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Electromagnetic compatibility (EMC) - Part 4: Testing and measurement techniques - Section 6: Immunity to conducted disturbances, induced by radio-frequency fields (IEC 1000-4-6:1996)

Electromagnetic compatibility (EMC) -- Part 4-6: Testing and measurement techniques - Immunity to conducted disturbances, induced by radio-frequency fields

Elektromagnetische Verträglichkeit (EMV) -- Teil 4-6: Prüf- und Meßverfahren - Störfestigkeit gegen leitungsgeführte Störgrößen, induziert durch hochfrequente Felder

Compatibilité électromagnétique (CEM) -- Partie 4-6: Techniques d'essai et de mesure - Immunité aux perturbations conduites, induites par les champs radioélectriques

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Electromagnetic compatibility (EMC)
Part 4: Testing and measurement techniques
Section 6: Immunity to conducted disturbances, induced by radio-frequency fields
(IEC 1000-4-6:1996)

Compatibilité électromagnétique (CEM)
Partie 4: Techniques d'essai et de mesure
Section 6: Immunité aux perturbations conduites, induites par les champs radioélectriques
(CEI 1000-4-6:1996)

Elektromagnetische Verträglichkeit (EMV)
Teil 4: Prüf- und Meßverfahren
Hauptabschnitt 6: Leitungsgeführte Störgrößen, induziert durch hochfrequente Felder
(IEC 1000-4-6:1996)

This European Standard was approved by CENELEC on 1996-07-02. 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.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CENELEC

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

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of document 65A/165/FDIS - 77B/144/FDIS, future edition 1 of IEC 1000-4-6, prepared by SC 65A, System aspects, of IEC TC 65, Industrial-process measurement and control and by SC 77B, High-frequency phenomena, of IEC TC 77, Electromagnetic compatibility, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61000-4-6 on 1996-07-02.

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) 1997-04-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 1997-04-01

Annexes designated "normative" are part of the body of the standard.
Annexes designated "informative" are given for information only.
In this standard, annexes A and ZA are normative and annexes B, C, D and E are informative.
Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 1000-4-6:1996 was approved by CENELEC as a European Standard without any modification.

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

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 50(131)	1978	International electrotechnical vocabulary (IEV) Chapter 131: Electric and magnetic circuits	-	-
IEC 50(161)	1990	Chapter 161: Electromagnetic compatibility	-	-
IEC 1000-4-3	1995	Electromagnetic compatibility (EMC) Part 4: Testing and measurement techniques Section 3: Radiated, radio-frequency, electromagnetic field immunity test	-	-
CISPR 16-1	1993	Specification for radio disturbance and immunity measuring apparatus and methods Part 1: Radio disturbance and immunity measuring apparatus	-	-
CISPR 20	1990	Limits and methods of measurement of immunity characteristics of sound and television broadcast receivers and associated equipment	-[1)]	-

1) See EN 55020:1994, Electromagnetic immunity of broadcast receivers and associated equipment.

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Section 6: Immunité aux perturbations conduites, induites par les champs radioélectriques

Electromagnetic compatibility (EMC) –
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Bureau Central de la Commission Electrotechnique Internationale 3, rue de Varembé Genève, Suisse

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTROMAGNETIC COMPATIBILITY (EMC) –
Part 4: Testing and measurement techniques –
Section 6: Immunity to conducted disturbances, induced by radio-frequency fields

FOREWORD

1) The IEC (International Electrotechnical Commission) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of the IEC is to promote international cooperation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, the IEC publishes International Standards. 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. The IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.

2) The formal decisions or agreements of the IEC on technical matters, express as nearly as possible an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested National Committees.

3) The documents produced have the form of recommendations for international use and are published in the form of standards, technical reports or guides and they are accepted by the National Committees in that sense.

4) In order to promote international unification, IEC National Committees undertake to apply IEC International Standards transparently to the maximum extent possible in their national and regional standards. Any divergence between the IEC Standard and the corresponding national or regional standard shall be clearly indicated in the latter.

5) The IEC provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with one of its standards.

6) Attention is drawn to the possibility that some of the elements of this International Standard may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

International Standard IEC 1000-4-6 has been prepared by subcommittee 65A: System aspects, of IEC technical committee 65: Industrial-process measurement and control and by subcommittee 77B: High-frequency phenomena, of IEC technical committee 77: Electromagnetic compatibility.

