EUT.

The rectifier diodes shall be of the same type.

To improve the balancing condition an additional resistor R_B can be introduced in both paths. Its value should be approximately 10 times the value of the EUT.

Figure A.1 – Test circuit diagram for half-wave rectification

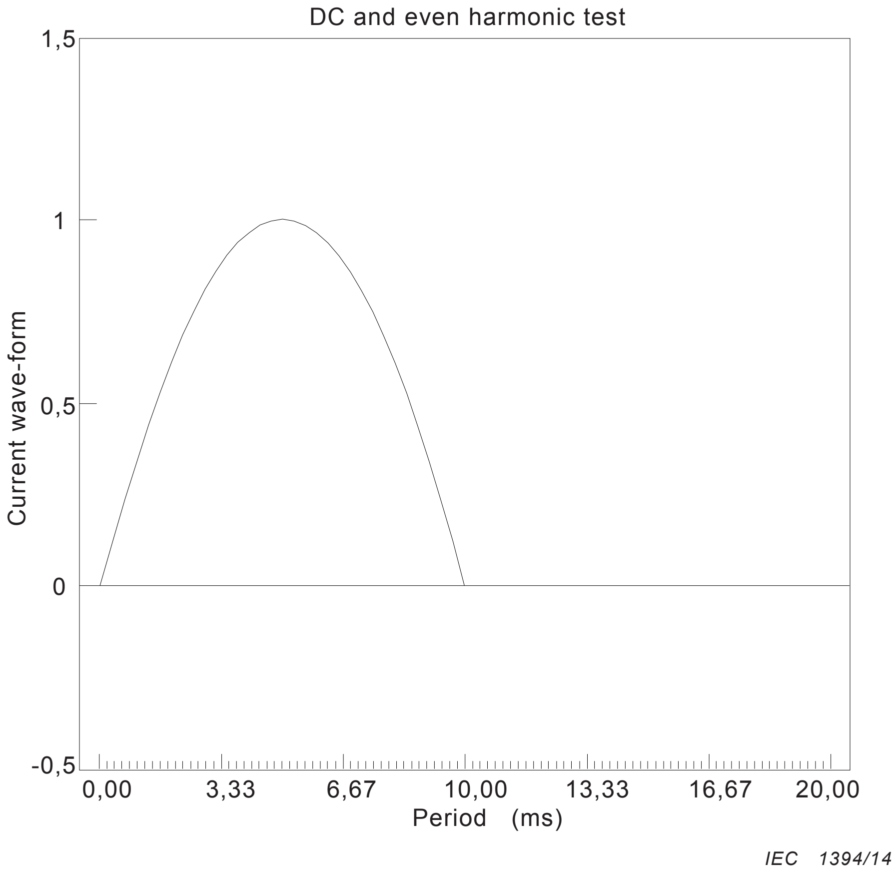


Figure A.2 – Half-wave rectified waveform

Annex B
(normative)

Electromagnet for testing the influence of externally produced magnetic fields

Scale 1:1 (all dimensions are in millimetres)

