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INTERNATIONAL STANDARD

NORME INTERNATIONALE

BASIC EMC PUBLICATION

PUBLICATION FONDAMENTALE EN CEM

Electromagnetic compatibility (EMC) –
Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test

Compatibilité électromagnétique (CEM) –
Partie 4-2: Techniques d'essai et de mesure – Essai d'immunité aux décharges électrostatiques

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ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test

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 co-operation 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.
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International Standard IEC 61000-4-2 has been prepared by subcommittee 77B: High-frequency phenomena, of IEC technical committee 77: Electromagnetic compatibility.

It forms section 2 of part 4 of IEC 61000. It has the status of a basic EMC publication in accordance with IEC Guide 107.

It is based on the IEC 60801-2 (second edition: 1991): *Electromagnetic compatibility for industrial process measurement and control equipment – Part 2: Electrostatic discharge requirements,* prepared by IEC technical committee 65: Industrial-process measurement and control.

According to a recommendation of ACEC at its meeting of December 1989, the scope of this standard has been extended to all kinds of electrical and electronic equipment. For this purpose it has been decided to transfer the 60801 series of publications to the 61000-4 series: *EMC testing and measurement techniques*, of technical committee 77.

No technical changes, only editorial amendments, have been made with this transfer and reference to IEC 60801-2 (1991) or IEC 61000-4-2 is equivalent.

This consolidated version of IEC 61000-4-2 consists of the first edition (1995) [documents 77B(CO)21 and 77B/145/RVD], its amendment 1 (1998) [documents 77B/216/FDIS and 77B/226/RVD] and amendment 2 (2000) [documents 77B/291+292/FDIS and 77B/298+299/RVD].

The technical content is therefore identical to the base edition and its amendments and has been prepared for user convenience.

It bears the edition number 1.2.

A vertical line in the margin shows where the base publication has been modified by amendments 1 and 2.

Annexes A and B are for information only.

The committee has decided that the contents of the base publication and its amendments will remain unchanged until 2003. At this date, the publication will be

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

INTRODUCTION

IEC 61000-4 is a part of the IEC 61000 series, according to the following structure:

Part 1: General

General consideration (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 sections which are to be published either as international standards or as technical reports.

These sections of IEC 61000-4 will be published in chronological order and numbered accordingly.

This section is an international standard which gives immunity requirements and test procedures related to "electrostatic discharge".

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test

1 Scope

This International Standard relates to the immunity requirements and test methods for electrical and electronic equipment subjected to static electricity discharges, from operators directly, and to adjacent objects. It additionally defines ranges of test levels which relate to different environmental and installation conditions and establishes test procedures.

The object of this standard is to establish a common and reproducible basis for evaluating the performance of electrical and electronic equipment when subjected to electrostatic discharges. In addition, it includes electrostatic discharges which may occur from personnel to objects near vital equipment.

This standard defines:

– typical waveform of the discharge current;
– range of test levels;
– test equipment;
– test set-up;
– test procedure.

This standard gives specifications for test performed in "laboratories" and "post-installation tests" performed on equipment in the final installation.

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 tests and the severity level to be applied to their equipment.

In order not to impede the task of coordination and standardization, the product committees or users and manufacturers are strongly recommended to consider (in their future work or revision of old standards) the adoption of the relevant immunity tests specified in this standard.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this section of IEC 61000-4. 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 61000-4 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

IEC 60050(161):1990, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

IEC 60068-1:1988, *Environmental testing – Part 1: General and guidance*

3 General

This standard relates to equipment, systems, subsystems and peripherals which may be involved in static electricity discharges owing to environmental and installation conditions, such as low relative humidity, use of low-conductivity (artificial-fibre) carpets, vinyl garments, etc., which may exist in allocations classified in standards relevant to electrical and electronic equipment (for more detailed information, see clause A.1 of annex A).

The tests described in this standard are considered to be a first step in the direction of commonly used tests for the qualitative evaluation of the performance of all electrical and electronic equipment as referred to in clause 1.

NOTE From the technical point of view the precise term for the phenomenon would be "static electricity discharge". However, the term "electrostatic discharge" (ESD) is widely used in the technical world and in technical literature. Therefore, it has been decided to retain the term ESD in the title of this standard.

