BS EN 50564:2011

BSI Standards Publication

Electrical and electronic household and office equipment — Measurement of low power consumption

bsi.

National foreword

This British Standard is the UK implementation of EN 50564:2011. It was derived from IEC 62301:2011. It supersedes BS EN 62301:2005 which will be withdrawn on 3 March 2014.

The UK participation in its preparation was entrusted to Technical Committee CPL/59, Performance of household electrical appliances.

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.

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Electrical and electronic household and office equipment - Measurement of low power consumption
(IEC 62301:2011, modified)

Appareils électriques et électroniques pour application domestique et équipement de bureau - Mesure de la consommation faible puissance
(CEI 62301:2011, modifiée)

Elektrische und elektronische Hauhalts- und Bürogeräte - Messung niedriger Leistungsaufnahmen
(IEC 62301:2011, modifiziert)

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

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CENELEC

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Foreword

This European Standard was prepared by Technical Committee CENELEC TC 59X, Performance of household and similar electrical appliances.

A draft amendment covering common modifications towards IEC 62301:2011, prepared by the Technical Committees CENELEC TC 59X, Performance of household and similar electrical appliances and CENELEC TC 108X, Safety of electronic equipment within the fields of audio/video, information technology and communication technology, was submitted to the formal vote.

The combined texts were approved by CENELEC as EN 50564 on 2011-03-03.

This European Standard supersedes EN 62301:2005.

The following dates were fixed:

– latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2012-03-03
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2014-03-03

Clauses, subclauses, notes, tables and figures which are additional to those in IEC 62301:2011 are prefixed “Z”.

This European standard was prepared under standardisation mandate M/439. To fulfill the requirements of the mandate the scope of EN 50564 had to be broadened in comparison with IEC 62301:2011 to cover a range of electrical and electronic household and office equipment. This is reflected in the title of EN 50564 in comparison with the title of IEC 62301:2011.

In this European Standard, the common modifications to the International Standard are indicated by a vertical line in the left margin of the text.

Words in **bold** in the text are defined in Clause 3 Terms and definitions.

Introduction

The methods defined in this European Standard are intended to define requirements for the measurement of low power. This standard may be used in support of other, more specific, product standards where it is required to measure power consumption.

The aim of the common modification is to ensure this European Standard is compatible with the objectives of EU legislation for ecodesign and for energy labeling.

Since the **mode** definitions are given in the relevant EU regulation they are not contained in this standard. Additional product specific **mode** definitions might be given in more specific product standards.

Contents

1 Scope

This European Standard specifies methods of measurement of electrical power consumption and the reporting of the results for a range of electrical and electronic household and office equipment, hereafter referred to as products.

This standard

– addresses issues associated with measuring electrical power, in particular low power (in the order of a few Watts or less), consumed by mains powered products,

– describes in detail the requirements for testing single phase products with a rated input voltage in the range of 100 V a.c. to 250 V a.c. but it may, with some adaptations, also be used with three phase products,

– may also be of assistance in determining the energy efficiency of products in conjunction with other, more specific, product standards.

The value of energy consumed will depend on the operating **mode** of the product under test, for instance whether the equipment is in an **off mode**, in a **standby mode** or in an **active mode**. This standard does not specify these **modes** and so it is not possible to use this standard on its own. Instead, it provides a method of measurement with a variety of **modes** which are defined elsewhere.

This standard does not

– specify safety requirements,

– specify minimum performance requirements,

– set maximum limits on power or energy consumption,

– contain limit values or procedures for verifying compliance with regulatory requirements.

NOTE Z1 This standard has been written in particular to support EC Commission Regulation n° 1275/2008 for the measurement of **off mode** and s**tandby mode** power consumption. This standard specifies methods of measurement of electrical power consumption in **standby mode(s)** and other **low power modes** (**off mode**), as applicable.

NOTE Z2 This standard is applicable to electrical products with a rated input voltage of 230 V a.c. for single phase products and 400 V a.c. for three phase products.

NOTE Z3 The measurement of energy consumption and performance of products during intended use are generally specified in more specific product standards and are not covered by this standard.

NOTE Z4 The term “products” in this standard includes household appliances or information technology products, consumer electronics, audio, video and multimedia systems, however the measurement methodology could be applied to other products.

NOTE Z5 Where this standard is referenced by more specific standards or procedures, these should define and name the relevant conditions to which this test procedure is applied.

2 Normative references

The following referenced documents are indispensable for the application 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 60050-131, *International Electrotechnical Vocabulary (IEV) – Part 131: Circuit theory*

IEC 60050-300, *International Electrotechnical Vocabulary (IEV) – Electrical and electronic measurements and measuring instruments – Part 311: General terms relating to measurements – Part 312: General terms relating to electrical measurements – Part 313: Types of electrical measuring instruments – Part 314: Specific terms according to the type of instrument*

3 Terms and definitions

For the purposes of this document, the terms and definitions contained in IEC 60050-131 and IEC 60050-300 as well as the following definitions apply.

3.1
function
a predetermined operation undertaken by the energy using product. **Functions** may be controlled by an interaction of the user, of other technical systems, of the system itself, from measurable inputs from the environment and/or time

In this standard, **functions** are grouped into 3 main types:

- user oriented secondary **functions** (see 3.6 - **standby mode**)
- primary **functions** (see 3.8 - **active mode**, which is not the focus of this standard)
- other **functions** (these **functions** do not affect the **mode** classification).

NOTE Accurate recording and documentation of **functions** in the relevant **product mode** is a key element of documentation in this standard (see 6.3). **Function** types are generally classified as primary or secondary (remote, network, sensing and protective).

3.2
mode
a state that has no **function**, one **function** or a combination of **functions** present

NOTE 1 The **low power mode** categories in this standard are intended to provide guidance for the development of specific **mode** definitions for TC59 products by the relevant subcommittees.

NOTE 2 Void.

NOTE 3 See Annex C for examples of how to calculate total energy consumption from power measurements where the duration of each relevant **mode** is known.

3.3
product mode
mode where the **functions** present, if any, and whether these are activated, depend on the particular product configuration

NOTE The issue of devising appropriate names for **product modes** is a matter for the relevant product committees. While a **product mode** name should generally reflect the **functions** that are activated, they need not contain the terms “standby” even where the **product mode** falls within that **mode** category.

3.4
low power mode
a **product mode** that falls into one of the following broad **mode** categories:

- **off mode**(s)
- **standby mode**(s)

NOTE Z1 Refer to relevant legislation or a more specific product standard. This term is not defined in EC Commission Regulation n° 1275/2008.

NOTE 1 **Low power modes** are classified into one of the **mode** categories above (where applicable) on the basis of the **functions** that are present and activated in each relevant **mode**. Where other **functions** are present in a **product mode** (in addition to the ones required for the **mode** categories specified above), these **functions** do not affect the **mode** classification.

NOTE 2 **Low power mode** categories are defined in order to provide guidance to users of this international standard and to provide a consistent framework for the development of **low power modes**.

NOTE 3 Any transition that occurs between **modes**, either through user intervention or automatically, is not considered to be a **mode**.

NOTE 4 Not all **low power mode** categories are present on all products. Some products may have more than one **product mode** in each of the **low power mode** categories with different combination of **functions** activated. The power consumption in each **low power mode** depends on the product design and the **functions** which are activated in the particular **product mode**.

3.5
off mode(s)
void

NOTE Z1 Refer to relevant legislation or a more specific product standard.

NOTE Z2 EC Commission Regulation n° 1275/2008 states:
" '**off mode**' means a condition in which the equipment is connected to the mains power source and is not providing any **function**; the following shall also be considered as **off mode**:

a) conditions providing only an indication of **off mode** condition;

b) conditions providing only functionalities intended to ensure electromagnetic compatibility pursuant to Directive 2004/108/EC of the European Parliament and of the Council"

3.6
standby mode(s)
void

NOTE Z1 Refer to relevant legislation or a more specific product standard

NOTE Z2 EC Commission Regulation n° 1275/2008 states:
" '**standby mode(s)**' means a condition where the equipment is connected to the mains power source, depends on energy input from the mains power source to work as intended and provides **only** the following **functions**, which may persist for an indefinite time:

– reactivation **function**, or reactivation **function** and only an indication of enabled reactivation **function**, and/or information or status display"

3.7
void

3.8
active mode(s)
void

NOTE Z1 Refer to relevant legislation or a more specific product standard

NOTE Z2 EC Commission Regulation n° 1275/2008 states:
" '**active mode(s)**' means a condition in which the equipment is connected to the mains power source and at least one of the main **function(s)** providing the intended service of the equipment has been activated"

3.9
void

3.10
rated voltage
supply voltage (range) designated by the manufacturer

3.11
rated frequency
supply frequency (range) designated by the manufacturer

3.12
instructions for use
information that is provided for users of the product

NOTE **Instructions for use** would include a user manual and may be in paper or electronic form. **Instructions for use** do not include any special directions provided by the product supplier to the test laboratory especially for testing purposes.