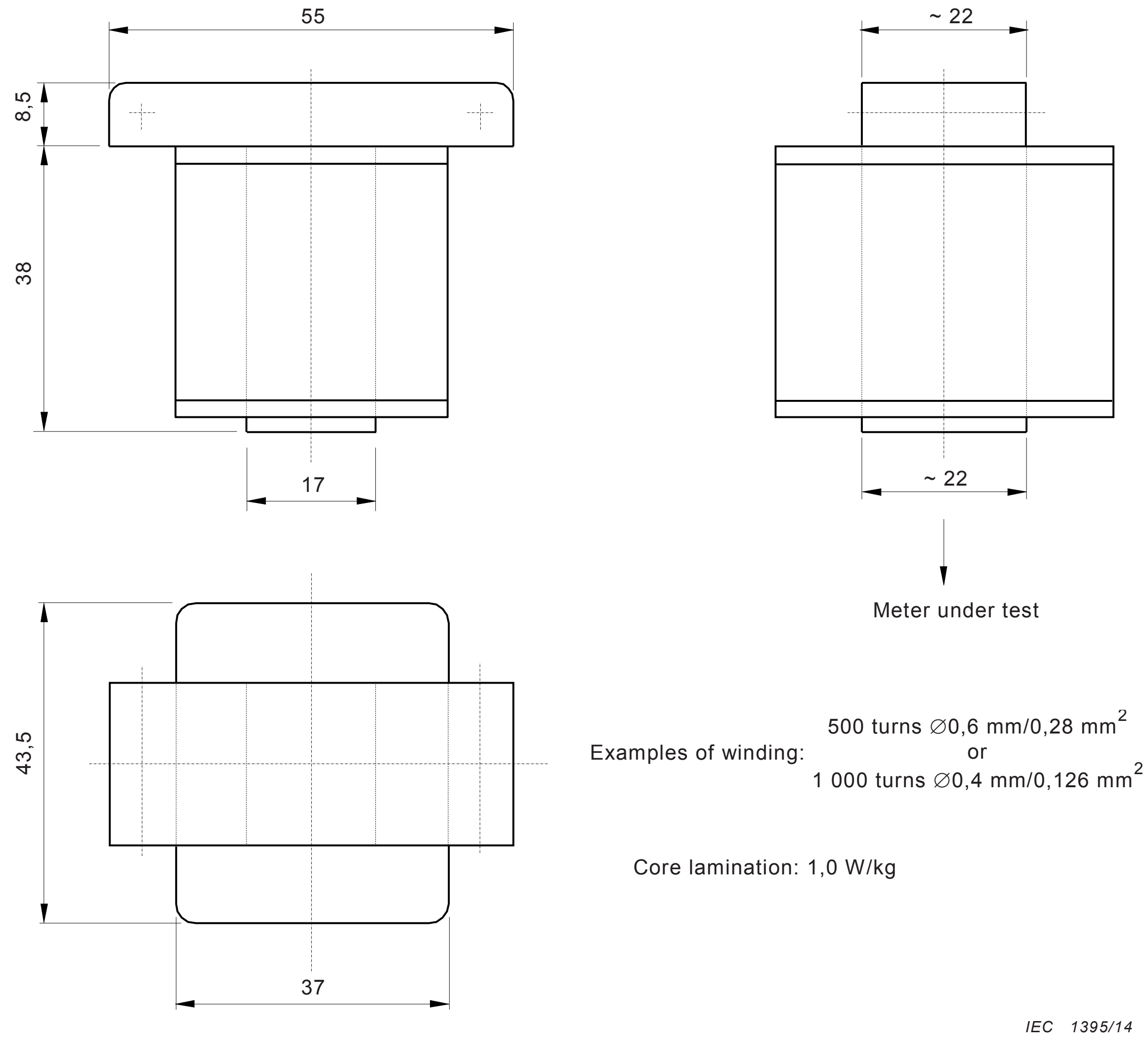
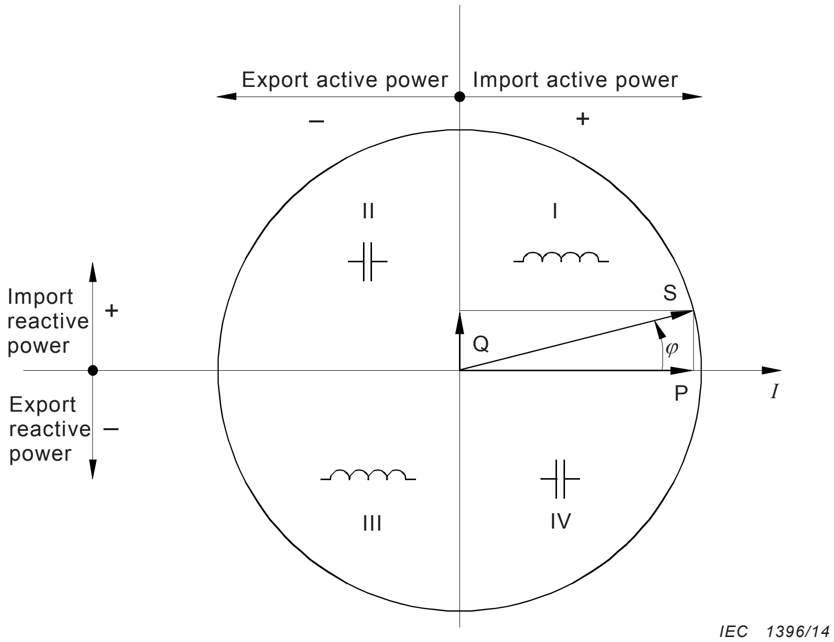


Figure B.1 – Electromagnet for testing the influence of externally produced magnetic fields

Annex C
(informative)

