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Edition 2.0 2016-07

INTERNATIONAL STANDARD

NORME INTERNATIONALE

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BASIC EMC PUBLICATION

PUBLICATION FONDAMENTALE EN CEM

Electromagnetic compatibility (EMC) – Part 4-9: Testing and measurement techniques – Impulse magnetic field immunity test

Compatibilité électromagnétique (CEM) – Partie 4-9: Techniques d'essai et de mesure – Essai d'immunité au champ magnétique impulsionnel

IEC 61000-4-9:2016-07(en-fr)

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ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 4-9: Testing and measurement techniques – Impulse magnetic field immunity test

FOREWORD

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International Standard IEC 61000-4-9 has been prepared by subcommittee 77B: High frequency phenomena, of IEC technical committee 77: Electromagnetic compatibility.

It forms Part 4-9 of the IEC 61000 series. 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 1993 and Amendment 1:2000. This edition constitutes a technical revision.

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

a) new Annex B on induction coil field distribution;
b) new Annex D on measurement uncertainty;
c) new Annex E on mathematical modeling of surge waveform;

d) new Annex F on characteristics using two standard induction coils;

e) new Annex G on 3D numerical simulations;

f) coil factor calculation and calibration using current measurement have been addressed in this edition.

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

CDV	Report on voting
77B/728/CDV	77B/745A/RVC

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

- 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- withdrawn,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 (insofar 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 "pulse magnetic field".

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 4-9: Testing and measurement techniques – Impulse magnetic field immunity test

1 Scope and object

This part of IEC 61000 specifies the immunity requirements, test methods, and range of recommended test levels for equipment subjected to impulse magnetic disturbances mainly encountered in:

– industrial installations,
– power plants,
– railway installations,
– medium voltage and high voltage sub-stations.

The applicability of this standard to equipment installed in different locations is determined by the presence of the phenomenon, as specified in Clause 4.

This standard does not consider disturbances due to capacitive or inductive coupling in cables or other parts of the field installation. Other IEC standards dealing with conducted disturbances cover these aspects.

The object of this standard is to establish a common reference for evaluating the immunity of electrical and electronic equipment when subjected to impulse magnetic fields. 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 levels for their products.

This standard defines:

– a range of test levels;
– test equipment;
– test setups;
– test procedures.

The task of the described laboratory test is to find the reaction of the equipment under test (EUT) under specified operational conditions to impulse magnetic fields caused by switching and lightning effects.

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.

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 as well as the following apply.

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
combination wave generator
CWG
generator with 1,2/50 μs open-circuit voltage waveform and 8/20 μs short-circuit current waveform

Note 1 to entry: This definition is abbreviated from the equivalent definition in IEC 61000-4-5.

Note 2 to entry: This note applies to the French language only.

3.1.3
duration
T_d

<surge current for 8/20 μs> virtual parameter defined as the time interval between the instant at which the surge current rises to 0,5 of its peak value, and then falls to 0,5 of its peak value (T_w), multiplied by 1,18

$T_d = 1{,}18 \times T_w$

SEE: Figure 2.

3.1.4
front time
T_f
<surge current> virtual parameter defined as 1,25 times the interval T_r between the instants when the impulse is 10 % and 90 % of the peak value

SEE: Figure 2.

3.1.5
immunity
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]

3.1.6
induction coil
conductor loop of defined shape and dimensions, in which a current flows, generating a magnetic field of defined uniformity in a defined volume

3.1.7
induction coil factor
ratio between the magnetic field strength generated by an induction coil of given dimensions and the corresponding current value

Note 1 to entry: The field is that measured at the centre of the coil plane, without the EUT.

3.1.8
proximity method
method of application of the magnetic field to the EUT, where a small induction coil is moved along the side of the EUT in order to detect particularly sensitive areas

3.1.9
reference ground plane
flat conductive surface whose potential is used as a common reference

3.1.10
rise time
T_r
interval of time between the instants at which the instantaneous value of an impulse first reaches 10 % value and then 90 % value

SEE: Figure 2.