4 General conditions for measurements

4.1 General

Unless otherwise specified, measurements shall be made under the test conditions and with measuring instruments specified in 4.2 to 4.4.

NOTE The measuring accuracy and consequently total measurement uncertainty depend not only on the specification of the individual equipment but also their combination. Some combinations of power source and power measurement equipment, which individually meet their respective specifications, are known to give anomalous readings with capacitive loads. This could be caused by, for example, the power supply having high frequency components above the 13^{th} harmonic.

4.2 Test room

The tests shall be carried out in a room that has an air speed close to the product under test of ≤0,5 m/s. The ambient temperature shall be maintained at (23 ± 5) °C throughout the test.

Where the product has an ambient light sensor that affects the power consumption, the test shall be carried out with controlled ambient light conditions. Where the illuminance levels are externally defined (in a test procedure or in the **instructions for use**), these values shall be used. Where no illuminance levels are stated or defined, reference illuminance levels of >300 lx and <10 lx shall be used.

Information on the method used to achieve the above illuminance levels, where relevant, shall be recorded in the test report (see 6.3). Where values of illuminance are given, they shall be measured as close to the product's light sensor as practical.

NOTE The measured power for some products and **modes** could be affected by the ambient conditions (e.g. illuminance, temperature).

4.3 Power supply

4.3.1 Supply voltage and frequency

Where this standard is referenced by a regulation or more specific product standard that specifies a voltage and frequency to be used during measurement, the test voltage and frequency so defined shall be used for all tests.

For single phase products, unless otherwise specified by a regulation or a more specific product standard, the voltage and frequency of the supply shall be:

- 230 V ± 1%,
- 50 Hz ± 1%.

NOTE Z1 A stabilised power supply may be required to meet these requirements.

For three-phase products, unless otherwise specified by a regulation or more specific product standard, the voltage and frequency of the supply shall be:

- 400 V ± 1%,
- 50 Hz ± 1%.

NOTE Z2 A stabilised power supply may be required to meet these requirements. Some stabilised power supplies have high frequency components and in such cases it is strongly recommended to use an artificial mains network between the power supply and the power measuring instrument, as described in B.4.2. Where an artificial mains network is used it should have a nominal impedance of 50 Ω/50 μH or 50 Ω/50 μH + 5 Ω as defined in EN 55016-1-2.

4.3.2 Supply voltage waveform

The total harmonic content of the supply voltage when supplying the product under test in the specified **mode** shall not exceed 2 % (up to and including the 13th harmonic); harmonic content is defined as the root-mean-square (r.m.s.) summation of the individual components using the fundamental as 100 %. The value of the harmonic content of the voltage supply shall be recorded during the test and reported (see 6.3).

In addition to the above, the ratio of peak value to r.m.s. value of the test voltage (i.e. crest factor) when supplying the product under test shall be between 1,34 and 1,49.

NOTE Power supplies meeting EN 61000-3-2 are likely to meet the above requirements.

4.4 Power measuring instruments

NOTE Many power meters can also record harmonic content, as required by 4.3.2.

4.4.1 Power measurement uncertainty

This section covers the requirements for uncertainty introduced by the instrument that measures the input power to the product under test, including any external shunts.

The maximum permitted uncertainty of measurement depends on the size of the load and the characteristics of the load. The key characteristic of the load used to determine the maximum permitted uncertainty is the Maximum Current Ratio (MCR), which is calculated as follows:

$$\text{Maximum Current Ratio (MCR)} = \frac{\text{Crest Factor (CF)}}{\text{Power Factor (PF)}}$$

where

- the Crest Factor (CF) is the measured peak current drawn by the product divided by the measured r.m.s. current drawn by the product;
- the Power Factor (PF) is a characteristic of the power consumed by the product. It is the ratio of the measured real power to the measured apparent power.

a) Permitted uncertainty for values of MCR ≤10

For measured power values of greater than or equal to 1,0 W, the maximum permitted relative uncertainty introduced by the power measurement equipment, U_{mr}, shall be equal to or less than 2 % of the measured power value at the 95 % confidence level.

For measured power values of less than 1,0 W, the maximum permitted absolute uncertainty introduced by the power measurement equipment, U_{ma}, shall be equal to or less than 0,02 W at the 95 % confidence level.

b) Permitted uncertainty for values of MCR >10

The value of U_{pc} shall be determined using the following equation:

$$U_{pc} = 0{,}02 \times [1 + (0{,}08 \times \{MCR - 10\})]$$

where U_{pc} is the maximum permitted relative uncertainty for cases where the MCR is > 10.

For measured power values of greater than or equal to 1,0 W, the maximum permitted relative uncertainty introduced by the power measurement equipment shall be equal to or less than U_{pc} at the 95 % confidence level.

For measured power values of less than 1,0 W, the permitted absolute uncertainty shall be the greater of U_{ma} (0,02 W) or U_{pc} when expressed as an absolute uncertainty in W ($U_{pc} \times$ measured value) at the 95 % confidence level.

NOTE 1 It is preferred that the power measuring instrument detects, indicates, signals and records any “out of range” conditions.

NOTE 2 See Annex D and the *Guide to the Expression of Uncertainty in Measurement (GUM)* for further details.

NOTE 3 Although a specification for the power meter in terms of allowable crest factor is not included here, it is important that the peak current of the measured waveform does not exceed the permitted measurable peak current for the range selected, otherwise the uncertainty requirements above will not be achieved. See B.1.2 for an example calculation for U_{pc} and for more information.

NOTE Z1 Clause B.1 explains why certain load types can result in increased uncertainty.

For products connected to more than one phase, the power measuring instrument shall be capable of measuring the total power of all phases connected.

Where the power is measured using the accumulated energy method (see 5.3.3) the calculated power measurement uncertainty shall meet the above requirements.

4.4.2 Power measurement frequency response

The power measuring instrument shall be capable of meeting the requirements of 4.4.1 when measuring the following:

- DC
- AC with a frequency from 10 Hz to 2 000 Hz.

NOTE If the power meter contains a bandwidth limiting filter, it should be capable of being taken out of the measurement circuit.

4.4.3 Power measurement long term averaging requirement

Where it is necessary to perform measurements in accordance with 5.3.3, the power measuring instrument shall either be capable of

– measuring the average power over any operated selected time interval, or;
– integrating energy over any operator selected time interval.

NOTE A data recording capability (sampling) or output to a computer or data recorder is the most desirable capability as required by 5.3.2 – see B.2.5 for further information.

5 Measurements

5.1 General

The purpose of this test method is to determine the power consumption in the relevant **product mode**, which is either persistent or of a limited duration. A **mode** is considered to be persistent where the power level is constant or where there are several power levels that occur in a regular sequence for an indefinite period of time.

NOTE 1 During transition from one **mode** to another (either automatic or user initiated) some products could wait in a higher power state while transition tasks are performed or circuits are energized or de-energized, so they can take some time to enter a stable state.

NOTE 2 Where the **product mode** changes automatically it can sometimes be necessary to operate a product through the automatic sequence several times on a trial basis to ensure that sequence is fully understood and documented before test results are recorded and reported. A sequence of separate **product modes** could also exhibit a regular ongoing pattern of power levels. See Annex B for further guidance.

NOTE 3 While limited duration **modes** may be documented using measurements to this standard, the results for such **modes** should be reported as an energy consumption (Wh) and duration. A **product mode** that is stable should persist without any user intervention.

5.2 Preparation of product

Tests in this standard are to be performed on a single product.

The product shall be prepared and set up in accordance with the **instructions for use**, except where these conflict with the requirements of this standard and / or the relevant product performance standard. If no **instructions for use** are available, then factory or “default” settings shall be used, or where there are no indications for such settings, the product is tested as supplied.

NOTE An appropriate product standard would be, for example, IEC 60436 (dishwashers) or EN 60456 (washing machines).