4 Definitions

For the purpose of this section of IEC 61000-4, the following definitions and terms apply and are applicable to the restricted field of electrostatic discharge; not all of them are included in IEC 60050(161) [IEV].

4.1
degradation (of performance)
an undesired departure in the operational performance of any device, equipment or system from its intended performance. [IEV 161-01-19]

NOTE The term "degradation" can apply to temporary or permanent failure.

4.2
electromagnetic compatibility (EMC)
the ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment. [IEV 161-01-07]

4.3
antistatic material
material exhibiting properties which minimize charge generation when rubbed against or separated from the same or other similar materials

4.4
energy storage capacitor
the capacitor of the ESD-generator representing the capacity of a human body charged to the test voltage value. This may be provided as a discrete component, or a distributed capacitance

4.5
ESD
electrostatic discharge (see 4.10)

4.6
EUT
equipment under test

4.7
ground reference plane (GRP)
a flat conductive surface whose potential is used as a common reference. [IEV 161-04-36]

4.8
coupling plane
a metal sheet or plate, to which discharges are applied to simulate electrostatic discharge to objects adjacent to the EUT. HCP: Horizontal Coupling Plane; VCP: Vertical Coupling Plane

4.9
holding time
interval of time within which the decrease of the test voltage due to leakage, prior to the discharge, is not greater than 10 %

4.10
electrostatic discharge; ESD
a transfer of electric charge between bodies of different electrostatic potential in proximity or through direct contact. [IEV 161-01-22]

4.11
immunity (to a disturbance)
the ability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance. [IEV 161-01-20]

4.12
contact discharge method
a method of testing, in which the electrode of the test generator is held in contact with the EUT, and the discharge actuated by the discharge switch within the generator

4.13
air discharge method
a method of testing, in which the charged electrode of the test generator is brought close to the EUT, and the discharge actuated by a spark to the EUT

4.14
direct application
application of the discharge directly to the EUT

4.15
indirect application
application of the discharge to a coupling plane in the vicinity of the EUT, and simulation of personnel discharge to objects which are adjacent to the EUT

5 Test levels

The preferential range of test levels for the ESD test is given in table 1.

Testing shall also be satisfied at the lower levels given in table 1.

Details concerning the various parameters which may influence the voltage level to which the human body may be charged are given in clause A.2 of annex A. Clause A.4 also contains examples of the application of the test levels related to environmental (installation) classes.

Contact discharge is the preferred test method. Air discharges shall be used where contact discharge cannot be applied. Voltages for each test method are given in tables 1a and 1b. The voltages shown are different for each method due to the differing methods of test. It is not intended to imply that the test severity is equivalent between test methods.

Further information is given in clauses A.3, A.4 and A.5 of annex A.

Table 1 – Test levels

1a – Contact discharge		1b – Air discharge	
Level	**Test voltage** kV	**Level**	**Test voltage** kV
1	2	1	2
2	4	2	4
3	6	3	8
4	8	4	15
x [1)]	Special	x [1)]	Special

[1)] "x" is an open level. The level has to be specified in the dedicated equipment specification. If higher voltages than those shown are specified, special test equipment may be needed.

6 Test generator

The test generator consists, in its main parts, of:

– charging resistor R_c;
– energy-storage capacitor C_s;
– distributed capacitance C_d;
– discharge resistor R_d;
– voltage indicator;
– discharge switch;
– interchangeable tips of the discharge electrode (see figure 4);
– discharge return cable;
– power supply unit.

A simplified diagram of the ESD generator is given in figure 1. Constructional details are not given.

The generator shall meet the requirements given in 6.1 and 6.2.

6.1 Characteristics and performance of the ESD generator

Specifications

– energy storage capacitance (C_s + C_d):	150 pF ± 10 %;
– discharge resistance (R_d):	330 Ω ± 10 %;
– charging resistance (R_c):	between 50 MΩ and 100 MΩ;
– output voltage (see note 1):	up to 8 kV (nominal) for contact discharge;
	up to 15 kV (nominal) for air discharge;
– tolerance of the output voltage indication:	±5 %;
– polarity of the output voltage:	positive and negative (switchable);
– holding time:	at least 5 s;
– discharge, mode of operation (see note 2):	single discharge (time between successive discharges at least 1 s);
– waveshape of the discharge current:	see 6.2.

