BS EN 61000-4-8:2010

BSI Standards Publication

Electromagnetic compatibility (EMC)

Part 4-8: Testing and measurement techniques — Power frequency magnetic field immunity test

National foreword

This British Standard is the UK implementation of EN 61000-4-8:2010. It is identical to IEC 61000-4-8:2009. It supersedes BS EN 61000-4-8:1994, which will be withdrawn on 1 February 2013.

The UK participation in its preparation was entrusted by Technical Committee GEL/210, EMC - Policy committee, to Subcommittee GEL/210/12, EMC basic, generic and low frequency phenomena Standardization.

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

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EN 61000-4-8

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English version

Electromagnetic compatibility (EMC) - Part 4-8: Testing and measurement techniques - Power frequency magnetic field immunity test
(IEC 61000-4-8:2009)

Compatibilité électromagnétique (CEM) -
Partie 4-8: Techniques d'essai
et de mesure -
Essai d'immunité au champ magnétique
à la fréquence du réseau
(CEI 61000-4-8:2009)

Elektromagnetische Verträglichkeit (EMV) -
Teil 4-8: Prüf- und Meßverfahren -
Prüfung der Störfestigkeit gegen
Magnetfelder mit energietechnischen
Frequenzen
(IEC 61000-4-8:2009)

This European Standard was approved by CENELEC on 2010-02-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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

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CENELEC

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

Central Secretariat: Avenue Marnix 17, B - 1000 Brussels

Foreword

The text of document 77A/694/FDIS, future edition 2 of IEC 61000-4-8, prepared by SC 77A, Low frequency phenomena, of IEC TC 77, Electromagnetic compatibility, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61000-4-8 on 2010-02-01.

This European Standard supersedes EN 61000-4-8:1993 + A1:2001.

EN 61000-4-8:2010 includes the following significant technical changes with respect to EN 61000-4-8:1993: the scope is extended in order to cover 60 Hz. Characteristics, performance and verification of the test generator and related inductive coils are revised. Modifications are also introduced in the test set-up (GRP) and test procedure.

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)	2010-11-01
– latest date by which the national standards conflicting with the EN have to be withdrawn	(dow)	2013-02-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61000-4-8:2009 was approved by CENELEC as a European Standard without any modification.

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

IEC 60068-1	NOTE	Harmonized as EN 60068-1.
IEC 61000-2-4	NOTE	Harmonized as EN 61000-2-4.

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

Publication	Year	Title	EN/HD	Year
IEC 60050-161	-	International Electrotechnical Vocabulary (IEV) - Chapter 161: Electromagnetic compatibility	-	-

CONTENTS

INTRODUCTION

This standard is part of the IEC 61000 series of standards, according to the following structure:

Part 1: General

General considerations (introduction, fundamental principles)

Definitions, terminology

Part 2: Environment

Description of the environment

Classification of the environment

Compatibility levels

Part 3: Limits

Emission limits

Immunity limits (in so far as they do not fall under the responsibility of the product committees)

Part 4: Testing and measurement techniques

Measurement techniques

Testing techniques

Part 5: Installation and mitigation guidelines

Installation guidelines

Mitigation methods and devices

Part 9: Miscellaneous

Each part is further subdivided into several parts, published either as international standards, as technical specifications or technical reports, some of which have already been published as sections. Others will be published with the part number followed by a dash and a second number identifying the subdivision (example: IEC 61000-6-1).

This part is an international standard which gives immunity requirements and test procedures related to "power frequency magnetic field".

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 4-8: Testing and measurement techniques – Power frequency magnetic field immunity test

1 Scope

This part of IEC 61000 relates to the immunity requirements of equipment, only under operational conditions, to magnetic disturbances at power frequencies 50 Hz and 60 Hz related to:

– residential and commercial locations;
– industrial installations and power plants;
– medium voltage and high voltage sub-stations.

The applicability of this standard to equipment installed in different locations is determined by the presence of the phenomenon, as specified in Clause 4. This standard does not consider disturbances due to capacitive or inductive coupling in cables or other parts of the field installation.

Other IEC standards dealing with conducted disturbances cover these aspects.

The object of this standard is to establish a common and reproducible basis for evaluating the performance of electrical and electronic equipment for household, commercial and industrial applications when subjected to magnetic fields at power frequency *(continuous and short duration field).*

The standard defines:

– recommended test levels;
– test equipment;
– test set-up;
– test procedure.

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(161), *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

3 Terms and definitions

For the purposes of this document the following terms and definitions apply to the restricted field of magnetic disturbances as well as the terms and definitions from IEC 60050(161) [IEV].

3.1
current distortion factor
ratio of the root-mean square value of the harmonics content of an alternating current to the root-mean square value of the fundamental current

3.2
EUT
equipment under test

3.3
inductive coil
conductor loop of defined shape and dimensions, in which flows a current, generating a magnetic field of defined constancy in its plane and in the enclosed volume

3.4
inductive coil factor
ratio between the magnetic field strength generated by an inductive coil of given dimensions and the corresponding current value; the field is that measured at the centre of the coil plane, without the EUT

3.5
immersion method
method of application of the magnetic field to the EUT, which is placed in the centre of an inductive coil (see Figure 1)

3.6
proximity method
method of application of the magnetic field to the EUT, where a small inductive coil is moved along the side of the EUT in order to detect particularly sensitive areas

3.7
ground (reference) plane
GRP
flat conductive surface whose potential is used as a common reference for the magnetic field generator and the auxiliary equipment (the ground plane can be used to close the loop of the inductive coil, as in Figure 5)

[IEV 161-04-36, modified]

3.8
decoupling network, back filter
electrical circuit intended to avoid reciprocal influence with other equipment not submitted to the magnetic field immunity test

4 General

The magnetic fields to which equipment is subjected may influence the reliable operation of equipment and systems.

The following tests are intended to demonstrate the immunity of equipment when subjected to power frequency magnetic fields related to the specific location and installation condition of the equipment (e.g. proximity of equipment to the disturbance source).

The power frequency magnetic field is generated by power frequency current in conductors or, more seldom, from other devices (e.g. leakage of transformers) in the proximity of equipment.

As for the influence of nearby conductors, one should differentiate between:

– the current under normal operating conditions, which produces a steady magnetic field, with a comparatively small magnitude;

– the current under fault conditions which can produce comparatively high magnetic fields but of short duration, until the protection devices operate (a few milliseconds with fuses, a few seconds for protection relays).

The test with a steady magnetic field may apply to all types of equipment intended for public or industrial low voltage distribution networks or for electrical plants.

The test with a short duration magnetic field related to fault conditions, requires test levels that differ from those for steady-state conditions; the highest values apply mainly to equipment to be installed in exposed places of electrical plants.

The test field waveform is that of power frequency.

In many cases (household areas, sub-stations and power plant under normal conditions), the magnetic field produced by harmonics is negligible.

5 Test levels

The preferential range of test levels, respectively for continuous and short duration application of the magnetic field, applicable to distribution networks at 50 Hz and 60 Hz, is given in Table 1 and Table 2.

The magnetic field strength is expressed in A/m; 1 A/m corresponds to a free space magnetic flux density of 1,26 µT.

Table 1 – Test levels for continuous field

Level	**Magnetic field strength** A/m
1	1
2	3
3	10
4	30
5	100
x[a]	special

[a] "*x*" can be any level, above, below or in-between the other levels. This level can be given in the product specification.

Table 2 – Test levels for short duration: 1 s to 3 s

Level	Magnetic field strength A/m
1	n.a.[b]
2	n.a.[b]
3	n.a.[b]
4	300
5	1 000
x[a]	special

[a] "*x*" can be any level, above, below or in-between the other levels. This level, as well the duration of the test, can be given in the product specification.

