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INTERNATIONAL STANDARD

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colour inside

BASIC EMC PUBLICATION

PUBLICATION FONDAMENTALE EN CEM

Electromagnetic compatibility (EMC) – Part 4-12: Testing and measurement techniques – Ring wave immunity test

Compatibilité électromagnétique (CEM) – Partie 4-12: Techniques d'essai et de mesure – Essai d'immunité à l'onde sinusoïdale fortement amortie

IEC 61000-4-12:2017-07(en-fr)

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FOREWORD

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International Standard IEC 61000-4-12 has been prepared by subcommittee 77B: High frequency phenomena, of IEC technical Committee 77: Electromagnetic compatibility.

It forms Part 4-12 of IEC 61000. It has the status of a basic EMC publication in accordance with IEC Guide 107.

This third edition cancels and replaces the second edition published in 2006. This edition constitutes a technical revision. This edition includes the following significant technical changes with respect to the previous edition:

a) addition of a mathematical modelling of ring wave waveform;
b) new Annex B on selection of generators and test levels;
c) new Annex C on explanatory notes;
d) new Annex D on measurement uncertainty;

e) addition of high speed CDN;

f) addition of a calibration procedure for CDN.

The text of this International Standard is based on the following documents:

CDV	Report on voting
77B/764/CDV	77B/774/RVC

Full information on the voting for the approval of this International 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 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- withdrawn,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.

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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: IEC 61000-6-1).

This part is an International Standard which gives immunity requirements and test procedures related to ring waves. It should be noted that edition 1 of IEC 61000-4-12, published in 1995, covered immunity tests against two phenomena, ring waves and damped oscillatory waves. This situation was changed in edition 2, published in 2006, where IEC 61000-4-12 covered the ring wave phenomena only and the damped oscillatory wave phenomenon was moved into a new standard IEC 61000-4-18.

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 4-12: Testing and measurement techniques – Ring wave immunity test

1 Scope

This part of IEC 61000 relates to the immunity requirements and test methods for electrical and electronic equipment, under operational conditions, to ring waves occurring in low-voltage power, control and signal lines supplied by public and non-public networks.

The object of this document is to establish a common reference for evaluating the immunity of electrical and electronic equipment when subjected to ring waves. The test method documented in this part of IEC 61000 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 is 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 test and test levels for their products.

This document defines:

– test voltage and current waveforms;
– a range of test levels;
– test equipment;
– test setups;
– test procedures.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 (all parts), *International Electrotechnical Vocabulary (IEV)* (available at www.electropedia.org)

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050 (all parts) as well as the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at http://www.electropedia.org/
- ISO Online browsing platform: available at http://www.iso.org/obp

3.1.1
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 to entry: This term is based on the "uncertainty" approach.

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

[SOURCE: IEC 60050-311:2001, 311-01-09]

3.1.2
coupling
interaction between circuits, transferring energy from one circuit to another

3.1.3
coupling network
CN
electrical circuit for the purpose of transferring energy from one circuit to another

3.1.4
coupling/decoupling network
CDN
combination of a coupling network and a decoupling network

3.1.5
decoupling network
DN
electrical circuit for the purpose of preventing test voltages applied to the equipment under test (EUT) from affecting other devices, equipment, or systems which are not under test

3.1.6
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]

3.1.7
port
particular interface of an equipment, which couples this equipment with the external electromagnetic environment (IEC 60050-161:1990, 161-01-01) and through which the equipment is influenced by the environment

[SOURCE: IEC 60050-161:1990, 161-01-27]

3.1.8
ring wave
damped oscillation, whose damping time constant is of the order of one period

[SOURCE: IEC 60050-161:1990, 161-02-30]

3.1.9
rise time
T_r
interval of time between the instants at which the instantaneous value of an impulse first reaches 10 % value and then the 90 % value

[SOURCE: IEC 60050-161:1990, 161-02-05, modified – the content of the note has been included in the definition and “pulse” has been changed to “impulse”]

3.1.10
transient (adj and noun)
pertaining to or designating a phenomenon or a quantity which varies between two consecutive steady states during a time interval short compared with the time-scale of interest

[SOURCE: IEC 60050-161:1990, 161-02-01]

3.1.11
verification
set of operations which is used to check the test equipment system (e.g. the test generator and its interconnecting cables) to demonstrate that the test system is functioning

Note 1 to entry: The methods used for verification may be different from those used for calibration.