Once a product has been selected and is ready for testing, the following steps shall be followed and documented in the test report as applicable:

- remove the product from packaging (where applicable);
- read the **instructions for use** and configure the product in accordance with these instructions;
- determine if the product contains a sensor affecting the measurement result, e.g. an ambient light sensor;
- determine if the product contains a battery and whether the product contains circuitry for recharging a rechargeable battery. Reference shall be made to determine whether there is a legal provision which specifies the conditions to be applied, otherwise the following shall apply. For products containing a recharging circuit, the power consumed in
  - **off mode** and **standby mode** shall be measured after precautions have been taken to ensure that the battery is not being charged during the test, e.g. by removing the battery where this is possible, or ensuring that the battery is kept fully charged if the battery is not removable;
  - a maintenance **mode** shall be measured with the batteries installed and fully charged before any measurements are undertaken.
- refer to the relevant product test procedure, external requirement (e.g. regulation) or **instructions for use** that specifies the **product mode(s)** to test (where applicable). The **product modes** tested should be consumer relevant and representative of expected normal use. Where **instructions for use** provide configuration options, each relevant option should be separately tested. **Active mode(s)** should be measured in accordance with the relevant performance standard for the product;
- undertake testing on relevant **product modes** in accordance with Subclause 5.3;
- classify each of the **product modes** tested into one of the **low power mode** categories (see Subclause 3.4) or other **mode** as applicable.

5.3 Procedure

5.3.1 General

Within this standard, power consumption shall be determined by

- the sampling method: by the use of an instrument to record power measurements at regular intervals throughout the measurement period (see 5.3.2). Sampling is the preferred method of measurement for all **modes** and product types under this standard.

For **modes** where power varies in a cyclic fashion or is unstable, or for limited duration **modes**, sampling is the only measurement method permitted under this standard; or

– the average reading method: where the power value is stable and the **mode** is stable, by averaging the instrument power readings over a specified period or, alternatively by recording the energy consumption over a specified period and dividing by the time (see 5.3.3 for details of when this method is valid); or
– the direct meter reading method: where the power value is stable and the **mode** is stable, by recording the instrument power reading (see 5.3.4 for details of when this method is valid).

NOTE Determination of an average power from accumulated energy over a time period is equivalent. Energy accumulators are more common than **functions** to average power over an operator specified period.

5.3.2 Sampling method

This methodology shall be used where either the power is not stable (cyclic or unstable) or the **mode** is of limited duration. It also provides the fastest test method when the **mode** is stable. However, it may also be used for all **modes** and is the recommended approach for all measurements under this International standard. It should be used if there is any doubt regarding the behaviour of the product or stability of the **mode**.

Connect the product to the power supply and power measuring instrument. Select the **product mode** to be measured (this could require a sequence of operations, including waiting for the product to automatically enter the desired **mode**) and commence recording the power. Power readings, together with other key parameters such as voltage and current, shall be recorded at equal intervals of not more than 1 s for the minimum period specified.

NOTE 1 Data collection at equal intervals of 0,25 s or faster is recommended for loads that are unsteady or where there are any regular or irregular power fluctuations.

Where the power consumption within a **mode** is not cyclic, the average power is assessed as follows:

– the product shall be energised for not less than 15 min; this is the total period;
– any data from the first one third of the total period is always discarded. Data recorded in the second two thirds of the total period is used to determine stability;
– establishment of stability depends on the average power recorded in the second two thirds of the total period. For input powers less than or equal to 1 W, stability is established when a linear regression through all power readings for the second two thirds of the total period has a slope of less than 10 mW/h. For input powers of more than 1 W, stability is established when a linear regression through all power readings for the second two thirds of the total period has a slope of less than is 1 % of the measured input power per hour.
– where a total period of 15 min does not result in the above stability criteria being satisfied, the total period is continuously extended until the relevant criteria above is achieved (in the second two thirds of the total period).
– once stability is achieved, the result is taken to be the average power consumed during the second two thirds of the total period.

NOTE 2 If stability cannot be achieved within a total period of 3 h, the raw data should be assessed to see whether there is any periodic or cyclic pattern present.

Modes that are known (based on **instructions for use**, specifications or measurements) to be non-cyclic and of varying power consumption shall be recorded for a long enough period so that the cumulative average of all data points taken during the second two thirds of the total period fall within a band of ±0,2 %. When testing such **modes**, the total period shall not be less than 60 min.

Where the power consumption within a **mode** is cyclic (i.e. a regular sequence of power states that occur over several minutes or hours), the average power over a minimum of four complete cycles is assessed as follows:

– the product shall be energised for an initial operation period of not less than 10 min. Data during this period is not used to assess the power consumption of the product;

– the product is then energised for a time sufficient to encompass two comparison periods, where each period shall include not less than two cycles and have a duration of not less than 10 min (comparison periods must contain the same number of cycles);

– calculate the average power for each comparison period;

– calculate the mid-point in time of each comparison period in hours;

– stability is established where the power difference between the two comparison periods divided by the time difference of the mid-points of the comparison periods has a slope of less than

  - 10 mW/h, for products where the input powers is less than or equal to 1 W; or
  - 1 % of the measured input power per hour, for products where the input powers is greater than 1 W.

– where the above stability criteria is not satisfied, additional cycles are added equally to each comparison period until the relevant criteria above is achieved;

– once stability is achieved, the power is determined as the average of all readings from both comparison periods.

Where cycles are not stable or are irregular, sufficient data shall be measured to adequately characterise the power consumption of the **mode** (a minimum of 10 cycles is recommended).

NOTE 3 In all cases it is recommended that power for the period where data is recorded be represented in graphical form to assist in the establishment of any warm up period, cyclic pattern, instability and stability period.

Modes that are known (based on **instructions for use**, specifications or measurements) to be of limited duration shall be recorded for their whole duration. The results for such **modes** shall be reported as an energy consumption (Wh) and duration together with a statement that the **mode** is of limited duration.

NOTE 4 The product is not required to operate for a minimum initial period before data measurements are recorded when performing the above test.

For products where a series of separate **product modes** occur in a regular pattern, the power level for each **mode** shall be determined in accordance with this clause and the known sequence and duration of each **mode** in the pattern documented. See Annex B for further guidance.

5.3.3 Average reading method

This method is not permitted for cyclic loads or limited duration **modes**.

NOTE 1 A shorter measurement period may be possible using the sampling method – see 5.3.2.

Connect the product to the power supply and power measuring instrument. Select the **mode** to be measured (this may require a sequence of operations and it could be necessary to wait for the product to automatically enter the desired **mode**) and monitor the power. After the product has been allowed to stabilize for at least 30 min for domestic appliances and 10 min for other products, unless otherwise specified in a more specific product standard, assess the stability of two adjacent measurement periods. The average power over the measurement periods is determined using either the ***average power*** or ***accumulated energy*** methods as follows:

– select two comparison periods, each made up of not less than 10 min duration (periods shall be approximately the same duration), noting the start time and duration of each period;
– determine the average power for each comparison period;
– stability is established where the power difference between the two comparison periods divided by the time difference of the mid-points of the comparison periods has a slope of less than
  - 10 mW/h, for products where the input powers is less than or equal to 1 W; or
  - 1 % of the measured input power per hour, for products where the input powers is greater than 1 W.
– where the above stability criteria is not satisfied, longer periods of approximately equal duration are added until the relevant criteria above is achieved;
– once stability is achieved, the power is determined as the average of readings from both comparison periods;
– where stability cannot be achieved with comparison periods of a 30 min duration each, the sampling method in 5.3.2 shall be used.

Average power approach: where the power measuring instrument can record a true average power over an operator selected period, the period selected shall not be less than 10 min.

Accumulated energy approach: where the power measuring instrument can measure energy over an operator selected period, the period selected shall not be less than 10 min. The integrating period shall be such that the total recorded value for energy and time is more than 200 times the resolution of the meter for energy and time. Determine the average power by dividing the measured energy by the time for the monitoring period.

NOTE 2 To ensure consistent units, it is recommended that watt-hours and hours be used above, to give watts.

NOTE 3 Example 1 – if an instrument has a time resolution of for example 1 s, then a minimum of 200 s (3,33 min) is required for integration on such an instrument.

NOTE 4 Example 2 – if an instrument has an energy resolution of for example 0,1 mWh, then a minimum of 20 mWh is required for the accumulation of energy on such an instrument (at a load of 0,1 W this would take about 12 min, at 1 W this would take 1,2 min). Note that both the time and energy resolution requirements should be satisfied by the reading, as well as the minimum recording period specified above (10 min).

5.3.4 Direct meter reading method

The direct meter reading method may only be used where the **mode** does not change and the power reading displayed on the measuring instrument is stable. This method shall not be used for verification purposes. Any result using the methods specified in 5.3.2 or 5.3.3 have precedence over results using this method in the case of a dispute.

NOTE A shorter measurement period may be possible using the sampling method – see 5.3.2.

