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INTERNATIONAL STANDARD

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BASIC EMC PUBLICATION

PUBLICATION FONDAMENTALE EN CEM

Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test

Compatibilité électromagnétique (CEM) – Partie 4-4: Techniques d'essai et de mesure – Essais d'immunité aux transitoires électriques rapides en salves

IEC 61000-4-4:2004+A1:2010

IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland
Email: inmail@iec.ch
Web: www.iec.ch

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Email: csc@iec.ch
Tél.: +41 22 919 02 11
Fax: +41 22 919 03 00

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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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This consolidated version of IEC 61000-4-4 consists of the second edition (2004) [documents 77B/419/FDIS and 77B/424/RVD], its amendment 1 (2010) [documents 77B/621/FDIS and 77B/627/RVD] and its corrigenda of August 2006 and June 2007. It bears the edition number 2.1.

The technical content is therefore identical to the base edition and its amendment and has been prepared for user convenience. A vertical line in the margin shows where the base publication has been modified by amendment 1. Additions and deletions are displayed in red, with deletions being struck through.

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

It forms Part 4-4 of IEC 61000. It has the status of a basic EMC publication in accordance with IEC Guide 107, *Electromagnetic compatibility – Guide to the drafting of electromagnetic compatibility publications*.

This second edition improves and clarifies simulator specifications, test criteria and test set-ups. Only common mode injection is required.

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

The committee has decided that the contents of the base publication and its amendments will remain unchanged until the stability 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.

IMPORTANT – The "colour inside" logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this publication using a colour printer.

INTRODUCTION

IEC 61000 is published in separate parts, 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 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: 61000-6-1).

This part is an international standard which gives immunity requirements and test procedures related to electrical fast transients/bursts.

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test

1 Scope

This part of IEC 61000-4 relates to the immunity of electrical and electronic equipment to repetitive electrical fast transients. It gives immunity requirements and test procedures related to electrical fast transients/bursts. It additionally defines ranges of test levels and establishes test procedures.

The object of this standard is to establish a common and reproducible reference for evaluating the immunity of electrical and electronic equipment when subjected to electrical fast transient/bursts on supply, signal, control and earth ports. The test method documented in this part of IEC 61000-4 describes a consistent method to assess the immunity of an equipment or system against a defined phenomenon.

NOTE As described in IEC Guide 107, this is a basic EMC publication for use by product committees of the IEC. As also stated in Guide 107, the IEC product committees are responsible for determining whether this immunity test standard should be applied or not, and if applied, they are responsible for determining the appropriate test levels and performance criteria. TC 77 and its sub-committees are prepared to co-operate with product committees in the evaluation of the value of particular immunity tests for their products.

The standard defines:

– test voltage waveform;
– range of test levels;
– test equipment;
– verification procedures of test equipment;
– test set-up;
– test procedure.

The standard gives specifications for laboratory and post-installation tests.

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

3 Terms and definitions

For the purposes of this document, the following terms and definitions, together with those in IEC 60050-161 apply.

NOTE Several of the most relevant terms and definitions from IEC 60050-161 are presented among the definitions below.

3.1
burst
sequence of a limited number of distinct pulses or an oscillation of limited duration

[IEV 161-02-07]

3.2
calibration
set of operations which establishes, by reference to standards, the relationship which exists, under specified conditions, between an indication and a result of a measurement

NOTE 1 This term is based on the "uncertainty" approach.

NOTE 2 The relationship between the indications and the results of measurement can be expressed, in principle, by a calibration diagram.