Note 2 to entry: For the purposes of this basic EMC standard this definition is different from the definition given in IEC 60050-311:2001, 311-01-13.

3.2 Abbreviated terms

AE	Auxiliary equipment
CD	Coupling device
CDN	Coupling/decoupling network
CLD	Clamping device
CN	Coupling network
DN	Decoupling network
EMC	Electromagnetic compatibility
EUT	Equipment under test
GDT	Gas discharge tube
MU	Measurement uncertainty
PDF	Probability density function
PE	Protective earth
RGP	Reference ground plane
RWG	Ring wave generator
SPD	Surge protective device

4 General

4.1 Description of the phenomenon

The ring wave (described in Figure 1) is an oscillatory transient, induced in low-voltage cables due to the switching of electrical networks and reactive loads, faults and insulation breakdown of power supply circuits or lightning. It is, in fact, the most diffused phenomenon occurring in power supply (high voltage, medium voltage, low voltage) networks, as well as in control and signal lines.

The ring wave is representative of a wide range of electromagnetic environments of residential, as well as industrial installations. It is suitable for checking the immunity of equipment in respect of the above-mentioned phenomena, which give rise to impulses characterized by sharp front-waves that, in the absence of filtering actions, are in the order of 10 ns to a fraction of μs. The duration of these impulses may range from 10 μs to 100 μs.

The rise time and duration of the impulse are dependent on the propagation characteristics of the media and the path.

The propagation of the wave in the lines (power and signal) is always subject to reflections, due to the mismatching impedance (the lines are terminated with loads or connected to protection devices, input line filters, etc.). These reflections produce oscillations, whose frequency is related to the propagation speed. The presence of parasitic parameters (e.g. stray capacitance of components like motors, transformer windings, etc.) are additional influencing factors.

The rise time can be increased by the low-pass characteristics of the line. This effect is more relevant for fast rise times (in the order of 10 ns), and less relevant for slow rise times (in the order of 1 μs).

Another cause of the ring wave is lightning, which itself is characterized by a unidirectional waveform (standard 1,2/50 μs impulse). Circuits subjected to the indirect effects of lightning (inductive coupling among lines) are influenced by the derivative of the primary impulse and the coupling mechanisms involved, which can cause oscillations. The characteristics of the resulting ring wave depend on the reactive parameters of the ground circuits, metal structures involved in the lightning current flow, and the propagation in the low-voltage transmission lines.

The phenomenon, which is created by the above mentioned effects at the equipment ports, is an oscillatory transient or a ring wave. Oscillatory transients are covered in IEC 61000-4-18. A ring wave with a defined 0,5 μs rise time and 100 kHz oscillation frequency has been determined to be typical and is widely used for testing products.

The formula of the ideal waveform of Figure 1, $w(t)$, is as follows:

$$w(t) = A \cdot K \cdot \frac{\left(\frac{t}{t_1}\right)^n}{1+\left(\frac{t}{t_1}\right)^n} \cdot \exp\left(-\frac{t}{t_2}\right) \cdot \cos(\beta t)$$