[b] "n.a." = not applicable.

Information on the selection of the test levels is given in Annex C.

Information on actual levels is given in Annex D.

6 Test equipment

6.1 General

The test magnetic field is obtained by a current flowing in an inductive coil; the application of the test field to the EUT is by the *immersion method.*

An example of application of the immersion method is given in Figure 1.

The test equipment includes the current source (test generator), the inductive coil and auxiliary test instrumentation, that are also given in Figure 3.

6.2 Test generator

6.2.1 Current source

The current source typically consists of a voltage regulator (connected to the mains distribution network, or other sources), a current transformer and a circuit for the control of short duration application. The generator shall be able to operate in continuous mode or short duration mode.

The connection between the current transformer and the inductive coil input should be as short as possible to avoid that the currents which flow in the connection produce magnetic fields that affect the magnetic field in the test volume. Preferably the cables should be twisted together.

The characteristics and performances of the current source or test generator for the different fields and for different inductive coils considered in this standard, are given in 6.2.2.

6.2.2 Characteristics and performances of the test generator for different inductive coils

Table 3 specifies characteristics and performances of the test generator for different inductive coils.

Table 3 – Specification of the generator for different inductive coils

	With standard square coil 1 m × 1 m 1 turn	**With standard rectangular coil 1 m × 2,6 m 1 turn**	**With other inductive coils**
Output current range for continuous operation	1 A up to 120 A	1 A up to 160 A	As necessary to achieve required field strength in Table 4
Output current range for short duration	320 A up to 1 200 A	500 A up to 1 600 A	As necessary to achieve required field strength in Table 4
Current/Magnetic field waveform	Sinusoidal	Sinusoidal	Sinusoidal
Current distortion factor	≤8 %	≤8 %	≤8 %
Continuous mode	Up to 8 h	Up to 8 h	Up to 8 h
Short time operation	1s up to 3 s	1s up to 3 s	1 s up to 3 s
Transformer output	Floating not connected to PE	Floating not connected to PE	Floating not connected to PE

The schematic circuit of the generator is given in Figure 2.

6.2.3 Verification of the characteristics of the test generator

In order to compare the results for different test generators, the essential characteristics of the current parameters in the standard inductive coils shall be verified.

The characteristics to be verified are:

– current value in the standard inductive coils;

– field strength in all other inductive coils;

– total distortion factor in the inductive coils.

For standard inductive coils the verifications shall be carried out with a current probe and measurement instrumentation having better than ±2 % accuracy. Figure 4 shows the verification set-up.

For all other inductive coils the verification should be carried out with field strength meter, having an <±1dB accuracy.

Table 4 – Verification parameter for the different inductive coils

Table 1 Level	**Current values for the 1 m × 1 m standard coil** A	**Current values for the 1 m × 2,6 m standard coil** A	**Field strength in the centre for all other inductive coils** A/m
1	1,15	1,51	1
2	3,45	4,54	3
3	11,5	15,15	10
4	34,48	45,45	30
5	114,95	151,5	100

6.3 Inductive coil

6.3.1 Field distribution

For the two 1 turn standard coils 1 m × 1 m and 1 m × 2,6 m, the field distribution is known and shown in Annex B. Therefore, no field verification or field calibration is necessary, the current measurement as shown in Figure 4 is sufficient.

Other coils such as multi-turn coils may be used in order to have a lower testing current, or for EUT not fitting into the two standard coils, inductive coils of different dimensions may be used. For these cases, the field distribution (maximum variation of ±3 dB) shall be verified.

6.3.2 Characteristics of the inductive standard coils 1 m × 1 m and 1 m × 2,6 m

The inductance for the 1 turn standard 1 m × 1 m coil is approximately 2,5 μH, for the 1 m × 2,6 m standard coil approximately 6 μH.

The inductive coil shall be made of copper, aluminium or any conductive non-magnetic material, of such cross-section and mechanical arrangement as to facilitate its stable positioning during the tests. For continuous tests up to 100 A/m the cross section of aluminium should be 1,5 cm^2 and for short time test up to 1 000 A/m the cross section should be 4 cm^2.

The tolerance of the standard coils is ±1 cm, measured between the centre lines (centre of the cross section). The characteristics of inductive coils with respect to the magnetic field distribution are given in Annex B.

6.3.3 Characteristics of the inductive coils for table top and floor standing equipment

The list below gives the testing requirements for table top and floor standing equipment.

a) Inductive coil for table-top equipment

   The inductive coil of standard dimensions for testing small equipment (e.g. computer monitors, watt-hour meters, transmitters for process control, etc.) has a square form with 1 m side. The test volume of the standard square coil is 0,6 m × 0,6 m × 0,5 m (height).

   Any other coils can be used to obtain a field homogeneity better than 3 dB.

   For example, a double coil of standard size (Helmholtz coil) could be used in order to obtain a field homogeneity better than 3 dB or for testing larger EUTs.

   The double coil (Helmholtz coil) shall be comprised of two or more series of turns, properly spaced (see Figure 7, Figure B.4, Figure B.5).

   The test volume of a double standard size coil, 0,8 m spaced, for a 3 dB homogeneity is 0,6 m × 0,6 m × 1 m (height).

   For example, the Helmholtz coils, for a 0,2 dB inhomogeneity, have dimensions and separation distances as given in Figure 7.

   No GRP is permitted as part of the coil nor on the insulating table below the EUT (see Figure 3).

b) Inductive coil for floor-standing equipment

   The inductive coil of standard dimensions for testing floor standing equipment (e.g. racks, etc.) has a square form with 1 m side and 2,6 m height.

   The test volume of the standard square coil is 0,6 m × 2 m (height) × 0,6 m.

   When an EUT does not fit into the standard inductive coil 1 m × 2,6 m, the product committee should select the test method: either the proximity method with the standard 1 m × 1 m 1 turn inductive coil (Figure 6 is an example) or inductive coils shall be made according to the dimensions of the EUT and the different field orientation of the magnetic field.

Note that larger inductive coils give comparable results, but it may be not practicable to construct very large coils. In this case the proximity method may give useful but not necessarily reproducible results.

A GRP shall be present as in Figure 5.

NOTE Due to the possible large dimensions of EUTs, the coils may be made of "C" or "T" sections in order to have sufficient mechanical rigidity.

6.3.4 Measurement of the inductive coil factor

In order to make it possible to compare the test results from different test equipment, the inductive coil factor shall be measured without the EUT, in free space condition.

For the two 1 turn standard coils 1 m × 1 m and 1 m × 2,6 m, the field distribution is known and shown in Annex B. Therefore, neither field verification nor field calibration is necessary, the current measurement, as shown in Figure 4, is sufficient.

For all other inductive coils the following procedure shall be carried out. An inductive coil of the correct dimensions for the EUT dimensions, shall be positioned at 1 m minimum distance from the wall of the laboratory and any magnetic material, by using insulating supports, and the inductive coil shall be connected to the test generator as prescribed in 6.2.

An appropriate magnetic field sensor shall be used to verify the magnetic field strength generated by the inductive coil.

The field sensor shall be positioned at the centre of the inductive coil (without the EUT) and with suitable orientation to detect the maximum value of the field.

The current in the inductive coil shall be adjusted to obtain the field strength specified by the test level.

The measurement shall be carried out at power frequency.

The measurement procedure shall be carried out with the test generator and inductive coil.

The coil factor is determined (and verified) by the above procedure.

The coil factor gives the current value to be injected in the coil to obtain the required test magnetic field (H/I) in the centre of the inductive coil.

Information on the measurement of the test magnetic field is given in Annex A.

6.4 Test and auxiliary instrumentation

6.4.1 Test instrumentation

The test instrumentation includes the current measuring system (sensors and instrument) for setting and measuring the current injected in the inductive coil.