Power consumption using the direct reading method is assessed as follows:

– connect the product to be tested to the power supply and measuring instrument, and select the **mode** to be measured;
– allow the product to operate for at least 30 min. If the power appears to be stable, take a power measurement reading from the instrument. If the reading still appears to be varying the 30 min period is extended until stability appears to have occurred;
– after a period of not less than 10 min, take an additional power measurement reading and note the time between the power measurement readings in hours;
– the result is the average of the two readings, providing that the difference in power between the two readings divided by the time interval between readings is less than
  - 10 mW/h, for products where the input powers is less than or equal to 1 W, or;

- 1 % of the measured input power per hour, for products where the input powers is greater than 1 W.

– where the relevant criterion above is not met the direct meter reading method shall not be used.

6 Test report

NOTE An example template for the test report is provided in Annex ZA.

6.1 Product details

The following information shall be recorded in the test report.

- Brand, model, type, and serial number
- Product description, *as appropriate*
- **Rated voltage**(s) and **frequency** (frequencies)
- Details of manufacturer marked on the product (if any)
- Source of information used to establish **product modes** (**instructions for use**) and a technical justification, where applicable, regarding the selection of the **modes** measured and any **modes** excluded.

In the case of products with multiple **functions** or with options to include additional modules or attachments, the configuration of the product as tested shall be noted in the report.

6.2 Test parameters

The following values shall be achieved and recorded during the test. If the values change during the test, the minimum and maximum values shall be recorded.

- Ambient temperature (°C)
- **Test voltage**(s) (V) and **frequency** (frequencies) (Hz)
- Total harmonic distortion of the electricity supply system
- Information and documentation on the instrumentation, set-up and circuits used for electrical testing.

6.3 Measured data, for each product mode as applicable

The following information shall be recorded in the test report:

- description of the **product mode** and documentation on the user oriented and other **functions** that are active and provide a description of how the **mode** was activated;
- sequence of events to reach the **mode** where the product automatically changes **modes**;
- average power in watts rounded to the second decimal place. For loads greater than or equal to 10 W, at least three significant figures shall be reported;
- calculated uncertainty of the result due to the measuring instrument (Ue)(see Annex D) and whether the result complies with 4.4.1;
- measurement method used (see 5.3.2, 5.3.3 or 5.3.4). In the case of 5.3.3, indicate whether average power or accumulated energy approach was used;
- sampling interval, total duration of measurements and stability period (5.3.2 if applicable);
- accumulated energy and period of measurement (seconds/minutes/hours) (5.3.3 if applicable);

- energy and duration of any **modes** of limited duration. Documentation describing the pattern (or patterns) for **modes** that automatically repeat sequentially;
- any notes regarding the operation of the product;
- record ambient conditions such as illuminance levels during the measurement where these affect the power reading;
- classification of the measured **product mode** into one of the relevant **mode** categories in Clause 3, or other **mode** as applicable.

NOTE 1 Apparent power (VA), real power factor and crest factor are also useful parameters and are recommended for inclusion in the test report. Presentation of data collected by sampling in graphical format is recommended.

NOTE 2 It is recommended that total uncertainty of the result (U_{total}) also be calculated and reported (see Annex D).

6.4 Test and laboratory details

The following information shall be recorded in the test report:

- test report number/reference
- date of test
- laboratory name and address
- test officer(s)

Annex A

(Void)

Annex B
(informative)

Notes on the measurement of low power modes

B.1 Low power measurement issues

B.1.1 General

There are a number of problems associated with power measurement of very small loads that are typically found in **low power modes** (typically less than 10 W). These mostly relate to the ability of the power measuring instrument to respond correctly to non sinusoidal current waveforms that are often presented in **low power modes**. Key points for consideration are discussed briefly below.

The intent of this standard is to measure power of the device in each relevant **product mode**. However in many **low power modes**, the current waveform is unlikely to be sinusoidal, so it is necessary to ensure that the meter has a scanning frequency that is sufficiently fast to capture the unusual current waveforms that are common (such as pulses or spikes). To determine the power, the meter has to multiply the instantaneous current and voltage values several hundred times per cycle (roughly 15 ms). Most digital instruments accumulate these values and display an average power once or twice a second. It is important to note that the power of many products in **low power modes** will be less than 10 W (some will be very small). This is partly due to low current levels, but also, in some cases, due to the current waveform being significantly different from the voltage waveform.

B.1.2 Effect of crest factor

The crest factor is defined as the ratio of peak current to r.m.s. current (or peak voltage to r.m.s. voltage). For a pure sinusoidal waveshape the crest factor is 1,414, while for a pure constant d.c. load the crest factor is 1,0. For power supplies meeting the requirements of 4.3.2, the voltage waveform will be generally sinusoidal and so the parameter of particular concern is the current waveform.

During the measurement, it is critical that the crest factor capability of the meter is greater than the actual crest factor of the load, otherwise the peak value of the current will be “lopped off” and the integration for power will be incorrect. Most meters will have a stated meter crest factor (or an allowable peak current) associated with each “current range”. Usually, the meter crest factor will increase as the actual load becomes smaller relative to the rated input range selected. However, if the range selected is too large, the accuracy resolution of the measurement will become poor and the uncertainty introduced from the (necessary) use of the larger range will have increased substantially. A meter that is able to handle higher peak currents within a given current range (i.e. no “out of range” signalled) will generally achieve a better overall uncertainty when measuring loads with a high crest factor and/or a low power factor, as it will be possible to select a smaller current range.

In order to make measurements in accordance with this standard it is important to use a power meter that gives an “out of range” reading if the peak current for that range is exceeded. For **low power modes** it is typical for the current waveform to have a crest factor in the range 3 to 10, sometimes even more and therefore it is important to verify that any “out of range” indicator has not operated.

For loads with a very high crest factor and / or very low power factor, Subclause 4.4.1 modifies the required uncertainty of measurement in recognition of the technical difficulty in reading these types of loads, even with highly accurate meters. An example calculation of the determination of uncertainty U_{pc} in Subclause 4.4.1 is set out below:

Example calculation for required uncertainty of measurement for a hypothetical product:

- power consumed by product = 0,2 W
- U_{mr} = 0,020 W for a load < 1 W (see 4.4.1)
- power factor = 0,12
- product current Crest Factor (CF) = 13

maximum Current Ratio (MCR) = CF / PF = 13 / 0,12 = 108,3

Where the Maximum Current Ratio (MCR) exceeds 10, the value of U_{pc} is given as

$$U_{pc} = 2\,\% \times (1 + (0{,}08 \times (108{,}3 - 10))) = 2\,\% \times 8{,}86 = 17{,}7\,\%$$

(i.e. about 8 times the permitted relative uncertainty)

The absolute uncertainty permitted for this load is the higher value of U_{pc} × measured value or 0,02 W:

$$U_{pc} \times \text{measured value} = 17{,}7\,\% \times 0{,}2\text{ W} = 0{,}0354\text{ W}$$

As 0,0354 W is greater than 0,02 W, the permitted uncertainty is 0,0354 W.

NOTE More detailed calculations of uncertainty are provided in Annex D.

B.1.3 Effect of low power factor

Low power factor loads can increase the uncertainty of measurement in several ways. A load with a low power factor will have a much higher calculated apparent power (in VA) than real power (in W). To accurately measure this relatively larger current without causing an ‘out of range’ condition may require a higher current range to be selected on the measuring instrument, but because the real power is still low this means that the instrument is operating at only a small percentage of the power range. Because only a small percentage of the power range is being utilised the measurement uncertainty is proportionally higher.

Another effect is that low power factor can introduce direct uncertainties into the power measurement reading itself, due to the way in which the measuring instrument operates. This effect varies from one power meter to another and between meter manufacturers. These effects can be significant in cases where the power factor is very low.

B.1.4 Products having large value X Capacitors

Certain products use capacitors between phase and neutral (so-called X capacitors) to reduce EMC emissions below regulatory limits. If the value of such a capacitor is sufficiently large the input current could be sinusoidal but out of phase with the input voltage, meaning that the calculated reactive power (in VA) is far greater than the measured true power (in W). Under such conditions it will be necessary to select a current range that does not result in an “out of range” condition. Care should be taken to ensure that the measurement uncertainty criteria for measured power are fulfilled.

B.1.5 Effect of spikes or fluctuations introduced by the product during test

Spikes or fluctuations in power levels can occur for a short time during a **mode**. Care is required to set the correct range if tracking these spikes is of interest (if the spikes are of very short duration it may be possible to ignore them as they would then not significantly affect the measured power).

B.2 Measurement instrument considerations

B.2.1 Instruments for power measurements

The following broad recommendations are made regarding the power measuring instrument. It should have

- the ability to measure the following: real power, true r.m.s. voltage and current and peak current;
- a power resolution of 1 mW or better;
- an available current crest factor of 3 (or more) at its rated range value;
- a minimum current range of 10 mA (or less);
- the capability to sample continuously throughout the measurement at intervals in accordance with the bandwidth such that all samples are taken into account when providing the measured result;
- the capability of signalling that an out-of-range condition has occurred;
- the capability of turning auto-range off.

