

Measurement methods for electromagnetic fields of household appliances and similar apparatus with regard to human exposure

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National foreword

This British Standard is the UK implementation of EN 62233:2008, incorporating corrigendum August 2008. It is derived by from IEC 62233:2005. It supersedes BS EN 50366:2003, which will be withdrawn on 1 December 2012.

The CENELEC common modifications have been implemented at the appropriate places in the text. The start and finish of each common modification is indicated in the text by tags **[C]** **[C]**.

The UK participation in its preparation was entrusted to Technical Committee CPL/61, Safety of household and similar electrical appliances.

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

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**Measurement methods for electromagnetic fields of household appliances
and similar apparatus with regard to human exposure**
(IEC 62233:2005, modified)

Méthodes de mesures des champs
électromagnétiques des appareils
électrodomestiques et similaires
en relation avec l'exposition humaine
(CEI 62233:2005, modifiée)

Verfahren zur Messung
der elektromagnetischen Felder
von Haushaltgeräten und ähnlichen
Elektrogeräten im Hinblick
auf die Sicherheit von Personen
in elektromagnetischen Feldern
(IEC 62233:2005, modifiziert)

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CENELEC

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

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Foreword

The text of the International Standard IEC 62233:2005, prepared by IEC TC 106, Methods for the assessment of electric, magnetic and electromagnetic fields associated with human exposure, together with common modifications prepared by a Joint Editing Group of the Technical Committee CENELEC TC 61, Safety of household and similar electrical appliances, and CENELEC TC 106X, Electromagnetic fields in the human environment, was submitted to the Unique Acceptance Procedure and was approved by CENELEC as EN 62233 on 2007-12-01.

This European Standard supersedes EN 50366:2003 + A1:2006, to which it is technically equivalent.

The following dates are applicable:

- latest date by which the EN has to be implemented
at national level by publication of an identical
national standard or by endorsement (dop) 2008-12-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2012-12-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 62233:2005 was approved by CENELEC as a European Standard with agreed common modifications.

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INTRODUCTION

This standard establishes a suitable evaluation method for determining the electromagnetic fields in the space around the equipment mentioned in the scope, and defines standardized operating conditions and measuring distances.

This document is designed as one method for measurement and assessment of electromagnetic (EM) fields and their potential effect on the human body by reference to exposure standards. Existing exposure standards, e.g. ICNIRP'98 [11]¹⁾, IEEE C95.1-1999 [22] and IEEE C95.6-2002 [12], present rules for the exposure of humans to EM fields. The simplest and more practical levels [limits] with which to comply are limits (suitably time-averaged in some cases) on the electric (E) and magnetic (B) fields, measured in the absence of the human to be exposed to these fields. These limits are called maximum permissible exposure levels, IEEE-based levels, or reference levels (ICNIRP). Suitable definitions and specified measurement techniques are applied in any exposure compliance measurement or assessment. Compliance with maximum permissible exposure or reference levels is sufficient for positive assessment of meeting these levels as specified in the appropriate exposure standard.

This document addresses the additional measurement and calculation techniques which permit determination of compliance under one set of specified circumstance, without reference to time of exposure or actual exposure conditions. This document is not meant to supplant definitions and procedures specified in exposure standards but is aimed at supplementing the procedure already specified for compliance with exposure.

¹⁾ Figures in square brackets refer to the Bibliography.

MEASUREMENT METHODS FOR ELECTROMAGNETIC FIELDS OF HOUSEHOLD APPLIANCES AND SIMILAR APPARATUS WITH REGARD TO HUMAN EXPOSURE

1 Scope

This International Standard deals with electromagnetic fields up to 300 GHz and defines methods for evaluating the electric field strength and magnetic flux density around household and similar electrical appliances, including the conditions during testing as well as measuring distances and positions.

Appliances may incorporate motors, heating elements or their combination, may contain electric or electronic circuitry, and may be powered by the mains, by batteries, or by any other electrical power source.

Appliances include such equipment as household electrical appliances, electric tools and electric toys.

Appliances not intended for normal household use but which nevertheless may be approached by the public, or may be used by laymen, are within the scope of this standard.