NOTE The termination networks, back filters, etc. on power supply, control and signal lines that is part of the test set-up for other tests may be maintained.

The current measuring system is a calibrated current, measuring instrument, probe or shunt.

The accuracy of the measurement instrumentation shall be ±2 %.

6.4.2 Auxiliary instrumentation

The auxiliary instrumentation comprises a simulator and any other instrument necessary for the operation and verification of the EUT functional specifications.

7 Test set-up

7.1 Test set-up components

The test set-up comprises the following components:

– equipment under test (EUT);
– inductive coil;
– test generator;
– GRP for floor standing equipment.

Precautions shall be taken if the test magnetic field may interfere with the test instrumentation and other sensitive equipment in the vicinity of the test set-up.

Examples of test set-ups are given in the following figures:

Figure 3: example of test set-up for table-top equipment;

Figure 5: example of test set-up for floor-standing equipment.

7.2 Ground (reference) plane for floor standing equipment

The ground plane (GRP) shall be placed in the laboratory; the floor standing EUT and auxiliary test equipment shall be placed on it and connected to GRP or to earth terminal.

The ground plane shall be a non-magnetic metal sheet (copper or aluminium) of 0,25 mm minimum thickness; other metals may be used but in this case they shall have at least 0,65 mm minimum thickness.

The minimum size of the ground plane is 1 m × 1 m.

The final size depends on the dimensions of the floor standing EUT.

The ground plane shall be connected to the safety earth system of the laboratory.

7.3 Equipment under test

The equipment is configured and connected to satisfy its functional requirements. Floor standing equipment shall be placed on the GRP with the interposition of a 0,1 m thickness insulating support (e.g. dry wood). For table top equipment see Figure 3.

The equipment cabinets which can be earthed shall be connected to the safety earth directly on the GRP or via the earth terminal to PE.

The power supply, input and output circuits shall be connected to the sources of power supply, control and signal.

The cables supplied or recommended by the equipment manufacturer shall be used. In absence of any recommendation, unshielded cables shall be adopted, of a type appropriate for the signals involved. All cables shall be exposed to the magnetic field for 1 m of their length.

The back filters, if any, shall be inserted in the circuits at 1 m cable length from the EUT and connected to the ground plane.

The communication lines (data lines) shall be connected to the EUT by the cables given in the technical specification or standard for this application.

7.4 Test generator

The test generator shall not influence the magnetic field and therefore shall not be placed close to the inductive coil.

7.5 Inductive coil

The inductive coil, of the type specified in 6.3.2, shall enclose the EUT. The EUT shall be positioned inside the 3 dB test volume of the inductive coil.

Different inductive coils may be selected for testing in the different orthogonal directions, according to the general criteria specified in 6.3.3 a) and in 6.3.3 b).

The inductive coil shall be connected to the test generator in the same way as for the procedure specified in 6.3.4.

The inductive coil selected for the tests shall be specified in the test plan.

8 Test procedure

8.1 General

The test procedure shall include:

– verification of the laboratory reference conditions;
– preliminary verification of the correct operation of the equipment;
– carrying out the test;
– evaluation of the test results.

8.2 Laboratory reference conditions

8.2.1 General

In order to minimize the effect of environmental parameters on the test results, the test shall be carried out in climatic and electromagnetic reference conditions as specified in 8.2.2. and 8.2.3.

8.2.2 Climatic conditions

Unless otherwise specified by the committee responsible for the generic or product standard, the climatic conditions in the laboratory shall be within any limits specified for the operation of the EUT and the test equipment by their respective manufacturers.

Tests shall not be performed if the relative humidity is so high as to cause condensation on the EUT or the test equipment.

NOTE Where it is considered that there is sufficient evidence to demonstrate that the effects of the phenomenon covered by this standard are influenced by climatic conditions, this should be brought to the attention of the committee responsible for this standard.

8.2.3 Electromagnetic conditions

The electromagnetic conditions of the laboratory shall be such as to guarantee the correct operation of the EUT in order not to influence the test results; otherwise, the tests shall be carried out in a Faraday cage.

In particular, the power frequency magnetic field value of the laboratory shall be at least 20 dB lower than the selected test level.

8.3 Carrying out the test

Care should be taken for any person in the laboratory with respect to applicable requirements regarding human exposure. If no requirements exist on human protection, a distance of 2 m is recommended.

The test shall be carried out on the basis of a test plan including verification of the performances of the EUT as defined in the technical specification.

The power supply, signal and other functional electrical quantities shall be applied within their rated range.

If the actual operating signals are not available, they may be simulated.

Preliminary verification of equipment performances shall be carried out prior to applying the test magnetic field.

The test magnetic field shall be applied by the immersion method to the EUT, previously set up as specified in 7.3.

The test level shall not exceed the product specification.

The test field strength and the duration of the test shall be as determined by the selected test level, according to the different type of fields (continuous or short duration field) established in the test plan.

a) Table-top equipment

   The equipment shall be subjected to the test magnetic field as shown in Figure 3.

   The plane of the inductive coil shall then be rotated by 90° in order to expose the EUT to the test field with different orientations.

b) Floor-standing equipment

   The equipment shall be subjected to the test magnetic field by using inductive coils of suitable dimensions as specified in 6.3.3 b). The test shall be repeated by moving and shifting the inductive coils, in order to test the whole volume of the EUT for each orthogonal direction (see Figure 5).

   If the EUT is larger than the 3 dB test volume of the inductive coil, then the test shall be repeated with the coil moved to different positions, in steps corresponding to 50 % of the shortest side of the coil, so that the entire EUT is progressively immersed in the 3 dB test volume.

   NOTE The moving of the inductive coil in steps corresponding to 50 % of the shortest side of the coil gives overlapping test fields.

   The plane of the inductive coil shall then be rotated by 90° in order to expose the EUT to the test field with different orientations and the same procedure.

9 Evaluation of the test results

The test results shall be classified in terms of the loss of function or degradation of performance of the equipment under test, relative to a performance level defined by its manufacturer or the requestor of the test, or agreed between the manufacturer and the purchaser of the product. The recommended classification is as follows:

a) normal performance within limits specified by the manufacturer, requestor or purchaser;
b) temporary loss of function or degradation of performance which ceases after the disturbance ceases, and from which the equipment under test recovers its normal performance, without operator intervention;
c) temporary loss of function or degradation of performance, the correction of which requires operator intervention;
d) loss of function or degradation of performance which is not recoverable, owing to damage to hardware or software, or loss of data.

The manufacturer's specification may define effects on the EUT which may be considered insignificant, and therefore acceptable.

This classification may be used as a guide in formulating performance criteria, by committees responsible for generic, product and product-family standards, or as a framework for the agreement on performance criteria between the manufacturer and the purchaser, for example where no suitable generic, product or product-family standard exists.

10 Test report

The test report shall contain all the information necessary to reproduce the test. In particular, the following shall be recorded:

- the items specified in the test plan required by Clause 8 of this standard;
- identification of the EUT and any associated equipment, for example, brand name, product type, serial number;
- identification of the test equipment, for example, brand name, product type, serial number;
- any special environmental conditions in which the test was performed, for example, shielded enclosure;
- any specific conditions necessary to enable the test to be performed;
- performance level defined by the manufacturer, requestor or purchaser;
- performance criterion specified in the generic, product or product-family standard;
- any effects on the EUT observed during or after the application of the test disturbance, and the duration for which these effects persist;
- the rationale for the pass/fail decision (based on the performance criterion specified in the generic, product or product-family standard, or agreed between the manufacturer and the purchaser);
- any specific conditions of use, for example cable length or type, shielding or grounding, or EUT operating conditions, which are required to achieve compliance.