NOTE When measuring non-resistive, time variant, loads, it may be necessary to turn off the auto-range functionality so as to prevent either an out of range or range-change condition during test.

When considering the purchase of a power measuring instrument, it is necessary to consider the impact of various parameters on the overall uncertainty of measurement. Factors such as power factor and crest factor, in addition to voltage, current and power uncertainty, can affect the overall uncertainty of the instrument reading. Some loads can have power factors as low as 0,05 and crest factors as high as 10 (or more for small capacitive loads).

Under this standard, products are measured over a defined period to determine their power consumption and whether there are any changes in power consumption over time. It is therefore critical that any power measuring instrument provide a consistent basis for determination of power over time. The variation in the power measurement over time of the power measuring instrument should be considered when selecting a power meter. For guidance, a variation of the power measurement of less than 0,1 % over a period of 8 h should be achieved when tested with a calibrated load source of around 1 W. It is also important to follow manufacturer’s instructions regarding the starting and warm up time for measurement equipment (power supply and measuring instrument) before they are used for measurements.

The resolution of power measuring instruments may have a significant affect on the overall uncertainty of the power measurement if this is insufficient to record the result accurately. The resolution available should be considerably better than the overall uncertainty of the power measurement if it is to have minimal effect on the overall uncertainty of the measurement.

The most desirable capability for a power meter is to be able to sample readings at an interval of 1 s or faster and output this data to a computer or data recorder in real time. All relevant parameters should be output in parallel (e.g. voltage, current, power, VA, crest factor). See B.2.5. In some cases it may also be desirable for measuring instruments to be able to average power accurately over any operator selected time interval (this is usually done with an internal mathematical calculation dividing accumulated energy by time within the meter, which is the most accurate approach). As an alternative, the power measuring instrument would have to be capable of integrating energy over any operator selected time interval with an energy resolution of less than or equal to 0,1 mWh and integrating time displayed with a resolution of 1 s or less.

B.2.2 Frequency response requirements (harmonics)

Where the current waveform is a smooth sine wave in phase with the voltage waveform (e.g. in a resistive heating load), there is no harmonic content in the current waveform. However, some current waveforms associated with **low power modes** are highly distorted and the current may appear as a series of short spikes or a series of pulses over a typical a.c. cycle. This effectively means that the current waveform is made up of a number of higher order harmonics which are multiples of the fundamental frequency (50 Hz or 60 Hz). Most digital power analysers will have no problem with the accurate measurement of higher order current harmonics presented by **low power modes**. However, it is recommended that a power measuring instrument should have the ability to measure harmonic components up to at least 2,5 kHz. Note that harmonic components greater than the 49th harmonic (2 450 Hz for 50 Hz supply) generally have little power associated with them. As a rule, the scanning frequency of a power measuring instrument should be at least twice the frequency of the highest order harmonic that has significant power associated with it.

B.2.3 Sampling requirements for cyclic and pulsing loads

Some **low power mode** loads will be cyclic or pulsing in nature. Such loads make it impossible to use normal power readouts from a power meter to determine **low power mode** power. In these cases it is necessary to use a meter that can sample and record data at 1 s or faster as specified in 5.3.2 (see also B.2.5). Other products may exhibit a sequence of distinct **product modes** that occur in a regular pattern.

Some **product modes** may be cyclical in nature in that they may be stable for a period (often many minutes) and may then go into a higher or lower energy state for a short period. Some products may draw a power pulse at infrequent intervals. In these cases, it is important to understand the behaviour of the product before measurements are commenced. Where there is a “regular” cycle of differing energy states, then a whole number of cycles should be examined when determining average power. To gain a better understanding of the product behaviour it can be useful to examine the load profile with an oscilloscope that is set to trigger on a significant change of load.

Some products may exhibit a sequence of different **product modes** that automatically occur in a regular pattern. In these cases, each of the separate **product modes** should be separately identified, measured and their duration documented.

In some cases, judgement may be required to determine whether a single **product mode** exhibits cyclic power patterns or whether the product in fact has a sequence of different **product modes** that occur in a regular pattern. The key determinant is whether there are different **functions** that become active or inactive during the different power levels – if this occurs then these should be treated as separate **product modes**.

As a general guide, cyclic loads within a **mode** would normally change power levels for seconds or perhaps minutes over a period of seconds to tens of minutes, whereas a pattern of **modes** would normally change power state for minutes or hours over a period of hours to days. However, it may not always be easy for a third party to differentiate these cases without further product documentation.

Examples of cyclic power patterns *within a **product mode*** include

– a heater that operates periodically to maintain an operating condition; and
– the short power draw required to recharge capacitors that maintain **functions** within a particular operating state.

It is for the above reasons that the measuring instrument provide a data output to a computer, as described in B.2.1.

B.2.4 Measurement of DC load components

Depending on the power supply configuration and design, some small loads (such as those associated with **low power modes)** can draw asymmetric current, i.e. drawing current only on either the positive or negative part of the a.c. voltage cycle. This is effectively a d.c. power load component supplied by an a.c. voltage supply.

Most digital power analysers can adequately handle low frequency and d.c. components during a power measurement. However, it is not possible to undertake accurate measurements of this type of current waveform using any type of transformer input such as a current transformer – d.c. components are not visible through a transformer input. It is therefore critical that any power measuring instrument use a direct shunt input to measure current. Rotating disk meters are unsuitable for any size load of this type because d.c. loads also exert a braking torque on the meter which creates further inaccuracies.

NOTE It is not usually possible to meet the requirements of this standard (either the required accuracy or the measurement method) using traditional rotating disk kilowatt-hour meters. **Low power mode** loads (less than 10 W) are often unable to overcome the starting torque required for the operation of a rotating disk meter and such loads may therefore appear as 0 W. This is unsatisfactory.

B.2.5 Automated software considerations

Sampling of power readings can be done using a data logger (i.e. a “device that can read various types of electrical signals and retains the data in internal memory for later download to a computer”) or by direct connections between a power measuring instrument and a computer which can record data directly at regular intervals. The latter configuration is probably the most common setup in modern laboratories, although there are many possible configurations. Most digital power analysers have an interface (e.g. GPIB or serial interface) that can allow regular recording of all key parameters directly to a computer or other laboratory data collection device.

While most measuring instruments are now very flexible in their operation, the operator needs to have a good understanding of their behaviour and how they interface with logging equipment or computers. One common issue in particular relates to the use of digital power analysers when they are controlled externally. For many types, once an external interface with a data logger or computer is engaged / active and data collection has commenced, the auto-ranging **function** is usually disabled. This means that the laboratory technician needs to anticipate the likely power range and crest factor required for the monitoring period and to manually set the meter up in the correct range prior to recording data (for both power and current). So a trial run to set the meter correctly (to avoid out of range readings) is usually recommended. Any automated software should also detect and indicate / record whether the power meter entered an “out of range” condition, see B.1.2 through B.1.4 for more information.

B.3 Application of this standard

This standard specifies tests to be performed on a single product to assess the relevant **low power modes**. It does not provide any indication of production variability which would require specified sampling for a range of products. For the purposes of compliance and conformity assessment, a properly devised sampling plan should be developed.

B.4 Connection of electrical instruments

B.4.1 Determination of connection arrangement

In order to achieve sufficient accuracy and to minimise variability between laboratories, it is important that electrical measuring instruments are connected in a consistent manner. The input resistance of the power meter’s voltage measuring circuit will be finite and the resistance of the current measuring shunt will not be zero: these factors need to be taken into account to achieve the required level of accuracy. Therefore it is recommended to organise the voltage and current measuring components of the power meter in a way that minimises the effect of internal power consumption of the measuring instrument for each measurement. The voltmeter should be connected to the supply side (see B.4.2) for lower powers and on the load side (see B.4.3) for higher powers.

Where the connection arrangement can be configured, it is selected as below:

Lower powers: $Im \leq Vs \times \sqrt{\left(\frac{1}{(Ra \times Rv}\right)}$, then use the connection arrangement in B.4.2.

Higher powers: $Im > Vs \times \sqrt{\left(\frac{1}{(Ra \times Rv}\right)}$, then use the connection arrangement in B.4.3.

where

– Im is the measured r.m.s. current of the load in amps (A);

– Vs is the supply voltage (V);

– Ra is the resistance of the current shunt for the selected current range (in Ω);

– Rv is the resistance of the voltmeter (in Ω).