It forms section 6 of part 4 of IEC 1000. 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	Reports on voting
65A/165/FDIS 77B/144/FDIS	65A/195/RVD

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

Annex A forms an integral part of this standard.

Annexes B to E are for information only.

INTRODUCTION

This standard is a part of IEC 1000 series, 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 6: Generic standards

Part 9: Miscellaneous

Each part is further subdivided into sections which are to be published either as international standards or as technical reports.

ELECTROMAGNETIC COMPATIBILITY (EMC) – Part 4: Testing and measurement techniques – Section 6: Immunity to conducted disturbances, induced by radio-frequency fields

1 Scope

This section of International Standard IEC 1000-4 relates to the conducted immunity requirements of electrical and electronic equipment to electromagnetic disturbances coming from intended radio-frequency (RF) transmitters in the frequency range 9 kHz up to 80 MHz. Equipment not having at least one conducting cable (such as mains supply, signal line or earth connection), which can couple the equipment to the disturbing RF fields is excluded.

NOTE – Test methods are defined in this section for measuring the effect that conducted disturbing signals, induced by electromagnetic radiation, have on the equipment concerned. The simulation and measurement of these conducted disturbances are not adequately exact for the quantitative determination of effects. The test methods defined are structured for the primary objective of establishing adequate repeatability of results at various facilities for qualitative analysis of effects.

This standard does not intend to specify the tests to be applied to particular apparatus or systems. Its main aim is to give a general basic reference to all concerned product committees of the IEC. The product committees (or users and manufacturers of equipment) remain responsible for the appropriate choice of the test and the severity level to be applied to their equipment.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this section of IEC 1000-4. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this section of IEC 1000-4 are encouraged to investigate the possibility of applying the most recent edition of the normative documents indicated below. Members of IEC and ISO maintain registers of valid International Standards.

IEC 50(131): 1978, *International Electrotechnical Vocabulary (IEV) – Chapter 131: Electric and magnetic circuits*

IEC 50(161): 1990, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

IEC 1000-4-3: 1995, *Electromagnetic compatibility (EMC) – Part 4: Testing and measurement techniques – Section 3: Radiated, radio frequency, electromagnetic field immunity test*

CISPR 16-1: 1993, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1: Radio disturbance and immunity measuring apparatus*

CISPR 20: 1990, *Limits and methods of measurement of immunity characteristics of sound and television broadcast receivers and associated equipment*

3 General

The source of disturbance covered by this section of IEC 1000-4 is basically an electromagnetic field, coming from intended RF transmitters, that may act on the whole length of cables connected to an installed equipment. The dimensions of the disturbed equipment, mostly a sub-part of a larger system, are assumed to be small compared with the wavelengths involved. The in-going and out-going leads: e.g. mains, communication lines, interface cables, behave as passive receiving antenna networks because they can be several wavelengths long.

Between those cable networks, the susceptible equipment is exposed to currents flowing "through" the equipment. Cable systems connected to an equipment are assumed to be in resonant mode ($\lambda/4$, $\lambda/2$ open or folded dipoles) and as such are represented by coupling and decoupling devices having a common-mode impedance of 150 Ω with respect to a ground reference plane.

This test method subjects the EUT to a source of disturbance comprising electric and magnetic fields, simulating those coming from intentional RF transmitters. These disturbing fields (E and H) are approximated by the electric and magnetic near-fields resulting from the voltages and currents caused by the test set-up as shown in figure 2a.

The use of coupling and decoupling devices to apply the disturbing signal to one cable at the time, while keeping all other cables non-excited, see figure 2b, can only approximate the real situation where disturbing sources act on all cables simultaneously, with a range of different amplitudes and phases.

Coupling and decoupling devices are defined by their characteristics given in 6.2. Any coupling and decoupling device fulfilling these characteristics can be used. The coupling and decoupling networks in annex D are only examples of commercially available networks.

4 Definitions

For the purpose of this section of IEC 1000-4, the following definitions, together with those in IEC 50 (161) apply.

4.1 **artificial hand:** An electrical network simulating the impedance of the human body under average operational conditions between a hand-held electrical appliance and earth.
[IEV 161-04-27]

NOTE – The construction should be in accordance with IEC CISPR 16-1.

4.2 **auxiliary equipment (AE):** Equipment necessary to provide the EUT with the signals required for normal operation **and** equipment to verify the performance of the equipment under test.

4.3 **clamp injection:** Clamp injection is obtained by means of a clamp-on "current" injecting device on the cable.

– **current clamp:** A transformer, the secondary winding of which consists of the cable into which the injection is made.