This standard does not apply to:

- apparatus designed exclusively for heavy industrial purposes;
- apparatus intended to be part of the fixed electrical installation of buildings (such as fuses, circuit breakers, cables and switches);
- radio and television receivers, audio and video equipment, and electronic music instruments;
- medical electrical appliances;
- personal computers and similar equipment;
- radio transmitters;
- apparatus designed to be used exclusively in vehicles;

The fields of multifunction equipment which is subjected simultaneously to different clauses of this standard and/or other standards shall be assessed using the provisions of each clause/standard for the relevant functions in operation.

Abnormal operation of the appliances is not taken into consideration.

This standard includes specific elements to assess human exposure:

- definition of sensor;
- definition of measuring methods;
- definition of operating mode for appliance under test;
- definition of measuring distance and position.

The measurement methods specified are valid from 10 Hz to 400 kHz. In the frequency range above 400 kHz and below 10 Hz appliances in the scope of this standard are deemed to comply without testing unless otherwise specified in IEC 60335 series.

 NOTE The methods are not suitable for comparing the fields of different appliances. 

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 60335 (all parts), *Safety of household and similar electrical appliances*

IEC 61786, *Measurement of low-frequency magnetic and electric fields with regard to exposure of human beings – Special requirements for instruments and guidance for measurements*

IEC 62311, *Assessment of electronic and electrical equipment related to human exposure restrictions for electromagnetic fields (0 Hz – 300 GHz)²⁾*

CISPR 14-1, *Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 1: Emission*

3 Terms and definitions

For the purpose of this standard the following terms and definitions apply. Internationally accepted SI-units are used throughout the standard.

3.1 Physical quantities and units

Quantity	Symbol	Unit	Dimension
Conductivity	σ	Siemens per metre	S/m
Current density	J	Ampere per square metre	A/m ²
Electric field strength	E	Volt per metre	V/m
Frequency	f	Hertz	Hz
Magnetic field strength	H	Ampere per metre	A/m
Magnetic flux density	B	Tesla	T (Wb/m ² or Vs/m ²)

3.2 Terms and definitions

3.2.1

basic restriction  *Text deleted* 

restrictions on exposure to time-varying electric, magnetic and electromagnetic fields that are based on established biological effects and include a safety factor. The basic restriction for the current density is J_{BR} , the basic restriction for the internal electric field strength is E_{BR}

²⁾ To be published.

3.2.9**response time**

time required for a field-measuring instrument to reach some specified percentage of the final value after being placed in the field to be measured

3.2.10**Weighted result*****W***

final result of the measurement, taking the frequency dependent reference level into account

3.2.Z1**operator distance**

distance between the surface of the appliance and the closest point of the head or torso of the operator

4 Choice of test method

For all appliances, independent of the spectrum of the produced fields, the procedure in 5.5.2 is applicable. This is the reference method, which has to be used in case of dispute.

Text deleted

The procedure in 5.5.3 may be applied for appliances producing a line spectrum composed of only one fundamental line and their harmonics lines.

For appliances producing significant fields only on the mains frequency and its harmonics, if any, one of the } simplified ~ test methods in 5.5.4 may be used.

Equipment where the full working cycle is less than 1 s shall be measured according to IEC 62311 for pulsed fields; however operating conditions, measuring distances and coupling factor are given in this standard.

A step by step procedure can be applied, from the easiest methods to the more complicated ones, see the flow diagram in Figure 1.

5 Measuring methods**5.1 Electric fields**

The measurement method is under consideration.

If appliances, with their internal transformer or electronic circuit, are working at voltage lower than 1 000 V, they are deemed to comply without testing.

5.2 Frequency range

The frequency range considered is from 10 Hz to 400 kHz. See Scope (Clause 1).

If it is not feasible to cover the frequency range in one measurement, the weighted results of each measured frequency range shall be added.

5.3 Measuring distances, positions and operating mode

The **measuring distances**, sensor locations and operating conditions are specified in Annex A.

The configuration and mode of operation during measurement shall be noted in the test report.

5.4 Magnetic field sensor

Measurement values of flux density are averaged over an area of 100 cm² in each direction. The reference sensor consist of three mutually perpendicular concentric coils with a measuring area of 100 cm² ± 5 cm² to provide isotropic sensitivity. The outside diameter of the reference sensor shall not exceed 13 cm.