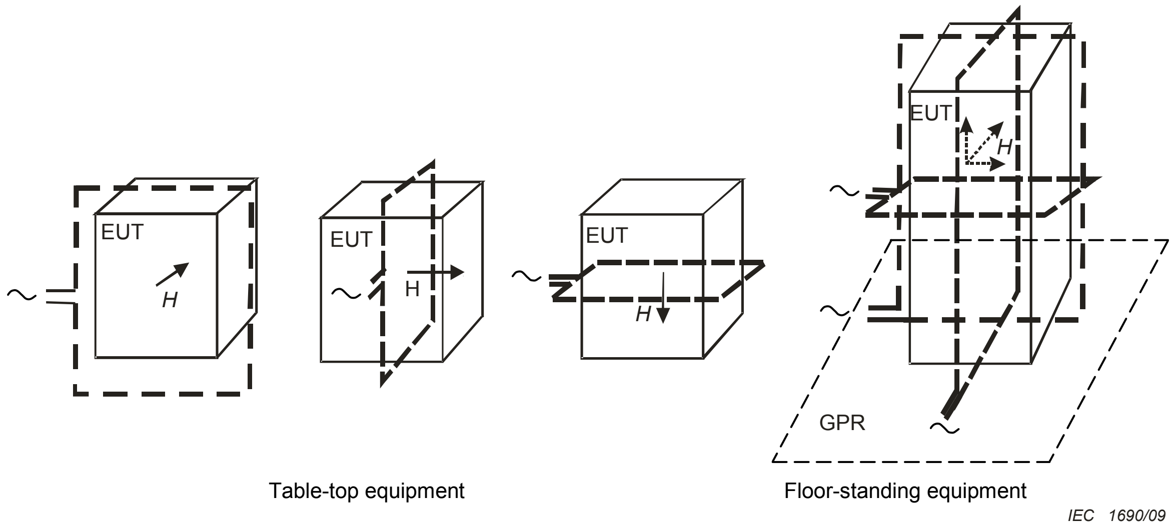
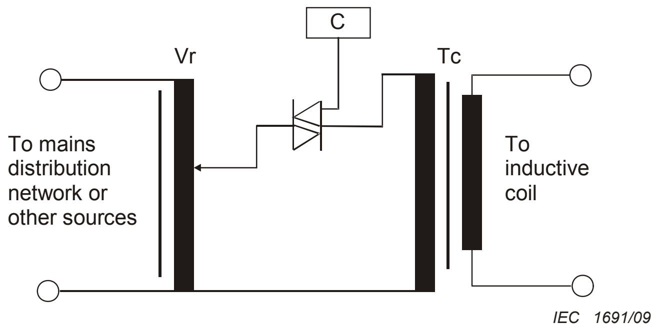


Figure 1 – Example of application of the test field by the immersion method



Components

Vr Voltage regulator

C Control circuit

Tc Current transformer

Figure 2 – Example of schematic circuit of the test generator for power frequency magnetic field

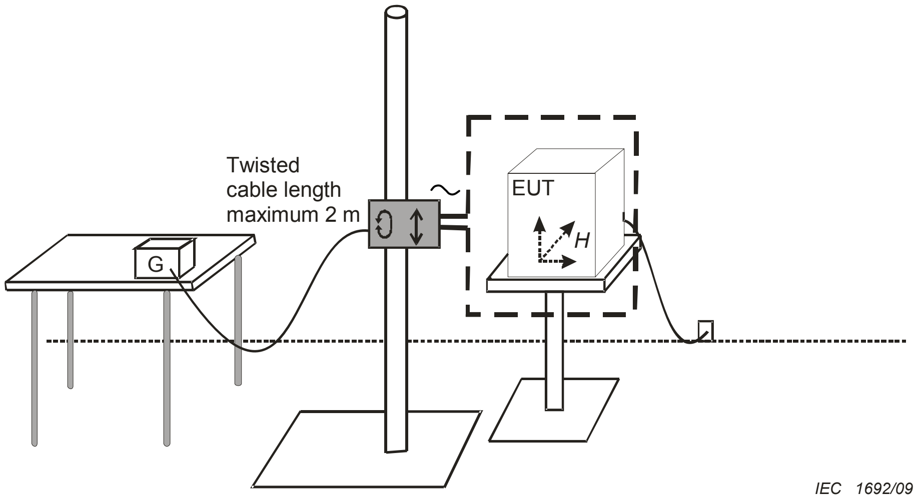


Figure 3 – Example of test set-up for table-top equipment

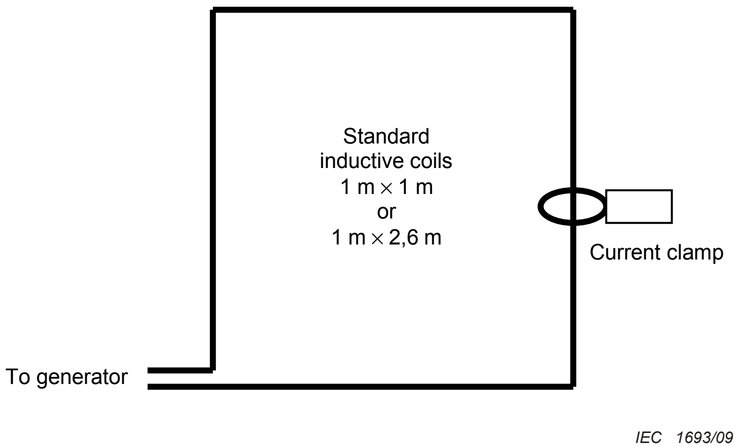
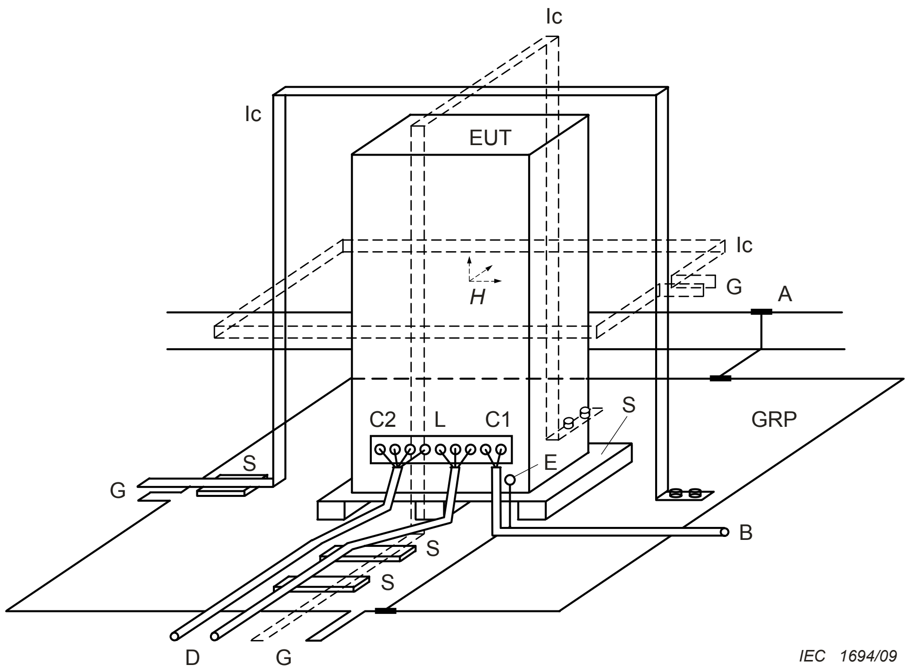


Figure 4 – Calibration of the standard coils



Components

GRP	Ground plane	C1	Power supply circuit
A	Safety earth	C2	Signal circuit
S	Insulating support	L	Communication line
EUT	Equipment under test	B	To power supply source
Ic	Inductive coil	D	To signal source, simulator
E	Earth terminal	G	To the test generator