– **electromagnetic clamp (EM-clamp):** Injection device with combined capacitive and inductive coupling.

4.4 **common-mode impedance:** The ratio of the common-mode voltage and the common-mode current at a certain port.

NOTE – This common-mode impedance can be determined by applying a unity common-mode voltage between the terminal(s) or screen of that port and a reference plane (point). The resulting common-mode current is then measured as the vectorial sum of all currents flowing through these terminal(s) or screen, see also figures 8a and 8b.

4.5 **coupling factor:** The ratio given by the open-circuit voltage (e.m.f.) obtained at the EUT port of the coupling (and decoupling) device divided by the open-circuit voltage obtained at the output of the test generator.

4.6 **coupling network:** Electrical circuit for transferring energy from one circuit to another with a defined impedance.

NOTE – Coupling and decoupling devices can be integrated into one box (coupling and decoupling networks (CDN)) or they can be in separate networks (commonly clamp injection).

4.7 **decoupling network:** Electrical circuit for preventing test signals applied to the EUT from affecting other devices, equipment or systems that are not under test.

4.8 **EUT:** Equipment under test.

4.9 **test generator:** A generator (RF generator, modulation source, attenuators, broadband power amplifier and filters) capable of generating the required signal (see figure 3).

4.10 **electromotive force (e.m.f.):** The voltage at the terminals of the ideal voltage source in the representation of an active element. [IEV 131-01-38]

4.11 **measurement result, U_{mr}:** Voltage reading of the measurement equipment.

4.12 **voltage standing wave ratio (VSWR):** The ratio of a maximum to an adjacent minimum voltage magnitude along the line.

5 Test levels

No tests are required for induced disturbances caused by electromagnetic fields coming from intentional RF transmitters in the frequency range 9 kHz to 150 kHz.

Table 1 – Test levels

Frequency range 150 kHz – 80 MHz		
Level	Voltage level (e.m.f.) U_0 [dB(μV)]	U_0 [V]
1	120	1
2	130	3
3	140	10
X[1)]	special	

[1)] X is an open level.

The open-circuit test levels (e.m.f.) of the unmodulated disturbing signal, expressed in r.m.s., are given in table 1. The test levels are set at the EUT port of the coupling and decoupling devices, see 6.4.1. For testing of equipment, this signal is 80 % amplitude modulated with a 1 kHz sine wave to simulate actual threats. The effective amplitude modulation is shown in figure 4. Guidance for selecting test levels is given in annex C.

NOTES

1 IEC 1000-4-3 also defines test methods for establishing the immunity of electrical and electronic equipment against radiated electromagnetic energy. It covers frequencies above 80 MHz. Product committees may decide to choose a lower or higher transition frequency than 80 MHz (see annex B).

2 Product committees may select alternative modulation schemes.

6 Test equipment

6.1 *Test generator*

The test generator includes all equipment and components for supplying the input port of each coupling device with the disturbing signal at the required signal level at the required point. A typical arrangement comprises the following items which may be separate or integrated into one or more test instruments (see 4.9 and figure 3).

– RF signal generator(s) G1 capable of covering the frequency band of interest and of being amplitude modulated by a 1 kHz sine wave with a modulation depth of 80 %. They shall have either an automated sweep capability $\leq 1{,}5 \times 10^{-3}$ decade/s and/or manual control, or in the case of RF synthesizers, they shall be programmable with frequency-dependent step sizes and dwell times;

– attenuator T1 (typically 0 dB ... 40 dB) of adequate frequency rating to control the disturbing test source output level. T1 may be included in the RF generator;

– RF switch, S1, by which the disturbing test signal can be switched on and off when measuring the immunity of the EUT. S1 may be included in the RF generator and is optional;

– broadband power amplifier(s) PA may be necessary to amplify the signal if the output power of the RF generator is insufficient;

– low-pass filters (LPF), and/or high-pass filters (HPF) may be necessary to avoid interference with some types of EUT, for example RF receivers caused by (sub-) harmonics. When required they shall be inserted in between the broadband power amplifier, PA, and the attenuator T2;

– attenuator, T2, (fixed ≥ 6 dB, Zo = 50 Ω), with sufficient power ratings. T2 is provided to reduce the mismatch from the power amplifier to the network and shall be located as close as possible to the coupling device.

NOTE – T2 may be included in a coupling and decoupling network and can be left out if the output impedance of the broadband power amplifier remains within the specification under any load condition.