For the determination of **coupling factors**, as specified in Annex C, an isotropic sensor having a measuring area of 3 cm² ± 0,3 cm² is used.

NOTE 1 It is permissible to use a single direction sensor (not isotropic) in combination with an appropriate summation method.

NOTE 2 The final value of the magnetic flux density is the vector addition of the values measured in each direction. This ensures that the measured value is independent of the direction of the magnetic field vector.

5.5 Measuring procedures for magnetic fields

5.5.1 General

The measuring signal shall be evaluated dependent on the frequency. Text deleted 

Transient magnetic fields with a duration of less than 200 ms, e.g. during switching events, are disregarded.

If a switching action occurs during the measurements, the measurement has to be repeated.

The measuring equipment is to have a maximum noise level of 5 % of the limit value. Any measured value below the maximum noise level is disregarded.

The background level is to be less than 5 % of the limit value.

The response time for the measuring equipment to reach 90 % of the final value is not to exceed 1 s.

The magnetic flux density is determined by using an averaging time of 1 s.

Shorter sampling times may be used if the source is shown to be constant over a period greater than 1 s for 10 Hz – 400 kHz signals.

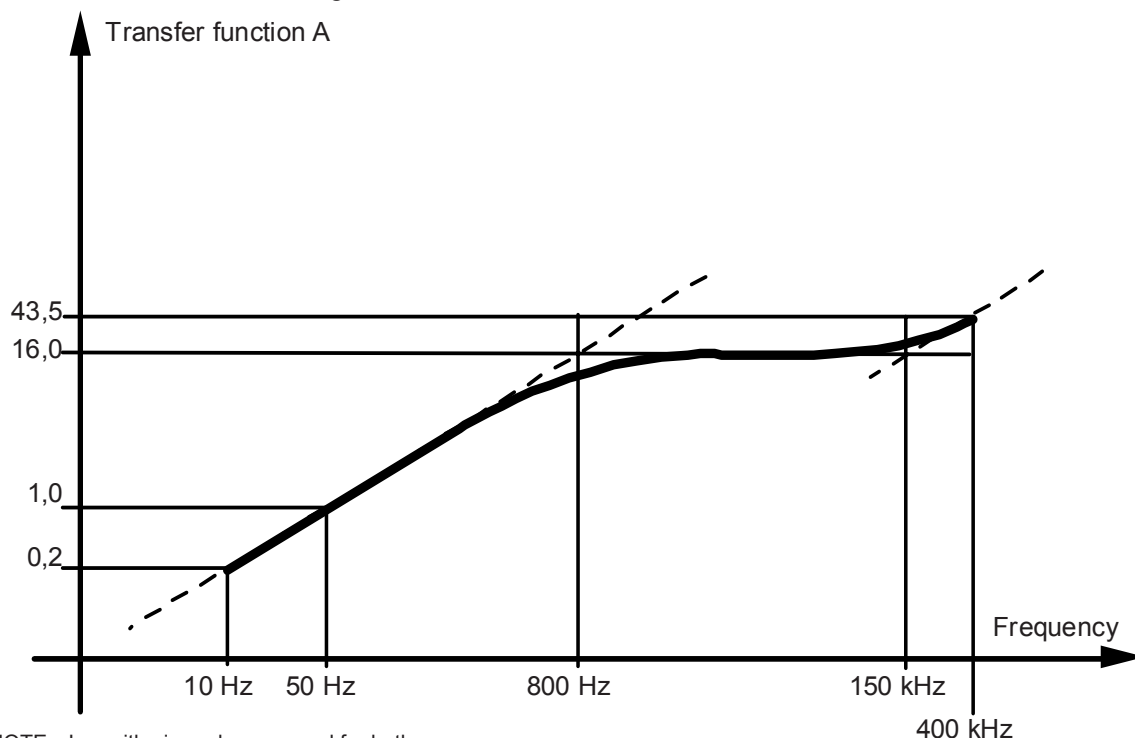
During the final measurement the sensor should remain stationary.

5.5.2 Time domain evaluation

 This is the reference method and is used in case of doubt.

