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BASIC EMC PUBLICATION

PUBLICATION FONDAMENTALE EN CEM

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

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

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ELECTROMAGNETIC COMPATIBILITY (EMC) –

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

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
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International Standard IEC 61000-4-8 has been prepared by subcommittee 77A: Low frequency phenomena, of IEC technical committee 77: Electromagnetic compatibility.

This second edition cancels and replaces the first edition published in 1993 and its Amendment 1 (2000). It forms a technical revision.

This edition includes the following significant technical changes with respect to the previous edition: 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.

It forms Part 4-8 of the IEC 61000 series of standards. It has the status of a basic EMC publication in accordance with IEC Guide 107.

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

FDIS	Report on voting
77A/694/FDIS	77A/706/RVD

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

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

A list of all parts of the IEC 61000 series, under the general title *Electromagnetic compatibility*, can be found on the IEC website.

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

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

INTRODUCTION

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 %.