Geometric representation of active and reactive power

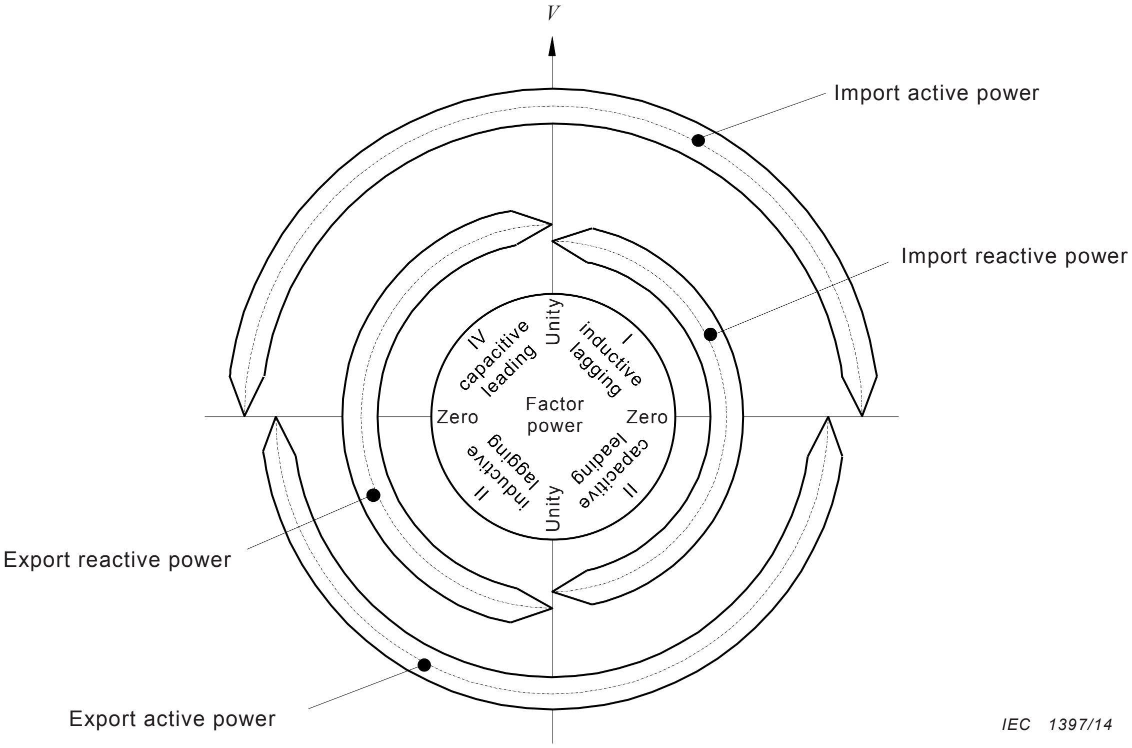


NOTE 1 Reference of this diagram is the current vector (fixed on right-hand line).

NOTE 2 The voltage vector V varies its direction according to the phase angle φ.

NOTE 3 The phase angle φ between voltage V and current I is taken to be positive in the mathematical sense (counter clockwise).

Figure C.1 – Recommended geometric representation



NOTE 1 If the upright line is taken as the voltage vector and a line is drawn to represent the current vector of a single-phase or a balanced three-phase system, this current vector will indicate the condition of the other quantities.

NOTE 2 Reference of this diagram is the voltage vector V (fixed on upright line).

NOTE 3 The current vector I varies its direction according to the phase angle φ.

NOTE 4 The phase angle φ between current I and voltage V is taken to be positive in the clockwise direction.

Figure C.2 – Alternative geometric representation

Annex D
(informative)

Effect of phase displacement

D.1 Phase displacement and matching of current transformers and meters for reactive energy

In usual operating conditions, the power factor on the electricity distribution network is above cos φ = 0,8. This means that sin φ is normally less than 0,6. Therefore, the performance at low sin φ is crucial for a meter measuring reactive energy. In order to meet the accuracy requirements of this standard, a reactive energy meter shall have a low phase displacement, similar to the phase displacement of a meter for active energy of accuracy class one step better. For example, the phase displacement of a reactive energy meter of accuracy class 1 S should be similar to that of an active energy meter of accuracy class 0,5 S. With this, the measurement error will not much exceed ± 1 % in the normal operating range between sin φ = 0,6 and sin φ = 0,2. Likewise, the phase displacement of a reactive energy meter of accuracy class 0,5 S should be similar to that of an active energy meter of accuracy class 0,2 S.

In the case of transformer connected meters, the phase displacement of the transformer comes also into play when considering the accuracy of the metering system. The phase displacement of current transformers of various accuracy classes at 100 % of the rated current is shown in Table D.1. The values are from IEC 61869-2:2012 Tables 201 and 202.