In practice it could be necessary to change the current range (see B.2.5) for different **mode** measurements on the same product, which could affect the value of Ra. This may change the connection arrangement. The arrangement needs to be assessed in each case.

In addition, the accuracy of the measurement could be further improved where it is possible to take account of the power dissipation in the voltage and current measuring components of the power meter. To do this would manually require detailed documentation on the internal characteristics of the meter. It is possible that some instruments may automatically undertake internal power corrections and in this case manual correction should not be applied.

A sample calculation to determine the connection arrangement using these equations is given below:

– load = 10,0 W

– power factor = 0,5

– supply voltage = 230 V

– current shunt resistance = 350 mΩ (0,350 Ω) (care is required to ensure that the current shunt is not overloaded (and the meter does not enter an ‘out of range’ condition), especially with products having a high crest factor and/or a low power factor)

– voltage input resistance 1,4 MΩ (1 400 000 Ω)

– measured current = 0,0867 A

Break point current for supply side voltage measurement is given by

$$Vs \times \sqrt{\left(\frac{1}{(Ra \times Rv}\right)} = 230 \times \sqrt{\left(\frac{1}{(0{,}350 \times 1400000}\right)} = 230 \times 0{,}00143 = 0{,}329 \text{ A}$$

So in this case the voltmeter should be connected to the supply side (see B.4.2) as the load current is less than the calculated value. For this example the change-over load would be approximately 37 W (for this power factor and current shunt), above which the higher power configuration in B.4.3 should be used (voltage measurement on the load side).

B.4.2 Lower power loads: supply side voltage measurement

Where determined in accordance with B.4.1, the connection arrangement for an end-use product powered directly from an a.c. power supply is shown in Figure B.1 and the connection arrangement for end-use product powered via an external power supply is shown in Figure B.2. The voltage should be measured on the supply side of the current sensor of the power meter where this can be configured by the operator.

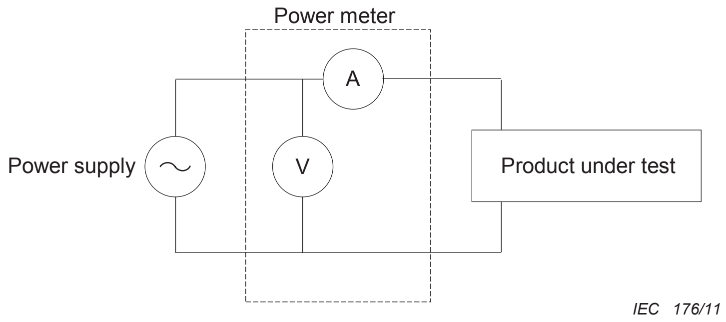
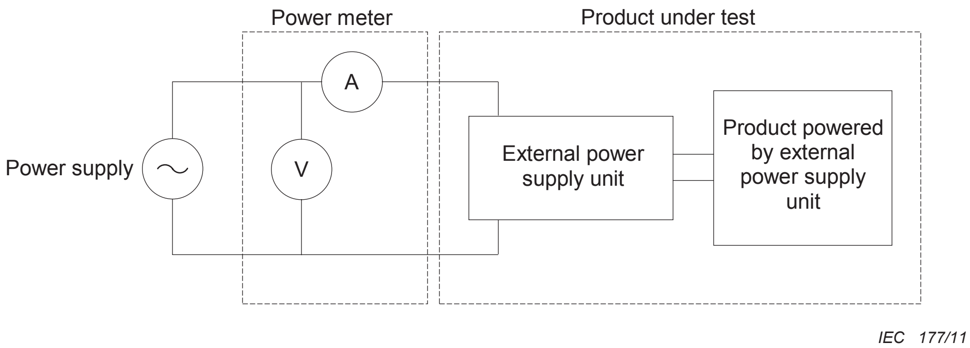


Figure B.1 – Connection arrangement for products powered directly from an a.c. power supply for lower power loads



Key

A current measuring part of the power meter

V voltage measuring part of the power meter

Figure B.2 – Connection arrangement for a product powered via an external power supply for lower power loads

When measuring input powers of 1 W or less, care should be taken to ensure that the connection arrangements do not give false readings due to interference. To minimise such effects, all leads should be kept as short as possible and the leads to the ammeter (shown as ‘A’ in Figures B.1 and B.2) should be twisted together.

B.4.3 Higher power loads: load-side voltage measurement

Where determined in accordance with B.4.1, the connection arrangement for end use product powered directly from an a.c. power supply is shown in Figure B.3 and the connection arrangement for an end-use product powered via an external power supply is shown in Figure B.4. The voltage should be measured on the product-side of the current sensor of the power meter where this can be configured by the operator.

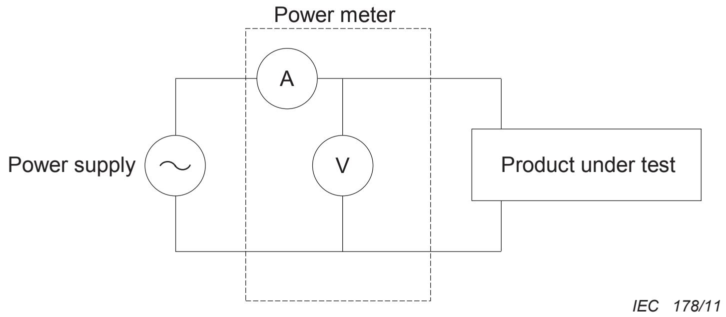
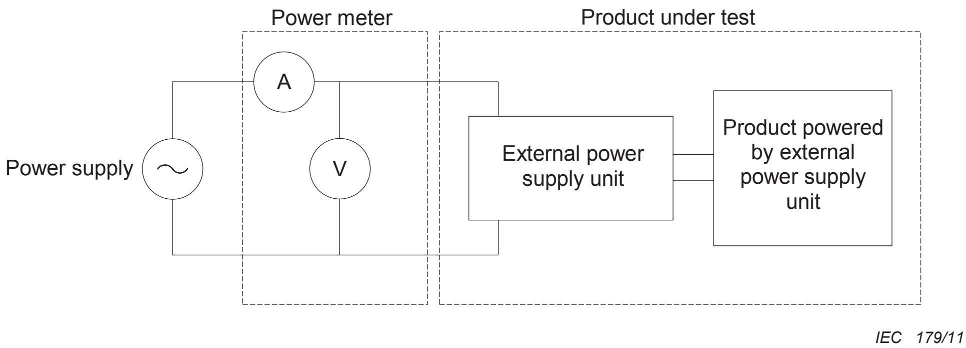


Figure B.3 – Connection arrangement for a product powered directly from the a.c. main supply for higher power loads



Key

A current measuring part of the power meter

V voltage measuring part of the power meter

Figure B.4 – Connection arrangement for a product powered via an external power supply for higher power loads

Annex C
(informative)

Converting power values to energy

This annex provides some guidance regarding the conversion of power measurements determined under this standard to energy consumption values.

Energy is the average power multiplied by the time. Electrical energy is generally expressed in watt-hours or kilowatt-hours. Energy can also be expressed in joules. One watt is the rate of energy consumption of 1 J/s. 1 kWh is equivalent to 3,6 MJ.

To convert power to energy (e.g. an annual energy consumption), the number of hours of operation in each **mode** must be assumed for a given period and the average power for each **mode** must also be known. As most products can operate in a number of **modes** and the usage patterns and profiles may vary considerably between countries, converting power values determined under this standard to energy values is potentially fraught with difficulty.

In the simplest case, a product that has only a single **mode** of operation can be converted to an annual energy value by assuming a constant power for a whole year. A year has 8 760 h (this ignores leap years), so a product that has for example a constant standby power of 5 W (assuming that there is no use in other **modes**) would consume 43 800 Wh per year or 43,8 kWh per year.

Annual energy consumption can be determined for more complex user patterns by the sum of power × hours of use for each **mode** during one year (i.e. hours 1 to 8 760).

When total energy consumption for a larger product is being considered, it is necessary to know as a minimum the "on" or **active mode** time and energy consumption per cycle. For some products, an assumed number of uses (cycles) per year and the **low power mode** (typically **off mode**) power may be sufficient. For more complex products where the **active mode** can vary considerably (e.g. heaters and air conditioners), more detailed data is required. For some products, consumers may disconnect the product from the power supply while not in use. There may also be several possible **low power modes** which may depend on consumer preferences or usage patterns and behaviour.

NOTE Since usage patterns and products may vary considerably, the number of uses and power levels in both examples below should be considered as hypothetical figures for the sole purpose of illustrating the calculation.

