

INTERNATIONAL STANDARD

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BASIC EMC PUBLICATION

PUBLICATION FONDAMENTALE EN CEM

**Electromagnetic compatibility (EMC) –
Part 4-16: Testing and measurement techniques – Test for immunity to
conducted, common mode disturbances in the frequency range 0 Hz to 150 kHz**

**Compatibilité électromagnétique (CEM) –
Partie 4-16: Techniques d'essai et de mesure – Essai d'immunité aux
perturbations conduites en mode commun dans la plage de fréquences de 0 Hz
à 150 kHz**



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INTERNATIONAL ELECTROTECHNICAL COMMISSION

ELECTROMAGNETIC COMPATIBILITY (EMC) –**Part 4-16: Testing and measurement techniques –
Test for immunity to conducted, common mode disturbances
in the frequency range 0 Hz to 150 kHz**

FOREWORD

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International Standard IEC 61000-4-16 has been prepared by subcommittee 77A: Low-frequency phenomena, of IEC technical committee 77: Electromagnetic compatibility.

It forms part 4-16 of IEC 61000. It has the status of a basic EMC publication in accordance with IEC Guide 107.

This second edition cancels and replaces the first edition published in 1998, Amendment 1:2001 and Amendment 2:2009. This edition constitutes a technical revision.

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

- a) clarification and complement of test generators' specifications and performances.

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

FDIS	Report on voting
77A/905/FDIS	77A/917/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 in the IEC 61000 series, published under the general title *Electromagnetic compatibility (EMC)*, can be found on the IEC website.

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

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INTRODUCTION

This standard is part of the IEC 61000 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

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Part 6: Generic standards

Part 9: Miscellaneous

Each part is further subdivided into several parts, published either as international standards or 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 conducted, common mode disturbances in the range d.c. to 150 kHz.

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 4-16: Testing and measurement techniques – Test for immunity to conducted, common mode disturbances in the frequency range 0 Hz to 150 kHz

1 Scope

This part of IEC 61000 relates to the immunity requirements and test methods for electrical and electronic equipment to conducted, common mode disturbances in the range d.c. to 150 kHz.

The object of this standard is to establish a common and reproducible basis for testing electrical and electronic equipment with the application of common mode disturbances to power supply, control, signal and communication ports.

This standard defines

- test voltage and current waveform;
- range of test levels;
- test equipment;
- test set-up;
- test procedures.

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For some types of ports, for example ports intended to be used with highly balanced lines, additional test provisions may be established by product committee specifications.

The test is intended to demonstrate the immunity of electrical and electronic equipment when subjected to conducted, common mode disturbances such as those originating from power line currents and return leakage currents in the earthing/grounding system.

The disturbances produced by 400 Hz mains systems are not included in the scope of this standard.

Actual interference due to these disturbance phenomena is relatively rare, except in industrial plants. Product committees should therefore consider whether there is a justification for applying this standard in their product/product family standards (see also Clause 4).

This test is not relevant for equipment ports intended to be connected to short cables, having a length less than 20 m or less.

The immunity to harmonics and interharmonics, including mains signalling, on a.c. power ports (in differential mode) is not included in the scope of this standard and is covered by IEC 61000-4-13 and IEC 61000-4-19.

The immunity to conducted disturbances generated by intentional radio-frequency transmitters is not included in the scope of this standard and is covered by IEC 61000-4-6.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

Void.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

NOTE Not all of the definitions given in Clause 3 are included in IEC 60050-161.

3.1

EUT

equipment under test

equipment (devices, appliances and systems) subjected to tests

Note 1 to entry: This note applies to the French language only.

3.2

auxiliary equipment

AE

equipment that is necessary for setting up all functions and assessing the correct performance (operation) of the EUT during the test

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3.3

port

particular interface of the specified equipment with the external electromagnetic environment

SEE: Figure 1.

3.4

coupling

interaction between circuits, transferring energy from one circuit to another

3.5

coupling network

electrical circuit for the purpose of transferring energy from one circuit to another

3.6

decoupling network

electrical circuit for the purpose of preventing test voltage applied to the equipment under test from affecting other devices, equipment or systems which are not under test

3.7

immunity (to a disturbance)

ability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance

[SOURCE: IEC 60050-161:1990, 161-01-20]

3.8

source impedance of the test generator

ratio between the open circuit voltage and the short circuit current, expressed as:

V_{OC} open circuit voltage / I_{SC} short circuit current

4 General

The conducted, common mode disturbances in the frequency range d.c. to 150 kHz may influence the reliable operation of equipment and systems installed in residential areas, industrial areas and electrical plants.

Only those ports of an EUT which are likely to be subjected to the disturbances dealt with by this standard shall be considered for the application of its requirements.

The disturbances are typically generated by

- the power distribution system, with its fundamental frequency, significant harmonics and interharmonics;
- power electronic equipment (e.g. power convertors), which may inject disturbances into the ground conductors and earthing system (through stray capacitance or filters), or generate disturbances in signal and control lines by induction.