NOTE 1 Open circuit voltage measured at the energy storage capacitor.

NOTE 2 The generator should be able to generate at a repetition rate of at least 20 discharges per second for exploratory purposes only.

The generator shall be provided with means of preventing unintended radiated or conducted emissions, either of pulse or continuous type, so as not to disturb the EUT or auxiliary test equipment by parasitic effects.

The energy storage capacitor, the discharge resistor, and the discharge switch shall be placed as close as possible to the discharge electrode.

The dimensions of the discharge tips are given in figure 4.

For the air discharge test method the same generator is used and the discharge switch has to be closed. The generator shall be fitted with the round tip shown in figure 4.

The discharge return cable of the test generator shall be in general 2 m long, and constructed to allow the generator to meet the waveform specification. It shall be sufficiently insulated to prevent the flow of the discharge current to personnel or conducting surfaces other than via its termination, during the ESD test.

In cases where a 2 m length of the discharge return cable is insufficient, (e.g. for tall EUTs), a length not exceeding 3 m may be used, but compliance with the waveform specification shall be verified.

6.2 Verification of the characteristics of the ESD generator

In order to compare the test results obtained from different test generators, the characteristics shown in table 2 shall be verified using the discharge return cable to be used in the testing.

Table 2 – Waveform parameters

Level	Indicated voltage kV	First peak current of discharge ±10 % A	Rise time t_r with discharge switch ns	Current (±30 %) at 30 ns A	Current (±30 %) at 60 ns A
1	2	7,5	0,7 to 1	4	2
2	4	15	0,7 to 1	8	4
3	6	22,5	0,7 to 1	12	6
4	8	30	0,7 to 1	16	8

The waveform of the output current of the ESD generator during the verification procedure shall conform to figure 3.

The values of the characteristics of the discharge current shall be verified with 1 000 MHz bandwidth measuring instrumentation.

A lower bandwidth implies limitations in the measurement of rise time and amplitude of the first current peak.

For verification, the tip of the discharge electrode shall be placed in direct contact with the current-sensing transducer, and the generator operated in the contact discharge mode.

The typical arrangement for the verification of the ESD generator performance is given in figure 2. The bandwidth of the target has to be more than 1 GHz. Constructional details of a possible design for the current-sensing transducer are given in annex B.

Other arrangements that imply the use of a laboratory Faraday cage having dimensions different from those in figure 2 are allowed; separation of the Faraday cage from the target plane is also allowed, but in both cases the distance between the sensor and the grounding terminal point of the ESD generator shall be respected (1 m), as well as the layout of the discharge return cable.

The ESD generator shall be re-calibrated in defined time periods in accordance with a recognized quality assurance system.

7 Test set-up

The test set-up consists of the test generator, EUT and auxiliary instrumentation necessary to perform direct and indirect application of discharges to the EUT in the following manner:

a) contact discharge to the conductive surfaces and to coupling planes;

b) air discharge at insulating surfaces.

Two different types of tests can be distinguished:

– type (conformance) tests performed in laboratories;

– post installation tests performed on equipment in its final installed conditions.

The preferred test method is that of type tests performed in laboratories.

The EUT shall be arranged in accordance with the manufacturer's instructions for installation (if any).

7.1 Test set-up for tests performed in laboratories

The following requirements apply to tests performed in laboratories under environmental reference conditions outlined in 8.1.

A ground reference plane shall be provided on the floor of the laboratory. It shall be a metallic sheet (copper or aluminium) of 0,25 mm minimum thickness; other metallic materials may be used but they shall have at least 0,65 mm minimum thickness.

The minimum size of the reference plane is 1 m^2, the exact size depending on the dimensions of the EUT. It shall project beyond the EUT or coupling plane by at least 0,5 m on all sides, and shall be connected to the protective grounding system.

Local safety regulations shall always be met.

The EUT shall be arranged and connected according to its functional requirements.

A distance of 1 m minimum shall be provided between the equipment under test and the walls of the laboratory and any other metallic structure.

The EUT shall be connected to the grounding system, in accordance with its installation specifications. No additional grounding connections are allowed.

The positioning of the power and signal cables shall be representative of installation practice.