Figure 5 – Example of test set-up for floor-standing equipment

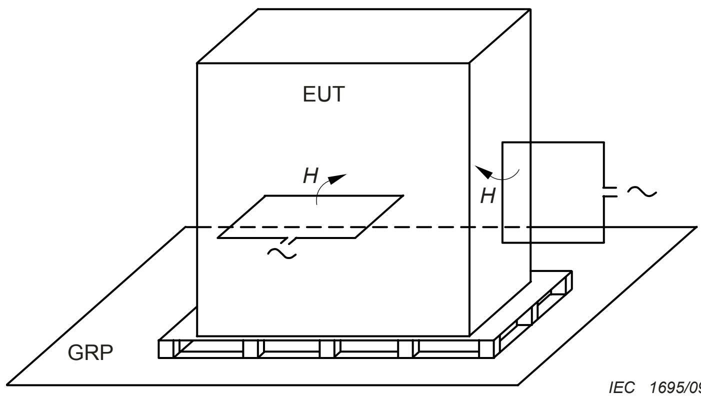
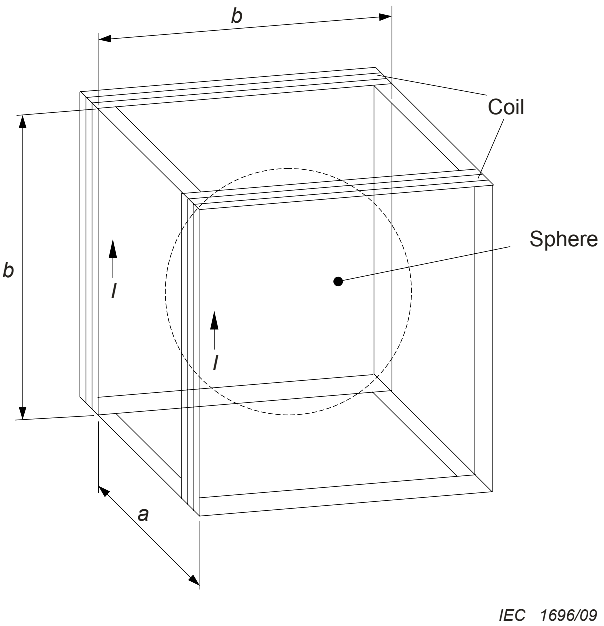


Figure 6 – Example of investigation of susceptibility to magnetic field by the proximity method with the 1 m × 1 m inductive coil



Key

n	Number of turns in each coil	*a*	Separation of the coils
b	Side of the coils (m)	*I*	Current value (A)
H	Magnetic field strength (A/m)	*H*	$1{,}22 \times n/b \times I$

(with $a = b/2{,}5$ the non-homogeneity of the magnetic field strength is ±0,2 dB)

Figure 7 – Illustration of Helmholtz coils

Annex A
(normative)

Inductive coil calibration method

A.1 Magnetic field measurement

The magnetic field test is related to free space condition, without the EUT and with the coil at 1 m minimum distance from any magnetic material and the laboratory walls. The exception to this is the GRP for floor standing equipment test set-up, which is part of the coil and has to be on the floor.

The measurement of the magnetic field may be done with a measurement system comprising calibrated sensors e.g. a "Hall effect" or multi-turn loop sensor with a diameter of at least one order of magnitude smaller than the test inductive coil and a power frequency narrow band instrument.

A.2 Calibration of the inductive coil

The calibration shall be carried out by injecting the calibration current at power frequency in the inductive coil and by measuring for standard inductive coils the current and for other inductive coils the magnetic field by sensors placed at its geometrical centre.

Proper orientation of the sensor shall be selected in order to obtain the maximum value.

The *"inductive coil factor"* shall be determined for each inductive coil as the ratio "field strength/current" of injection (H/A).

The "coil factor", determined at a.c. current, is not related to the current waveform, because it is a characteristic parameter of the inductive coil; it is therefore applicable for the evaluation of magnetic fields at power frequency.

Annex B
(normative)

Characteristics of the inductive coils

B.1 General

This annex considers the relevant aspects with respect to the generation of magnetic fields for immunity tests.

In the first stage, both the immersion and proximity methods were considered.

In order to know the limits of application of such methods, some questions have been emphasized.

In the following the reasons for the values are explained.

B.2 Inductive coil requirements

The requirement of the inductive coil is "*3 dB tolerance of the test field in the volume of the EUT*"; this tolerance has been considered a reasonable technical compromise in respect of a test characterized by severity levels in 10 dB steps, due to practical limits in the generation of uniform field over a wide range of volumes.

The constancy of the field is a requirement limited to a single direction, orthogonal to the coil plane. The field in different directions is obtainable in successive test steps by rotating the inductive coil.

B.3 Inductive coil characteristics

The characteristics of inductive coils of different dimensions suitable for testing *table-top equipment* or *floor-standing equipment* are given in diagrams showing:

– profile of the field generated by a square inductive coil (1 m side) in its plane (see Figure B.1);
– 3 dB area of the field generated by a square inductive coil (1 m side) in its plane (see Figure B.2);
– 3 dB area of the field generated by a square inductive coil (1 m side) in the mean orthogonal plane (component orthogonal to the plane of the coil) (see Figure B.3);
– 3 dB area of the field generated by two square inductive coils (1 m side) 0,6 m spaced, in the mean orthogonal plane (component orthogonal to the plane of the coils) (see Figure B.4);
– 3 dB area of the field generated by two square inductive coils (1 m side) 0,8 m spaced, in the mean orthogonal plane (component orthogonal to the plane of the coils) (see Figure B.5);
– 3 dB area of the field generated by a rectangular inductive coil (1 m × 2,6 m) in its plane (see Figure B.6);
– 3 dB area of the field generated by a rectangular inductive coil (1 m × 2,6 m) in its plane (ground plane as a side of the inductive coil) (see Figure B.7);
– 3 dB area of the field generated by a rectangular inductive coil (1 m × 2,6 m), with ground plane, in the mean orthogonal plane (component orthogonal to the plane of the coil) (see Figure B.8).

In the selection of the form, arrangement and dimensions of the test coil, the following points have been considered:

– the 3 dB area, inside and outside the inductive coil, is related to the shape and dimensions of the inductive coil;
– for a given field strength, driving current value, power and energy of the test generator are proportional to the dimensions of the inductive coil.

B.4 Summary of characteristics of inductive coils

On the basis of the data on the field distribution of coils with different sizes, and in view of adopting the test method given in this standard to different classes of equipment, the conclusions that can be drawn are as follows:

– *single square coil, 1 m side:* test volume 0,6 m × 0,6 m × 0,5 m (height) (0,2 m minimum distance from EUT to the coil);
– *double square coils, 1 m side, 0,6 m spaced:* test volume 0,6 m × 0,6 m × 1 m (height) (0,2 m minimum distance from EUT to the coil); increasing of the separation of the coils up to 0,8 m extends the maximum height of testable EUT (see the 3 dB area, in the mean orthogonal plane) up to 1,2 m.
– *single rectangular coil, 1 m × 2,6 m:* test volume 0,6 m × 2 m (height) × 0,6 m (0,2 m and 0,3 m minimum distance from EUT to the coil, respectively, for the horizontal and vertical dimensions of EUT); if the inductive coil is bonded to the GRP, a 0,1 m distance from it is sufficient.