At the mains frequency and harmonics of the mains frequency, the disturbances are usually generated by the power distribution system (fault and leakage currents in the ground and earthing systems).

At frequencies above the range of harmonics of the mains frequency (up to 150 kHz) the disturbances are usually generated by power electronic equipment, which is often found in industrial and electrical plants.

The coupling of the source of disturbances with the power supply, signal, control and communication cables, transfer these disturbances to the ports of the equipment under test.

Because the coupling mechanisms defined above cannot be completely eliminated, it is necessary for equipment to have adequate immunity to the disturbances.

Depending on the type of installation, the disturbances may be classified as follows:

- a) voltage/current at power frequency: d.c., $16^{2/3}$ Hz, 50 Hz and 60 Hz;
- b) voltage/current in the frequency range 15 Hz to 150 kHz (including the harmonics of the mains frequency).

This standard defines the test procedures for both the categories of disturbance defined above. The applicability of the tests should be defined in the product standard.

Annex A contains more information on the phenomena.

5 Test levels

5.1 General

The preferred range of test levels, applicable to equipment ports as a function of the different types and sources of disturbances, is given in 5.2 and 5.3.

The levels are given for the tests at the mains frequency (d.c., $16^{2/3}$ Hz, 50 Hz and 60 Hz) and in the frequency range 15 Hz to 150 kHz.

The applicability of each test shall be defined in the product standard.

The test voltage shall be applied in common mode to power supply, control, signal and communication ports (the differential mode voltage is dependent on the circuit unbalance).

A guide for the selection of the test levels is given in Annex B.

5.2 Test levels at mains frequency

Tables 1 and 2 define the preferred test levels.

The levels apply to test voltage at d.c. and at the mains frequencies of $16^{2/3}$ Hz, 50 Hz and 60 Hz.

Table 1 – Levels for continuous disturbance

Level	Open circuit test voltage V (r.m.s.)
1	1
2	3
3	10
4	30
x	Special
NOTE x is an open level. This level may be defined in the product standard.	

Table 2 – Levels for short duration disturbance

Level	Open circuit test voltage V (r.m.s.)
1	10
2	30
3	100
4	300
x	Special
NOTE x is an open level. This level may be defined in the product standard.	

For short duration disturbances, the normal duration for each applied disturbance is 1 s; however, product standards may specify different durations for specific applications.

The test shall be carried out at one or more of the following frequencies: d.c., $16^{2/3}$ Hz, 50 Hz or 60 Hz, according to the relevant mains frequency in the equipment location (see annex A); the test at $16^{2/3}$ Hz is therefore only applicable where the equipment is intended to be used in the proximity of railway systems at this frequency.

The test level shall not exceed the test voltage defined in the product standard.

Information on the proposed test levels is given in Annex B.

5.3 Test levels in the frequency range 15 Hz-150 kHz

Table 3 defines the preferred test levels.

Table 3 – Test levels in the frequency range 15 Hz to 150 kHz

Level	Profile of the test voltage (open circuit) V (r.m.s.)			
	15 Hz – 150 Hz	150 Hz – 1,5 kHz	1,5 kHz – 15 kHz	15 kHz – 150 kHz
1	1 – 0,1	0,1	0,1 – 1	1
2	3 – 0,3	0,3	0,3 – 3	3
3	10 – 1	1	1 – 10	10
4	30 – 3	3	3 – 30	30
x	x	x	x	x

NOTE 1 x is an open level. This level can be given in the product specification.

NOTE 2 The profile of the test voltage in relation to frequency (see Annex B for information) is as follows:

- starting from the frequency 15 Hz, the level decreases up to 150 Hz at 20 dB/decade;
- the level is constant from 150 Hz to 1,5 kHz;
- the level increases from 1,5 kHz to 15 kHz at 20 dB/decade;
- the level is constant from 15 kHz to 150 kHz.

The profile of the test voltage is represented in Figure 2.

No test level is defined below 15 Hz, excluding d.c., as tests in this frequency range are not considered to be relevant.

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6 Test equipment

6.1 Test generators

6.1.1 General

The features of the test generators for each specific test are given in 6.1.2, 6.1.3 and 6.1.4.

The generators shall have provisions to prevent the emission of disturbances which, if injected in the power supply network, may influence the test results.

Information on the impedance of the test generators is given in Annex A.

6.1.2 Characteristics and performance of the generator for d.c. tests

The test generator typically consists of a d.c. power supply unit with variable output voltage and a time controlled switch for the short duration test.

Generator for continuous disturbance

- waveform: direct current, ripple less than 5 %;
- open circuit output voltage range (r.m.s.): 1 V, with a relative tolerance of –10 % to 30 V, with a relative tolerance of +10 %;
- source impedance: $V_{oc}/I_{sc} = 50 \Omega$, with a relative tolerance of ± 10 %.