[IEV 311-01-09]

3.3
coupling
interaction between circuits, transferring energy from one circuit to another

3.4
common mode (coupling)
simultaneous coupling to all lines versus the ground reference plane

3.5
coupling clamp
device of defined dimensions and characteristics for common mode coupling of the disturbance signal to the circuit under test without any galvanic connection to it

3.6
coupling network
electrical circuit for the purpose of transferring energy from one circuit to another

3.7
decoupling network
electrical circuit for the purpose of preventing EFT voltage applied to the EUT from affecting other devices, equipment or systems which are not under test

3.8
degradation (of performance)
undesired departure in the operational performance of any device, equipment or system from its intended performance

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

[IEV 161-01-19]

3.9
EFT/B
electrical fast transient/burst

3.10
electromagnetic compatibility (EMC)
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]

3.11
EUT
equipment under test

3.12
ground reference plane
flat conductive surface whose potential is used as a common reference

[IEV 161-04-36]

3.13
immunity (to a disturbance)
ability of a device, equipment or system to perform without degradation in the presence of an electromagnetic disturbance

[IEV 161-01-20]

3.14
port
particular interface of the EUT with the external electromagnetic environment

3.15
rise time
interval of time between the instants at which the instantaneous value of a pulse first reaches 10 % value and then the 90 % value

[IEV 161-02-05, modified]

3.16
transient
pertaining to or designating a phenomenon or a quantity which varies between two consecutive steady states during a time interval which is short compared with the time-scale of interest

[IEV 161-02-01]

3.17
verification
set of operations which is used to check the test equipment system (e.g. the test generator and the interconnecting cables) and to demonstrate that the test system is functioning within the specifications given in Clause 6

NOTE 1 The methods used for verification may be different from those used for calibration.

NOTE 2 The procedure of 6.1.2 and 6.2.2 is meant as a guide to insure the correct operation of the test generator, and other items making up the test set-up so that the intended waveform is delivered to the EUT.

NOTE 3 For the purpose of this basic EMC standard this definition is different from the definition given in IEV 311-01-13.

4 General

The repetitive fast transient test is a test with bursts consisting of a number of fast transients, coupled into power supply, control, signal and earth ports of electrical and electronic equipment. Significant for the test are the high amplitude, the short rise time, the high repetition rate, and the low energy of the transients.

The test is intended to demonstrate the immunity of electrical and electronic equipment when subjected to types of transient disturbances such as those originating from switching transients (interruption of inductive loads, relay contact bounce, etc.).

5 Test levels

The preferred test levels for the electrical fast transient test, applicable to power, ground, signal and control ports of the equipment are given in Table 1.

Table 1 – Test levels

Open circuit output test voltage and repetition rate of the impulses				
Level	On power port, PE		On I/O (input/output) signal, data and control ports	
	Voltage peak kV	Repetition rate kHz	Voltage peak kV	Repetition rate kHz
1	0,5	5 or 100	0,25	5 or 100
2	1	5 or 100	0,5	5 or 100
3	2	5 or 100	1	5 or 100
4	4	5 or 100	2	5 or 100
X [a]	Special	Special	Special	Special
NOTE 1 Use of 5 kHz repetition rates is traditional; however, 100 kHz is closer to reality. Product committees should determine which frequencies are relevant for specific products or product types. NOTE 2 With some products, there may be no clear distinction between power ports and I/O ports, in which case it is up to product committees to make this determination for test purposes.				
[a] "X" is an open level. The level has to be specified in the dedicated equipment specification.				

These open-circuit output voltages will be displayed on the EFT/B generator. For selection of levels, see Annex B.

6 Test equipment

The verification procedures of 6.1.2 and 6.2.2 are meant as a guide to insure the correct operation of the test generator, coupling/decoupling networks, and other items making up the test set-up so that the intended waveform is delivered to the EUT.

6.1 Burst generator

The simplified circuit diagram of the generator is given in Figure 1. The circuit elements C_c, R_s, R_m, and C_d are selected so that the generator delivers a fast transient under open circuit conditions and with a 50 Ω resistive load. The effective output impedance of the generator shall be 50 Ω.

The major elements of the test generator are:

– high-voltage source;
– charging resistor;
– energy storage capacitor;
– high voltage switch;
– impulse duration shaping resistor;
– impedance matching resistor;
– d.c. blocking capacitor.