Example 1

Say a clothes washer has a program time of 85 min and an energy consumption of 0,95 kWh per cycle (**active mode**) and an **off mode** power consumption of 1,30 W. The annual energy consumption for 300 uses per year would be (assuming no use of delay start and assuming "left on" **mode** power is equal to the **off mode** power consumption):

time in use = 85 × 300 ÷ 60 = 425 hours per year (h/yr);

time in **off mode** = 8 760 – 425 = 8 335 h/yr;

energy consumption in **active mode** = 300 × 0,95 = 285 kWh/yr;

energy consumption in **off mode** = 8 335 × 1,30 ÷ 1 000 = 10,836 kWh/yr;

energy consumption total = 285 + 10,836 = 295,836 kWh/yr.

Example 2

Say a breadmaker takes 4 h to bake a standard 700 g loaf of bread and uses 0,33 kWh in the process. It is used to bake three loaves a week. The rest of the time it is left plugged in. It has a **standby mode** power consumption of 2 W. The annual energy consumption for 156 uses per year would be as follows:

time in **active mode** = 4 × 3 × 52 = 624 h/yr (whole weeks used for simplicity);

time in **standby mode** = 8 760 – 624 = 8 136 h/yr;

energy consumption in **active mode** = 0,33 × 52 × 3 = 51,48 kWh/yr;

energy consumption in **standby mode** = 8 136 × 2,0 ÷ 1 000 = 16,272 kWh/yr;

energy consumption total = 51,48 + 16,272 = 67,752 kWh per year.

= 68 kWh per year (rounded to the near whole kWh).

Annex D
(informative)

Determination of uncertainty of measurement

D.1 Determination of uncertainty of measurement

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

In order to determine the total measurement uncertainty, it is necessary to consider a number of parameters when measuring a single product:

– power measuring instrument;
– wiring;
– voltage and THD of the power supply;
– ambient temperature of the product being measured.

Measurement uncertainties may occur due to variations in the product itself:

– non consistent behaviour of the product, e.g. status of a battery, time dependency;
– production variability, e.g. due to component variability.

These latter uncertainties contribute to the uncertainty of the specification of the power of the product, but are not to be included in the uncertainty of the power measurement on a single product.

When reporting measurement uncertainty it is important to determine what measurement uncertainty figure is to be reported (e.g. because there is a requirement defined in an external standard or regulation). For example, the limit values in 4.4.1 apply only to the power measuring instrument.

The procedure below describes the steps that should be taken when determining the total measurement uncertainty of a particular product tested for a particular time in accordance with the procedures described in Clause 5. If the external standard or regulation does not require a determination of total uncertainty, then the approach below (and the example given in D.2) is adjusted accordingly. The test report shall clearly identify which elements of uncertainty have been considered.

To determine the total measurement uncertainty, the following steps can be taken.

1) Calculate the uncertainty relating to the measuring instrument (Ue).

For a power meter, the measurement uncertainty usually depends on

– the measured value (the reading);
– the power range (voltage range x current range);
– the power factor;
– the temperature of the power meter and shunt.

These dependencies should be given clearly in the specification of the power meter.

NOTE 1 The above procedure is provided so as to verify conformity with the uncertainty requirement given in 4.4.1.

NOTE 2 With input current waveforms having a low power factor or high crest factor, the power range will be high relative to the measured value, resulting in a higher measurement uncertainty.

2) Calculate or estimate the uncertainty due to the connection method and wiring.

This is mainly caused by dissipation in the shunt or the voltmeter (see Annex B for guidance) and depends on the meter configuration for each measurement and the meter attributes. Partly, the measurement value can be corrected for this error. If no correction is done, this whole error is regarded as measurement uncertainty (Uw).

If this correction is done, an uncertainty remains because the correction also has an uncertainty.

3) Estimate the uncertainty due to the power supply (Us).

The influence of the voltage and THD of the power supply depends on the type of product. For a resistive load, a 1 % change of input voltage will result in a 2 % change of power of the product. If this relationship between input voltage and power is accurately known, the measurement value could be corrected. However, usually this relationship is not known and an estimation has to be made of the resulting measurement uncertainty. If no information is available about the correlation between input voltage and power dissipation of the product, at least a resulting measurement uncertainty of 2 % is assumed for 1 % voltage tolerance.

NOTE 1 When a high correlation is suspected, an investigation could be necessary. The relationship between voltage and power consumption could be determined by experimentation at different supply voltages.

NOTE 2 For some products, a flattened voltage sine wave could have a relatively high effect on the power.

NOTE 3 A smaller measurement uncertainty can be realised if a more precisely controlled power supply is used.

4) Estimate the uncertainty due to variations in the temperature of the product (Ut)

A temperature difference of 1 °C would give a change of power of about 0,4 % if the dissipation is wholly within copper. This could, for example, occur in products with low PF when most of the dissipation is in the copper losses in EMI inductors. In this case, a range of ±5 °C results in a measurement uncertainty of 2 %. In most applications however, the influence of the temperature will be negligible (where ambient temperatures are quite stable).

5) Consider other sources of uncertainty (Ux)

Consider other sources of uncertainty in your situation that are not described above.

6) Calculate the total uncertainty (U_{total})

The total measurement uncertainty is calculated using the following formula:

$$U_{total} = \sqrt{(Ue^2 + Uw^2 + Us^2 + Ut^2 + Ux^2)}$$

NOTE 1 All uncertainties should be for a confidence level of 95 %.

NOTE 2 Further detail should be obtained from the Guide to the Expression of Uncertainty in Measurement (GUM).

D.2 Example calculations

Consider the following hypothetical product and power measuring instrument:

– power: 0,5 W;
– power factor: 0,1;
– crest factor: 3;
– supply voltage fluctuating between 229 V a.c. and 231 V a.c.;

– total Harmonic Distortion of the supply: 0 %;
– measurement uncertainty of supply voltage: 0,3 V;
– ambient temperature: fluctuating between 22 °C and 24 °C;
– measurement uncertainty of ambient temperature: 1 K;
– measurement uncertainty of power meter, as specified by the measuring instrument manufacturer: (0,15 + 0,01/PF) % of reading + 0,1 % of range;
– input resistance of voltage measurement, as specified by the measuring instrument manufacturer: 1,5 MΩ;
– current shunt resistance, as specified by the measuring instrument manufacturer: 400 mΩ (0,40 Ω);
– maximum permitted current crest factor within each range: 3,5.

1) Calculate the measurement uncertainty (Ue) relating to the measuring instrument.

The r.m.s. current drawn by the product is

$$\text{r.m.s current} = \frac{P}{Vs \times PF} = \frac{0{,}5}{230 \times 0{,}1} = 0{,}0217A = 22\text{ mA}$$

The minimum current range on the measuring instrument for this current is the 50 mA range. In this current range, the instrument supplier states that the maximum continuous peak current that can be accurately measured is 150 mA. Check that the peak current drawn by the product is within this permitted range:

$$\text{Peak current} = \frac{P \times CF}{Vs \times PF} = \frac{0{,}5 \times 3}{230 \times 0{,}1} = 0{,}065A = 65\text{ mA}$$

The peak current is within the allowable range (which is given by 50 mA × 3,5 = 175 mA), therefore the 50 mA range is confirmed for the measurement and uncertainty calculations.

NOTE 1 If the peak current exceeds the allowable peak current, a higher current range that could cover the peak current would have to be selected. This would increase the uncertainty of the measurement.

The voltage range of the power meter is set at 300 Va.c.

The resulting calculated power range is 300 × 0,05 = 15 W

The measurement uncertainty due to the power meter is

(0,15 + 0,1) % × 0,5 + 0,1 % × 15 = 0,016 W

NOTE 2 The uncertainty in the voltage measurement and current measurement are included in the overall uncertainty of the specified power measurement.

The ambient temperature of the power meter is within the specifications for which the uncertainty is specified.

2) Calculate or estimate the measurement error and uncertainty due to the wiring.

The value of Im is calculated in accordance with B.4.1:

$$Vs \times \sqrt{\left(\frac{1}{(Ra \times Rv)}\right)} = 230 \times \sqrt{\left(\frac{1}{(0{,}40 \times 1500000)}\right)} = 230 \times 0{,}00129 = 0{,}297\text{ A}$$

As the actual r.m.s value of the load current (0,022 A) is less than the value of Im specified in B.4.1 (0,297 A), the wiring arrangement in Figure B.1 should be used where possible.

The power dissipation in the shunt, which is not included in the power measurement, is given by

$$Uw = \left[\frac{P}{Vs}\right]^2 \times R_{shunt} = \left[\frac{0{,}5}{230}\right]^2 \times 0{,}40 = 1{,}89 \times 10^{-6}\ \text{W} = 0{,}00189\ \text{mW}$$

where

P is the measured power of the product under test in W;

Vs is the supply voltage in V;

R_{shunt} is the resistance of the power meter shunt in Ω.