Independent of the type of the signal, a time domain measurement of the value of the magnetic flux density can be carried out. For fields with several frequency components, the dependency on frequency of the reference levels is taken into account by implementing a transfer function A which is inverse of the reference level expressed as a function of the frequency. 

} The transfer function is to be established using a first order filter and shall have the characteristics shown in Figure Z1.



NOTE Logarithmic scales are used for both axes.

Figure Z1 - Transfer function

The following sequence is used for the measurements:

- perform a separate measurement of each coil signal;
- apply a weighting to each signal using the transfer function;
- square the weighted signals;
- add the squared signals;
- average the sum;
- obtain the square root of the average.

The result is the weighted r.m.s. value of the magnetic flux density.

This procedure is shown schematically in Figure Z2.

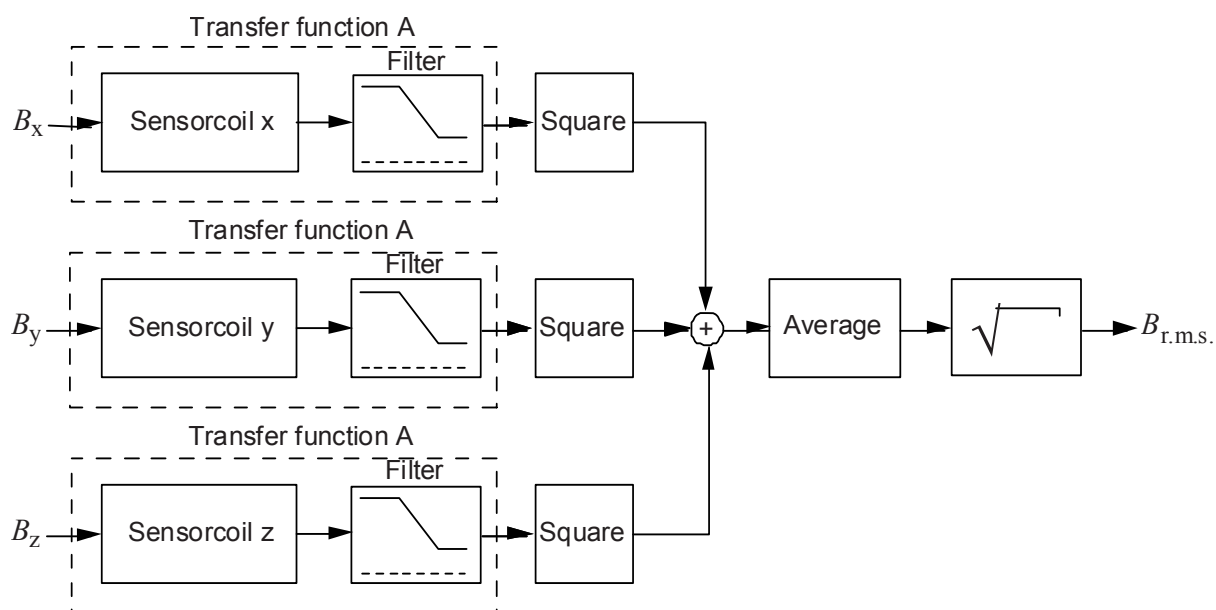


Figure Z2 - Schematic diagram of the reference method

NOTE Different ways that the transfer function can be applied to a time domain signal include: analog filter in an electronic circuit, pre-programmed DSP chip, a signal analyser, or a digital computer calculation with a spreadsheet package or a custom-written program. ©

☐ The actual measured value shall be compared directly with the reference level B_{RL} of the flux density at 50 Hz. With appliances with highly localized fields, this has to be performed after taking the coupling factor $a_c(r_1)$ given in Annex C into account. The final weighted result, W , can be derived as follows:

$$W_n = \frac{B_{r.m.s.}}{B_{RL}}$$

or applying the coupling factor $a_c(r_1)$

$$W_{nc} = a_c(r_1) \cdot W_n$$

where

W_n weighted result for one measurement;

$B_{r.m.s.}$ r.m.s. value of the magnetic flux density;

B_{RL} reference level of the magnetic flux density at f_{c0} ;

$a_c(r_1)$ coupling factor according to Annex C or Table D.3.