6.1.1 Characteristics of the fast transient/burst generator

The characteristics of the fast transient/burst generator are the following:

– Output voltage range with 1 000 Ω load shall be at least 0,25 kV to 4 kV
– Output voltage range with 50 Ω load shall be at least 0,125 kV to 2 kV

The generator shall be capable of operating under short-circuit conditions.

Characteristics:

– polarity:	positive/negative
– output type:	coaxial, 50 Ω
– d.c. blocking capacitor	10 nF ± 20 %
– repetition frequency:	(see Table 2) ± 20 %
– relation to power supply:	asynchronous
– burst duration:	15 ms ± 20 % at 5 kHz
(see Figure 2)	0,75 ms ± 20 % at 100 kHz
– burst period:	300 ms ± 20 %
(see Figure 2)	
– wave shape of the pulse	
• into 50 Ω load	rise time t_r = 5 ns ± 30 %
	duration t_d (to 50 %) = 50 ns ± 30 %
	peak voltage = according to Table 2, ±10 %
	(see Figure 3 for the 50 Ω waveshape)
• into 1 000 Ω load	rise time t_r = 5 ns ± 30 %
	duration t_d (to 50 %) = 50 ns with a tolerance of –15 ns to +100 ns
	peak voltage = according to Table 2, ±20% (see Note 2 below Table 2)

– test load impedance 50 Ω ± 2 %
1 000 Ω ± 2 % in parallel with ≤ 6 pF. The resistance measurement is made at d.c. and the capacitance measurement is made using a commercially available capacitance meter that operates at low frequencies.

6.1.2 Verification of the characteristics of the fast transient/burst generator

The test generator characteristics shall be verified in order to establish a common reference for all generators. For this purpose, the following procedure shall be undertaken.

The test generator output shall be connected to a 50 Ω and 1 000 Ω coaxial termination respectively and the voltage monitored with an oscilloscope. The –3 dB bandwidth of the measuring equipment and the test load impedance shall be at least 400 MHz. The test load impedance at 1 000 Ω is likely to become a complex network. The rise time, impulse duration and repetition rate of the impulses within one burst shall be monitored as well as the burst duration and burst period.

For each of the set voltages of Table 2, measure the output voltage at a 50 Ω load [V_p (50 Ω)]. This measured voltage shall be [0,5 × V_p (open circuit)] ± 10%.

With the same generator setting (set voltage), measure the voltage at a 1 000 Ω load – [V_p (1 000 Ω)]. This measured voltage shall be V_p (open circuit) ± 20%.

NOTE 1 Measures should be taken to ensure that stray capacitance is kept to a minimum.

Table 2 – Output voltage peak values and repetition rates

Set voltage kV	V_p (open circuit) kV	V_p (1 000 Ω) kV	V_p (50 Ω) kV	Repetition frequency kHz
0,25	0,25	0,24	0,125	5 or 100
0,5	0,5	0,48	0,25	5 or 100
1	1	0,95	0,5	5 or 100
2	2	1,9	1	5 or 100
4	4	3,8	2	5 or 100

NOTE 2 Use of a 1 000 Ω load resistor will automatically result in a voltage reading that is 5 % lower than the set voltage as shown in column V_p (1 000 Ω). The reading V_p at 1000 Ω = V_p (open circuit) multiplied times 1000/1050 (the ratio of the test load to the total circuit impedance of 1000 Ω plus 50 Ω).

NOTE 3 With the 50 Ω load, the measured output voltage is 0,5 times the value of the unloaded voltage as reflected in the table above.

6.2 Coupling/decoupling network for a.c./d.c. mains supply port

The coupling/decoupling network is required for acceptance tests of a.c./d.c. power supply ports.

The circuit diagram (example for a three-phase power mains supply) is given in Figure 4.

The waveform of the EFT/B generator shall be verified at the output of the coupling network according to 6.2.2.