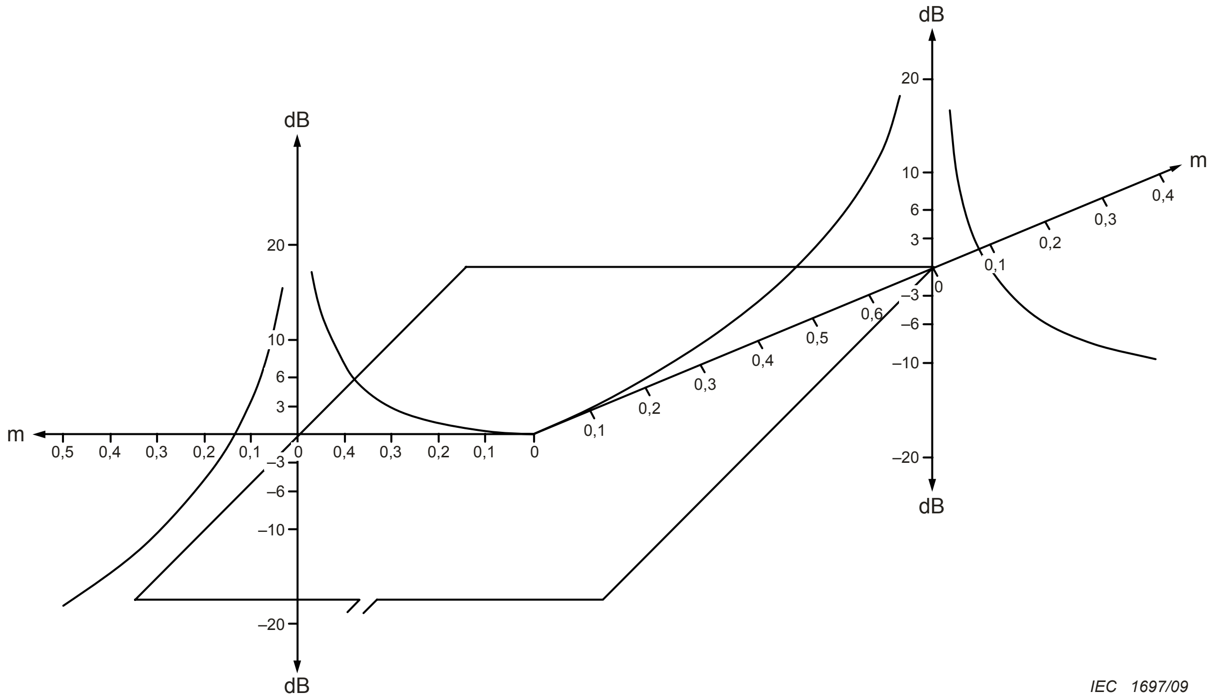


Figure B.1 – Characteristics of the field generated by a square inductive coil (1 m side) in its plane

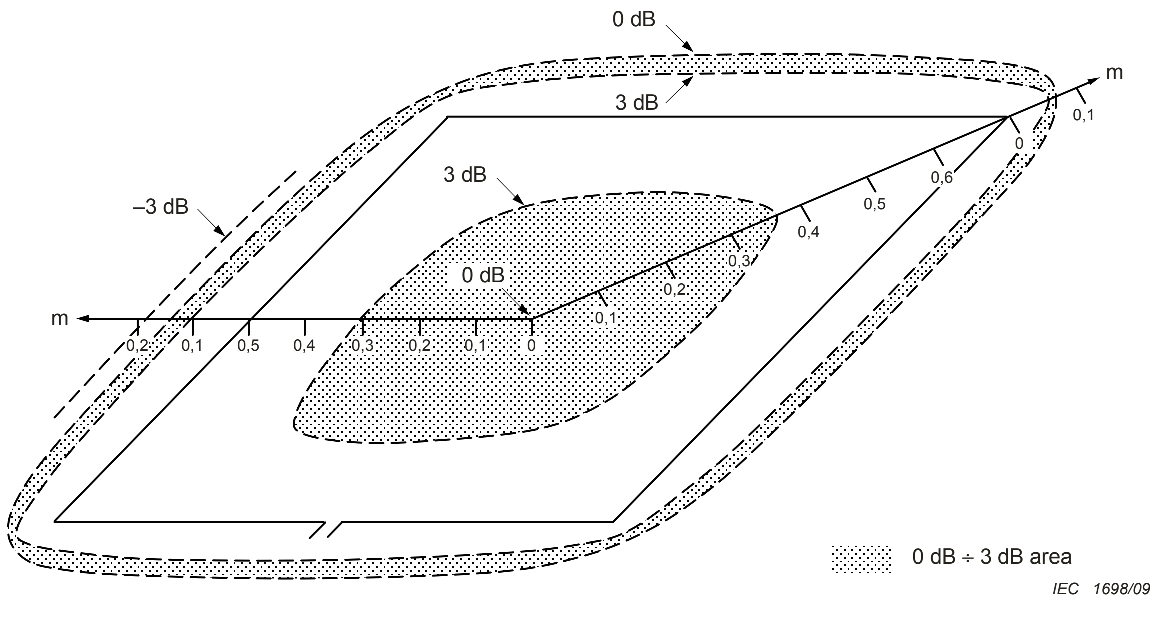


Figure B.2 – 3 dB area of the field generated by a square inductive coil (1 m side) in its plane

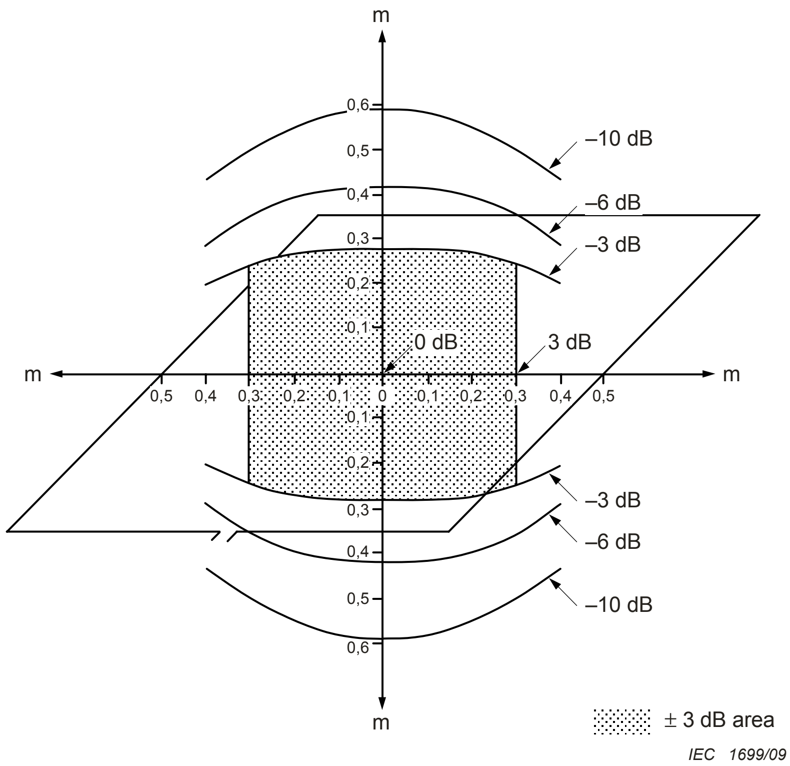


Figure B.3 – 3 dB area of the field generated by a square inductive coil (1 m side) in the mean orthogonal plane (component orthogonal to the plane of the coil)