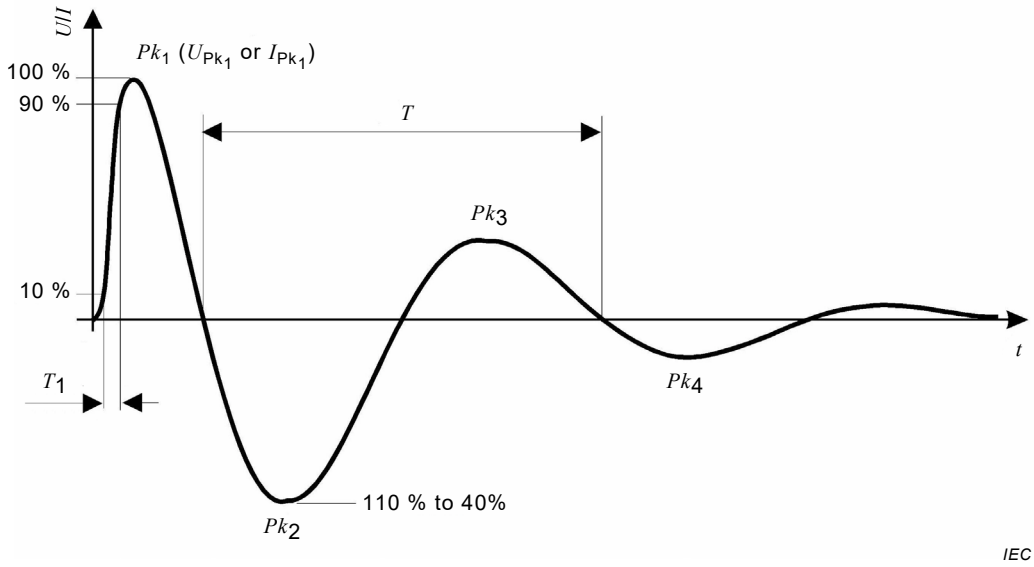
with

$$t_2 = \frac{T}{2} \cdot \frac{1}{\ln R} = 7{,}21\,\mu s \text{ and } \beta = \frac{2\pi}{T} \text{ and } T = 10\ \mu s$$

where the parameters for oscillation period T = 10 μs are:

$$A = 1;\ K = 1{,}81;\ n = 1{,}83;\ t_1 = 0{,}507\ \mu s$$

NOTE R is the ratio between Pk_2 and Pk_3, Pk_3 and Pk_4. The value of R ensures that the ratios Pk_2/Pk_3 , Pk_3/Pk_4 are in the range specified by this document. The value of R cannot be too small otherwise the ratio Pk_1/Pk_2 exceeds the specified tolerance. R = 2 has been selected. The parameters n and t_1 are adjusted to obtain T_1 = 0,5 μs.



Key

T_1 Rise time

T Oscillation period

NOTE Only Pk_1 is specified for the current waveform.

Figure 1 – Waveform of the ring wave (open-circuit voltage and short-circuit current)

Other IEC standards, such as IEC 61000-4-5, refer to the 1,2/50 µs standard lightning impulse, which may be considered to be complementary to the ring wave described in this document.

It is the responsibility of the product committees to define the most appropriate test, according to the phenomenon considered as relevant.

4.2 Relevant parameters

4.2.1 Repetition rate

The repetition rate of the transient is directly related to the frequency of occurrence of the primary phenomenon (lightning and switching). It is higher whenever the primary cause is the load switching in control lines, and less frequent in the case of faults and lightning. The occurrence may typically range from once per second down to once per year.

The repetition rate may be increased in order to reduce the duration of the test. It should be selected according to the characteristics of the protection device used for mitigation/suppression of transients.

4.2.2 Phase angle

Equipment failures related to the ring wave on power supply sources can depend on the phase angle of the AC mains at which the transient is applied. When a protection element operates during a ring wave test, follow current may occur depending on the phase angle at which the transient occurs. Follow current is the current from the connected power source that flows through a protective element, or from any arc in the EUT both during and following the transient.

For semiconductors, the phenomenon may be related to the conduction state of the device at the time the ring wave occurs. Semiconductor parameters that may be involved, include forward and reverse recovery characteristics and secondary breakdown performance.

Devices most likely to fail in a phase-related way are semiconductors involved in the power input circuitry. Other devices in different areas of the EUT can also exhibit such failure modes.

5 Test levels

The preferred test levels for the ring wave applicable to power, signal and control ports of the equipment, are given in Table 1. The test level is defined as the voltage of the first peak (maximum or minimum) in the test waveform (Pk_1 in Figure 1).

Different test levels may apply to power, signal and control ports.

Table 1 – Test levels

Level	Open-circuit test voltage kV	
	Line-to-line	Line-to-ground[b]
1	0,25	0,5
2	0,5	1
3	1	2
4	2	4
X[a]	Special	Special

[a] "X" can be any level, above, below or in between the others. This level shall be specified by product committees and/or equipment specification.

[b] For symmetrical interconnection lines the test can be applied to multiple lines simultaneously with respect to ground, i.e. “lines to ground”.

The test levels shall be selected according to the installation conditions; classes of installation are given in Annex C. Annex A gives information on test levels.

The test shall be applied at all test levels in Table 1 up to and including the specified test level (see 8.3).

For selection of the test levels for the different interfaces, refer to Annex B.

6 Test instrumentation

6.1 Ring wave generator

6.1.1 Ring wave generator circuit

The generator output shall have the capability to operate under short-circuit conditions. A block diagram of a representative ring wave generator is shown in Figure 2.