Table D.1 – Limits of phase displacement for measuring current transformers and corresponding measurement error for reactive energy measurement

Accuracy class	± Phase displacement at 100 % of rated current		Reactive energy measurement error contribution at sin φ = 0,5	Reactive energy measurement error contribution at sin φ = 0,2
	Minutes	Centi-radians		
1	60	1,8	3,0 %	8,5 %
0,5 S	30	0,9	1,5 %	4,3 %
0,2 S	10	0,3	0,5 %	1,4 %

If a reactive energy meter of accuracy class 1 would be used with a current transformer of accuracy class 1, this would cause up to ± 3 % measurement error at sin φ = 0,5 and ± 8,5 % at sin φ = 0,2; this would not be acceptable.

For this reason, this standard recommends using:

- class 0,5 S current transformers or better with class 1 S current transformer operated reactive energy meters; and
- class 0,2 S current transformers with class 0,5 S current transformer operated reactive energy meters.

A note has been added in Table 6 and Table 7 to this end.

Annex E
(informative)

Treatment of harmonics and tests for harmonics

E.1 Non-sinusoidal conditions and reactive power definition

Many meter types designed prior to the establishment of this standard exhibit large differences in metered reactive energy under non-sinusoidal conditions (in the presence of harmonics).

Earlier standards for electricity meters for reactive energy were based on a definition of reactive energy for sinusoidal currents and voltages. Consequently, they could not specify any requirements for the performance under non-sinusoidal conditions.

In order to ensure that the differences in measurement results between different meter types remain within reasonable limits, it is necessary to base the standard on a definition of reactive energy that allows including performance requirements in the presence of harmonics.

There are many definitions available for reactive, or non-active, power under non-sinusoidal conditions. Some of them are more theoretical, some are very suitable for some particular applications, but none of them have the same wide usefulness as the definition of reactive energy under sinusoidal conditions.

A wide consensus on a single definition of reactive power under non-sinusoidal conditions, suitable for a wide spectrum of applications is not expected in the foreseeable future.

This standard defines reactive power for the fundamental components of voltage and current, see Clause 3.

This reactive power will to a great extent reflect the generally unnecessary current flowing in the distribution network due to a phase angle displacement of the load current, which can be cancelled by introducing a correcting device such as a capacitor. This is considered to be one of the most important applications of reactive energy metering.

This definition does not reflect the unnecessary harmonic current flowing in the distribution network; it is believed that the harmonic current should be handled separately from the phase displacement current. One reason is that the phase angle of the fundamental component of the load current is most often a direct property of the load; it is most often inductive and will add in the network. In contrast, harmonic currents are more due to a combination of load and source properties and can to a great extent be affected by neighbouring loads. Harmonics have no particular phase angle and do rather average out than add in the network. This makes billing for harmonic current controversial.

Additional standards for meters for non-active energy based on other definitions may be developed in the future.

E.2 Tests for accuracy under non-sinusoidal conditions

As this standard requires that meters for reactive energy measure the fundamental component only, a test with harmonics has been specified, to verify that the influence of the harmonics does not exceed the limits of variation in percentage error specified. This is especially important, as it is known that that the behaviour of meters implementing different algorithms may be very different when harmonics are present.

The test was chosen:

a) to ensure testability;
b) to take into account the possibilities of test equipment currently available;
c) to ensure reproducibility of the tests.

E.3 Fifth harmonic test

The test chosen specified in 8.3.4 is similar to the one specified in IEC 62053-23 for meters for active energy.

The test is made with harmonics present both in the voltage and the current. This allows discriminating between meters measuring fundamental reactive energy correctly and meters which are not.

Meters not appropriately filtering harmonics will fail the test with the 5^{th} harmonic. This ability to discriminate between acceptable and not acceptable designs depends on the allowed variation in percentage error. If it was chosen to be ± 4,5 %, most meters based on phase shift or time shift would pass since the “harmonic reactive power” of the test is 4 %. This standard specifies ± 2,5 % for all accuracy classes. To meet this requirement, meters shall have some sort of harmonic filtering.

Since the test is very similar to the test specified for meters of active energy, most test sources can provide the test current and voltage required.

It has to be verified, that the reference standard meter measures the fundamental reactive power only. At the time when this standard was drafted, there were quite a few reference standard meter types that could meet this requirement. In addition, watt meters and power quality meters measuring fundamental reactive power are available. The var indication of these instruments can be used for comparison with the metrology LED, if the test source is stable. Because of the current range limitation of these instruments the test current for direct connected meters has been chosen to be I_b.

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