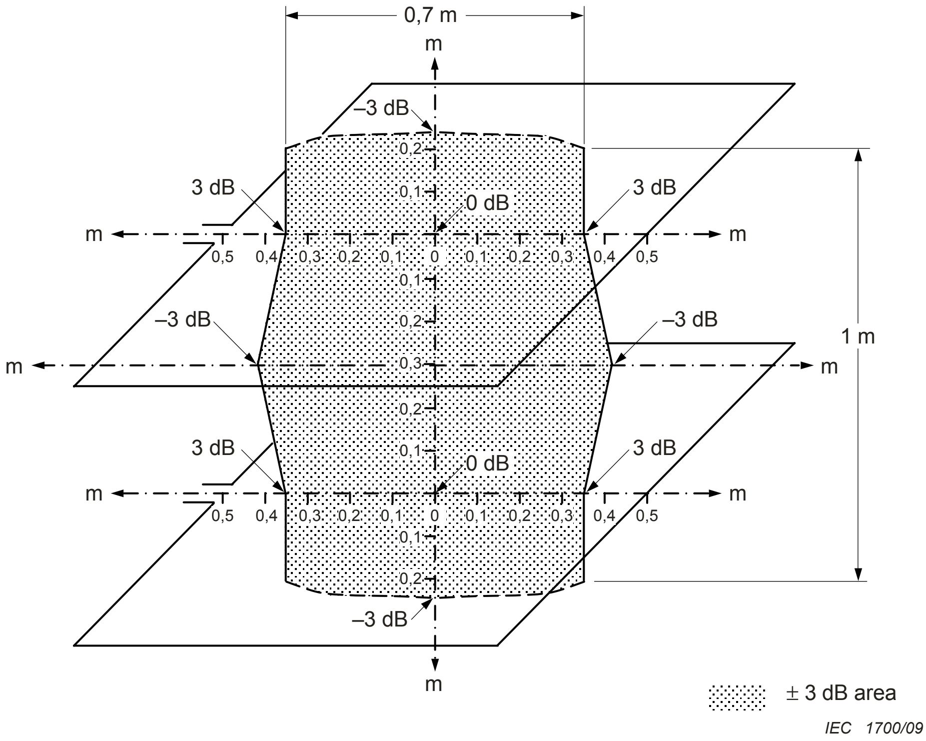


Figure B.4 – 3 dB area of the field generated by two square inductive coils (1 m side) 0,6 m spaced, in the mean orthogonal plane (component orthogonal to the plane of the coils)

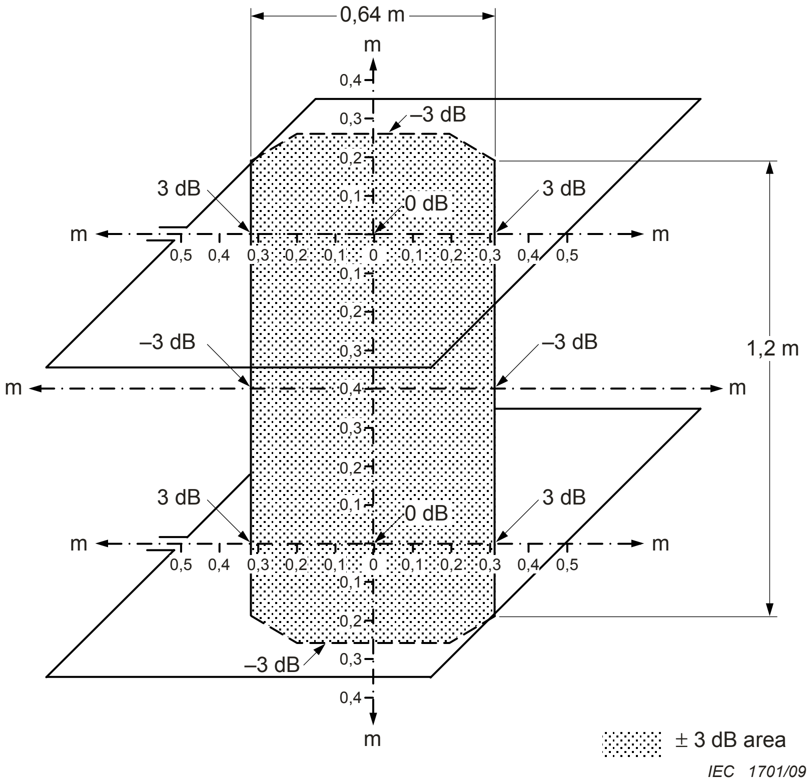


Figure B.5 – 3 dB area of the field generated by two square inductive coils (1 m side) 0,8 m spaced, in the mean orthogonal plane (component orthogonal to the plane of the coils)

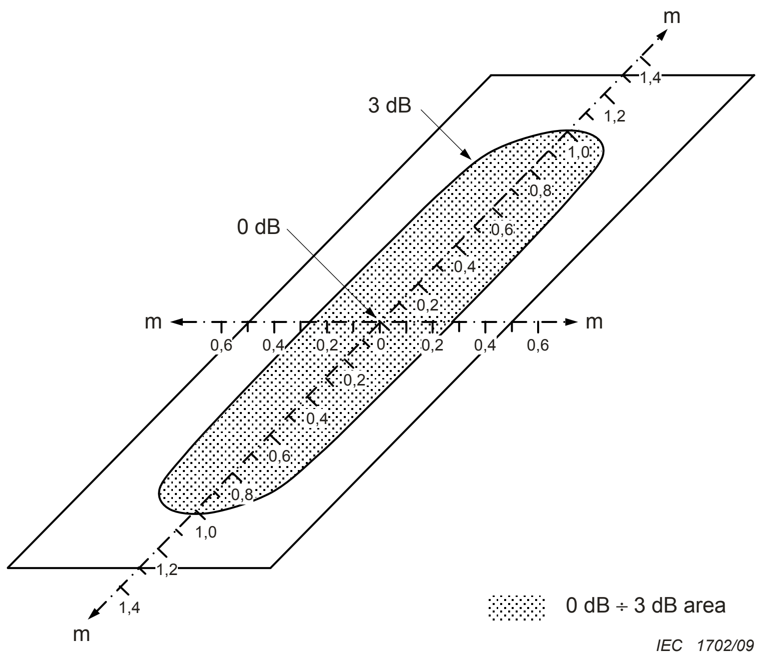


Figure B.6 – 3 dB area of the field generated by a rectangular inductive coil (1 m × 2,6 m) in its plane

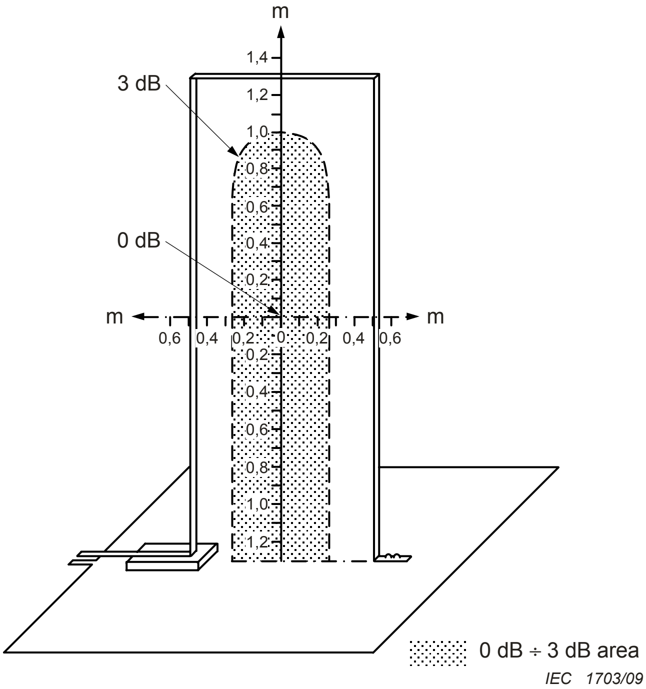


Figure B.7 – 3 dB area of the field generated by a rectangular inductive coil (1 m × 2,6 m) in its plane (ground plane as a side of the inductive coil)