W_{nc} weighted result for one measurement taking the coupling of the inhomogeneous field into account by applying $a_c(r_1)$.

The determined weighted result W shall not exceed the value 1. ☐

5.5.3 Line spectrum evaluation

This method may be used when there is only a line spectrum, for example for magnetic fields having a fundamental frequency 50 Hz and some harmonics. See Clause 4.

The magnetic flux density is measured at each relevant frequency. This can be achieved by recording the time signal of the flux density and using a Fourier transformation for evaluating the spectral components.

The following sequence is used for the measurements:

- perform a separate measurement of each coil signal (x, y, z);
- integrate the signals to get a value which is directly proportional to $B(t)$;
- perform a discrete Fourier transform for each coil to obtain the estimated discrete magnitude spectrum $B(i)$ representing r.m.s values at the discrete frequencies $f(i) = i / T0$. ($T0$ = observation time);
- find the local maxima with $B(j)$ at frequency $f(j)$ by interpolating the discrete spectrum $B(i)$;
- perform a vector addition of all three directions for every discrete spectral line $B(j)$.

$$B(j) = \sqrt{B_x^2(j) + B_y^2(j) + B_z^2(j)} \quad (4)$$

NOTE The last two operations of the algorithm can be interchanged by using Equation (4) with $B(i)$ instead of $B(j)$. Result is the amount of the magnetic flux density for each detected frequency.

To compare the measured values with limits, the reference level $B_{RL}(j)$ must be used. For appliances with highly localised fields the coupling factor $a_c(r_1)$ given in Annex C can be taken into account. For fields with several frequency proportions the calculation of a frequency weighted sum is necessary.

The weighted result is obtained from the following formula:

$$W_n = \sqrt{\sum_{j=1}^n \left(\frac{B(j)}{B_{RL}(j)} \right)^2} \quad (5)$$

or applying the coupling factor $a_c(r_1)$:

$$W_{nc} = a_c(r_1) \cdot W_n \quad (6)$$

NOTE Coupling factor can be independent of frequency, for details see Annex C

$B(j)$: magnetic flux density at the order of j frequency line of the measured spectrum

$B_{RL}(j)$: reference level of the magnetic flux density at the order of j frequency.

$a_c(r_1)$: coupling factor according to Annex C or Table D.3.

W_n : weighted result for one measurement.

W_{nc} : weighted result for one measurement taking the coupling of the inhomogeneous field into account by applying $a_c(r_1)$

The determined weighted W shall not exceed the value 1.

Text deleted

NOTE A pure summation always results in an overestimation of the exposure and for broadband fields consisting of higher frequencies harmonic components or noise, the limitation based on summation formula is very conservative because the amplitudes are not in the same phase. With most measurement equipment the relative phases are not measured (for example if a spectrum analyser is used), but an rms summation of frequency components can be undertaken. This will usually give a more realistic outcome than neglecting phase completely.

5.5.4 Simplified test methods

Appliances that are constructed so that they can only produce magnetic fields at mains frequency and its harmonics need only be tested in the frequency range below 2 kHz.

Appliances are considered to meet the requirements of this standard when all the following conditions are fulfilled:

- the currents, including the harmonic currents, generating the magnetic fields are known;
- all harmonic currents with amplitudes higher than 10 % of the amplitude of the mains frequency decrease continuously over the frequency range;
- the magnetic flux density measured at mains frequency is less than 50 % of the reference level specified for the mains frequency;
- the magnetic flux density measured during a broadband measurement over the frequency range, with the mains frequency suppressed, is less than 15 % of the reference level specified for the mains frequency.

NOTE An active notch filter is a suitable means for suppressing the mains frequency. If the conditions are not fulfilled another measurement according to the reference method is recommended.

Appliances that are constructed so that they only produce very weak magnetic fields, when the mains frequency is dominating, are considered to meet the requirements of this standard when all the following conditions are fulfilled:

- the currents, including the harmonic currents, generating the magnetic fields are known;
- all harmonic currents with amplitudes higher than 10 % of the amplitude of the mains frequency decrease continuously over the frequency range;
- the magnetic flux density measured over the whole frequency range is less than 30 % of the reference level specified for the mains frequency. **Text deleted**