Generator for short duration disturbance

- waveform: direct current, ripple less than 5 %;
- open circuit output voltage range: 10 V, with a relative tolerance of –10 % to 300 V, with a relative tolerance of +10 %;
- source impedance: $V_{oc}/I_{sc} = 50 \Omega$, with a relative tolerance of ± 10 %;
- rise and fall time of the output voltage at on/off switching: between 1 μ s and 5 μ s.

The schematic in principle of the test generator is given in Figure 3.

6.1.3 Characteristics and performance of the generator for tests at mains frequency: 16^{2/3} Hz, 50 Hz and 60 Hz

The test generator typically consists of a variable transformer (connected to the mains distribution network), an isolation transformer and a time controlled switch for the short duration test; the switch shall be synchronized at 0° of the mains voltage waveform.

Generator for continuous disturbance

- waveform: sinusoidal, total harmonic distortion less than 10 %;
- open circuit output voltage range (r.m.s.): 1 V, with a relative tolerance of –10 % to 30 V, with a relative tolerance of +10 %;
- source impedance: $V_{oc}/I_{sc} = 50 \Omega$, with a relative tolerance of ± 10 %;
- frequency: selected mains frequency.

Generator for short duration disturbance

- waveform: sinusoidal, total harmonic distortion less than 10 %;
- open circuit output voltage range: 10 V, with a relative tolerance of –10 % to 300 V, with a relative tolerance of +10 %;
- source impedance: $V_{oc}/I_{sc} = 50 \Omega$, with a relative tolerance of ± 10 %;
- frequency: selected mains frequency;
- on/off switching of the output voltage: synchronized at zero crossing ($0^\circ \pm 5^\circ$).

The schematic in principle of the test generator is given in Figure 4.

6.1.4 Characteristics and performance of the generator for tests in the frequency range 15 Hz to 150 kHz

The test generator typically consists of a waveform generator capable of covering the frequency band of interest. It shall have an automated sweep capability of 1×10^{-2} decade/s or slower or, in the case of a synthesizer, be capable of being programmed with frequency-dependent step-sizes of 10 % of the preceding frequency value. It shall also be capable of being set manually.

Specifications

- waveform: sinusoidal, total harmonic distortion less than 1 %;
- open circuit output voltage range (r.m.s.): 0,1 V, with a relative tolerance of –10 % to 30 V, with a relative tolerance of +10 %;
- source impedance: $V_{oc}/I_{sc} = 50 \Omega$, with a relative tolerance of ± 10 %;
- frequency range: 15 Hz, with a relative tolerance of –10 % to 150 kHz, with a relative tolerance of +10 %.

6.2 Verification of the characteristics of the test generators

In order to make it possible to compare the results dealing with different test generators, they shall be calibrated or verified for the most essential characteristics.

The following generator characteristics shall be verified:

- output voltage waveform;
- source impedance (V_{oc} open circuit voltage / I_{sc} short circuit current). The source impedance has to be verified:
 - at highest and lowest test level for all generators: d.c.; a.c.; sweep;
 - additionally for sweep generator at frequencies: 15 Hz, 1,5 kHz, 15 kHz, 150 kHz.
 For the verification of the source impedance of short duration disturbance generator, the first 50 ms may be disregarded;
- frequency accuracy;
- open circuit output voltage accuracy;
- rise and fall time of the output voltage at on/off switching (where applicable).

The verifications shall be carried out with voltage and current probes together with an oscilloscope or other equivalent measurement instrumentation with 1 MHz minimum bandwidth.

The accuracy of the measuring equipment shall be better than $\pm 5\%$.

6.3 Coupling/decoupling networks

6.3.1 General

The coupling networks enable the test voltage to be applied, in common mode, to the power supply, input/output (signal and control) and communication ports of the EUT. The decoupling networks prevent the application of the test voltage to the auxiliary equipment needed to perform the test.

6.3.2 Coupling networks

6.3.2.1 Coupling network for power supply and input/output ports

For power supply and input/output ports, the coupling network for each conductor is composed of a resistor and a capacitor in series. The coupling networks of each conductor are connected in parallel to form the coupling network of the port.

Figure 6 shows a schematic circuit for a coupling network, the value of the capacitor is $C = 1,0 \mu\text{F}$ and the resistor is $R = 100 \times n \Omega$ where n is the number of the conductors (n is greater than or equal to 2).

The capacitors and the resistors for each of the conductors in the coupling network for a port shall be matched with a tolerance of 1 %.

For the d.c. voltage test the $1,0 \mu\text{F}$ capacitors shall be short-circuited.

NOTE When performing the d.c. voltage test on a signal port, the impedance of the coupling network may cause the operating signal to be degraded.

For screened cables, the test signal is injected directly onto the cable shield, so no coupling network is required (see Figure 6).