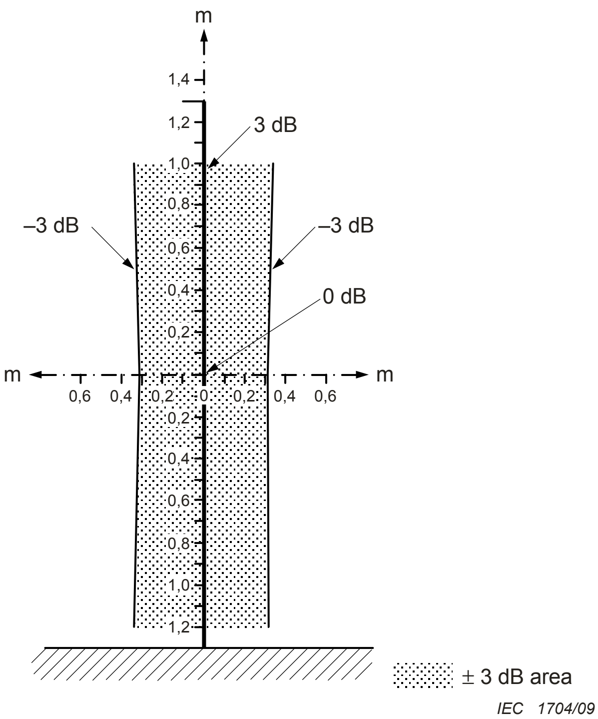


Figure B.8 – 3 dB area of the field generated by a rectangular inductive coil (1 m × 2,6 m) with ground plane, in the mean orthogonal plane (component orthogonal to the plane of the coil)

Annex C
(informative)

Selection of the test levels

The test levels shall be selected in accordance with the most realistic installation and environmental conditions.

These levels are outlined in Clause 5.

The immunity tests are correlated with these levels in order to establish a performance level for the environment in which the equipment is expected to operate. A survey of power frequency magnetic field strength is given in Annex D.

The test level shall be chosen according to:

– the electromagnetic environment;
– the proximity of the disturbance sources to the equipment concerned;
– the compatibility margins.

Based on common installation practices, a guide for the selection of test levels for magnetic fields testing may be the following:

Class 1: Environmental level where sensitive device using electron beam can be used.

CRT Monitors, electron microscope, etc., are representative of these devices.

Class 2: Well protected environment

The environment is characterized by the following attributes:

– absence of electrical equipment like power transformers that may give rise to leakage fluxes;
– areas not subjected to the influence of H.V. bus-bars.

Household, office, hospital protected areas far away from earth protection conductors, areas of industrial installations and H.V. sub-stations may be representative of this environment.

Class 3: Protected environment

The environment is characterized by the following attributes:

– electrical equipment and cables that may give rise to leakage fluxes or magnetic field;
– proximity of earth conductors of protection systems;
– M.V. circuits and H.V. bus-bars far away (a few hundred metres) from equipment concerned.

Commercial areas, control building, field of not heavy industrial plants, computer room of H.V. sub-stations may be representative of this environment.

Class 4: Typical industrial environment

The environment is characterized by the following attributes:

– short branch power lines as bus-bars, etc.;
– high power electrical equipment that may give rise to leakage fluxes;
– ground conductors of protection system;
– M.V. circuits and H.V. bus-bars at relative distance (a few tens of metres) from equipment concerned.

Fields of heavy industrial and power plants and the *control room of H.V. sub-stations* may be representative of this environment.

Class 5: Severe industrial environment

The environment is characterized by the following attributes:

- conductors, bus-bars or M.V., H.V. lines carrying tens of kA;
- ground conductors of the protection system;
- proximity of M.V. and H.V. bus-bars;
- proximity of high power electrical equipment.

Switchyard areas of heavy industrial plants, M.V., H.V. and power stations may be representative of this environment.

Class X: Special environment

The minor or major electromagnetic separation of interference sources from equipment circuits, cables, lines etc., and the quality of the installations may require the use of a higher or lower environmental level than those described above. It should be noted that the equipment lines of a higher level can penetrate a lower severity environment.

Annex D
(informative)

Information on power frequency magnetic field strength

Data on the strength of the magnetic field considered are given below. Although not exhaustive, they may give information on the field strength expected at different locations and/or situations. Product committees may take them into account in the selection of the test levels, strictly related to each specific application.

Data are limited to available bibliography and/or measurements.

a) Household appliances

A survey on the magnetic fields produced by about 100 different appliances of 25 basic types is given in Table D.1. The field strength is related to the surfaces of appliances (it is quite localized) and at greater distances. At a distance of 1 m or more it would vary from the maximum expected field at that distance by only 10 % to 20 % when measured in any direction from the appliance. Background magnetic field in the homes where appliances were measured ranged from 0,05 A/m to 0,1 A/m.

The faults in domestic low-voltage power lines gives field strength higher than specified, depending on the short-circuit current of each installation; the duration is in the order of hundreds of milliseconds, depending on the protection devices installed.

Table D.1 – Values of the maximum magnetic field produced by household appliances (results of the measurements of 100 different devices of 25 basic types)

Distance from the surface of the device	*d* = 0,3 m	*d* = 1,5 m
95 % of the measurements	0,03 A/m – 10 A/m	<0,1 A/m
Highest measurements	21 A/m	0,4 A/m

b) High voltage lines

Because the magnetic field is dependent on the line configuration, load and fault conditions, the field profile may be more significant to determine the electromagnetic environment to which equipment may be exposed.

General information on the environment produced by high voltage lines is given in IEC 61000-2-3.

The quantitative survey of the actual field measurement is given in Table D.2.

Table D.2 – Values of the magnetic field generated by a 400 kV line

Under the line tower	Under a mid-span section	At 30 m lateral distance
10 A/m/kA	16 A/m/kA	about 1/3 of previous values

c) H.V. sub-station area

The quantitative survey of the actual field measurements related to 220 kV and 400 kV high voltage sub-stations is given in Table D.3.

Table D.3 – Values of the magnetic field in high voltage sub-station areas

Sub-station	220 kV	400 kV
Under the bus-bars near connection to a line carrying about 0,5 kA	14 A/m	9 A/m
In the relay room (kiosk)	Near event recorders at about 0,5 m distance: 3,3 A/m Near measurement voltage transformer: *d* = 0,1 m: 7,0 A/m *d* = 0,3 m: 1,1 A/m	
In the equipment room	Maximum 0,7 A/m	

d) Power plants and industrial plants

Measurements were carried out at different areas of a power plant; most of them are comparable, for the kind of power supply lines and electrical equipment, to industrial plants.

The survey of the actual field measurement is given in Table D.4.

Table D.4 – Values of the magnetic field in power plants

Source of magnetic field	Field (A/m) at a distance of:			
	0,3 m	**0,5 m**	**1 m**	**1,5 m**
Medium voltage bus-bars carrying 2,2 kA[a]	14 – 85	13,5 – 71	8,5 – 35	5,7
190 MVA, MV/HV transformer, 50 % load	–	–	6,4	–
6 kV cells[a]	8 – 13	6,5 – 9	3,5 – 4,3	2 – 2,4
6 kV twisted power cables	–	2,5	–	–
6 MVA pumps (at full load, 0,65 kA)	26	15	7	–
600 kVA, MV/LV transformer	14	9,6	4,4	–
Control building, multipoint paper recorder	10,7	–	–	–
Control room, far away from sources	0,9			

[a] These ranges include the values related to the different direction of the distance and geometry of the installation.

Bibliography

IEC 60068-1, *Environmental testing – Part 1: General and guidance*

IEC 61000-2-4, *Electromagnetic compatibility (EMC) – Part 2-4: Environment – Compatibility levels in industrial plants for low-frequency conducted disturbances*

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