In this case the power dissipation in the current shunt is negligible (1,9 μW) so no systematic correction to the reading in necessary. The uncertainty in this value can also be ignored as a small error in the estimated resistance of the shunt does not significantly affect the overall result.

NOTE If the arrangement in Figure B.3 was used for the measurement (instead of Figure B.1 as recommended), the error due to power dissipation in the voltmeter (1,5 MΩ) can be calculated as

$$\frac{Vs^2}{R} = \frac{230^2}{1{,}5 \times 10^6} = 0{,}035\ \text{W}$$

In this case, the measurement value has to be corrected with this systematic error by subtracting this value from the reading on the power measuring instrument (if this is not done automatically by the instrument).

This systematic error also has an uncertainty, which has to be estimated, because often the manufacturer does not supply the uncertainty of the voltmeter resistance (impedance). An input resistance that lies between 1,3 MΩ and 1,7 MΩ (for example) corresponds to an uncertainty of 0,0407 – 0,0311 = 0,0096 W (Uw) in this case, which is significant. This uncertainty would be reduced if the resistance was known accurately (or measured during calibration, for example). This example illustrates the importance of correctly configuring the meter (where possible) in a way that minimizes uncertainty due to wiring.

3) Estimate the measurement uncertainty due to the supply source (Us).

The maximum difference between the nominal value and the supply source is as follows:

230 – 229 + 0,3 = 1,3 V, which equals 0,57 %.

Where the relationship between power and voltage is not known for a specific product, the safest assumption is to assume that the load is effectively resistive in nature, so the influence on the uncertainty of the power measurement is double the uncertainty of the supply voltage. Therefore, Us is estimated to be

$2 \times 0{,}0057 \times 0{,}5 = 0{,}0057$ W

4) Estimate the measurement uncertainty (Ut) due to the temperature of the product.

Since there is no information about the distribution of the power dissipation, it is assumed that the main part is copper losses.

The maximum difference between the ambient temperature and the nominal temperature is

24 – 23 + 1 = 2 K, resulting in a measurement uncertainty of $2 \times 0{,}4 = 0{,}8$ %, equalling 0,004 W.

5) Other sources of uncertainty Ux: there are no other known sources of uncertainty in this example, so Ux is set to zero.

6) The total measurement uncertainty is given by

$$U_{total} = \sqrt{(Ue^2 + Uw^2 + Us^2 + Ut^2 + Ux^2)} = \sqrt{0{,}016^2 + 0{,}000^2 + 0{,}0057^2 + 0{,}004^2 + 0{,}000^2}$$

U_{total} = 0,0174 W

7) Compliance with the requirements of 4.4.1: check that the actual uncertainty associated with the measuring instrument is within the permitted limits in 4.4.1.

Power consumed by product = 0,5 W

U_{mr} = 0,020 W for a load $<$ 1 W (see 4.4.1)

NOTE The uncertainty associated with the measuring instrument U_e is less than the value for U_{mr}, so the measurement complies. However, the following calculations illustrate the maximum permitted uncertainty U_{pc} for this particular measurement.

Power factor = 0,1

Product current Crest Factor (CF) = 3

Maximum Current Ratio (MCR) = CF / PF = 3,00 / 0,1 = 30,0

As specified in 4.4.1, U_{pc} is only determined where the value of MCR exceeds 10.

U_{pc} = 2 % × (1 + (0,08 × (30,0 – 10))) = 2 % × 2,6 = 5,2 %

The absolute uncertainty permitted for this load is the higher value of U_{pc} × measured value or 0,02 W:

U_{pc} × measured value = 5,2 % × 0,5 W = 0,026 W

As 0,026 W is greater than 0,02 W, the permitted uncertainty for this load is 0,026 W.

As U_e is less than the required uncertainty specified in 4.4.1 (U_{pc}) for the measurement instrument, the measurement is acceptable.

Annex ZA
(informative)

Test report template

Product under test			
Brand name as identified on product			
Model identification			
Version or serial number			
Product description			
Regulatory reference			
Name of applicant			
Address of applicant			
Name of test laboratory			
Address of test laboratory			
Test report number		Test date	
Prepared by		Approved by	
Test results			
Name of mode [1]		Test standard / measurement method	
How is the mode selected or programmed			
Sequence of events to reach the mode where the product automatically changes mode			
Any notes regarding the operation of the product			
Result in W			
Limit applied			
Verdict			
If applicable, technical justification of inappropriateness for intended use [2]			
Test conditions			
Ambient temperature in °C			
Test voltage in V			
Test frequency in Hz			
Total harmonic distortion of the supply system in %			
Information and documentation on the instrumentation, set-up and circuits used for electrical testing			
Test equipment information			
Test equipment description			
Test equipment model number			
Test equipment serial number			
Calibration due date			

1) The definition of off-mode mode and standby mode is given in EC Commission Regulation n° 1275/2008.

2) EC Commission Regulation n° 1275/2008 requires that, if applicable, the technical justification shall be provided where the requirements set out in Annex II point 1(c), or the requirements set out in Annex II points 2(c) and/or 2(d), are inappropriate for the intended use of equipment.

Bibliography

NOTE This bibliography lists standards and other reports relevant to the measurement of energy and performance of household electrical products. Not all products covered below necessarily have a **low power mode**.

EN 50229, *Electric clothes washer-dryers for household use – Methods of measuring the performance*

EN 55016-1-2, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-2: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Conducted disturbances* (CISPR 16-1-2)

EN 60299, *Household electric blankets – Methods for measuring performance*

EN 60311, *Electric irons for household or similar use – Methods for measuring performance*

EN 60312, *Vacuum cleaners for household use – Methods of measuring the performance*

EN 60350, *Electric cooking ranges, hobs, ovens and grills for household use – Methods for measuring performance*

EN 60379, *Methods for measuring the performance of electric storage water-heaters for household purposes*

EN 60442, *Electric toasters for household and similar purposes – Methods for measuring the performance*

EN 60456, *Clothes washing machines for household use – Methods for measuring the performance*

EN 60531, *Household electric thermal storage room heaters – Methods for measuring the performance*

EN 60619, *Electrically operated food preparation appliances – Methods for measuring the performance*

EN 60661, *Methods for measuring the performance of electric household coffee makers*

EN 60675, *Household electric direct-acting room heaters – Methods for measuring performance*

EN 60705, *Household microwave ovens – Methods for measuring performance*

EN 61000-3-2, *Electromagnetic compatibility (EMC) – Part 3-2: Limits – Limits for harmonic current emissions (equipment input current ≤ 16 A per phase)*

EN 61121, *Tumble dryers for household use – Methods for measuring the performance*

EN 61176, *Hand-held electric mains voltage operated circular saws – Methods for measuring the performance*

EN 61254, *Electric shavers for household use – Methods for measuring the performance*

EN 61591, *Household range hoods – Methods for measuring performance*

EN 62087, *Methods of measurement for the power consumption of audio, video and related equipment*

IEC 60436, *Electric dishwashers for household use – Methods for measuring the performance*

IEC 60508, *Methods for measuring the performance of electric ironing machines for household and similar purposes*

IEC 60530, *Methods for measuring the performance of electric kettles and jugs for household and similar use*

IEC 60535, *Jet fans and regulators*

IEC 60665, *AC electric ventilating fans and regulators for household and similar purposes*

IEC 60879, *Performance and construction of electric circulating fans and regulators*

IEC 62552, *Household refrigerating appliances – Characteristics and test methods*

Commission Regulation (EC) No 1275/2008 of 17 December 2008 implementing Directive 2005/32/EC of the European Parliament and of the Council with regard to ecodesign requirements for standby and off mode electric power consumption of electrical and electronic household and office equipment, OJ L 339, 18.12.2008, p. 45-52

Directive 2004/108/EC of the European Parliament and of the Council of 15 December 2004 on the approximation of the laws of the Member States relating to electromagnetic compatibility and repealing Directive 89/336/EEC, OJ L 390, 31.12.2004, p. 24-37

Guide to the Expression of Uncertainty in Measurement (GUM) [ISO/IEC/BIPM/IFCC/IUPAC/IUPAP/OIML:1995]

COOK, RR. *Assessment of uncertainties of measurement for calibration and testing laboratories.* National Association of Testing Authorities (NATA), Australia, 1999

NOTE The following standard provides information that may be of value to product designers regarding the design of the power control user interface.

IEEE 1621, *Standard for User Interface Elements in Power Control of Electronic Devices Employed in Office/Consumer Environments*

Refer to http://eetd.lbl.gov/controls/1621/1621index.html

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