3.1.11
surge
transient wave of electrical current, voltage or power propagating along a line or a circuit and characterized by a rapid increase followed by a slower decrease

3.1.12
system
set of interdependent elements constituted to achieve a given objective by performing a specified function

Note 1 to entry: The system is considered to be separated from the environment and other external systems by an imaginary surface which cuts the links between them and the considered system. Through these links, the system is affected by the environment, is acted upon by the external systems, or acts itself on the environment or the external systems.

3.1.13
transient, adjective and noun
pertaining to or designating a phenomenon or a quantity which varies between two consecutive steady states during a time interval short compared to the time scale of interest

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

3.1.14
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
CDN	Coupling/decoupling network

CWG	Combination wave generator
EFT/B	Electrical fast transient/burst
EMC	Electromagnetic compatibility
ESD	Electrostatic discharge
EUT	Equipment under test
MU	Measurement uncertainty
RGP	Reference ground plane

4 General

The magnetic fields to which equipment is subjected may influence the reliable operation of equipment and systems.

The following tests are intended to demonstrate the immunity of equipment when subjected to impulse magnetic fields related to the specific location and installation condition of the equipment (e.g. proximity of equipment to the disturbance source).

Pulse magnetic fields are generated by lightning strikes on buildings and other metal structures including aerial masts, earth conductors and earth networks and by initial fault transients in low, medium and high voltage electrical systems.

In high voltage sub-stations, an impulse magnetic field may also be generated by the switching of high voltage bus-bars and lines by circuit breakers.

The test is mainly applicable to electronic equipment to be installed in electrical generation and distribution plants as well as in their control centres. It is not relevant for distribution network equipment (e.g. transformers, power lines).

Product committees may consider other applications.

5 Test levels

The preferred range of test levels is given in Table 1.

Table 1 – Test levels

Level	Pulse magnetic field strength A/m (peak)
1	not applicable
2	not applicable
3	100
4	300
5	1 000
X[a]	special
NOTE The magnetic field strength is expressed in A/m; 1 A/m corresponds to a free space magnetic flux density of 1,26 μT. [a] "X" can be any level, above, below or in between the others. The level shall be specified in the dedicated equipment specification.	

The test levels shall be selected according to the installation conditions. Classes of installation are given in Annex C.

6 Test instrumentation

6.1 General

The test system comprises the combination wave generator and the induction coil for a table-top test setup and, in addition, an RGP for a floor-standing test setup.

6.2 Combination wave generator

6.2.1 General

For this application, the combination wave generator is used as a current source.

NOTE The combination wave generator specified in this standard has identical wave shape definitions to the ones given in IEC 61000-4-5.

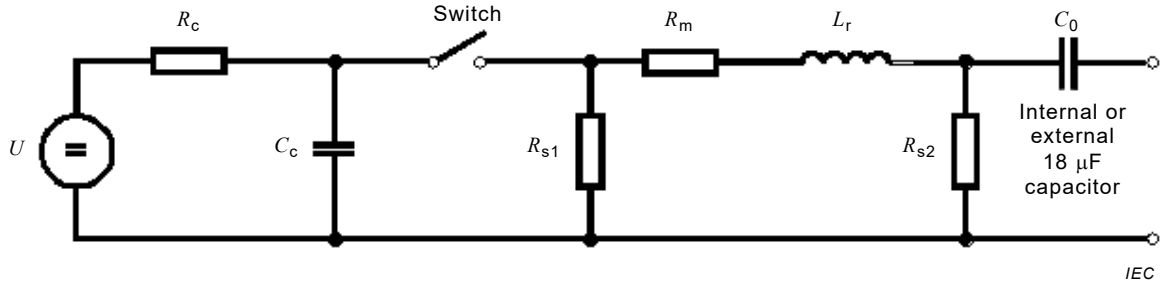
Therefore only the 8/20 μs waveform is relevant. The combination wave generator shall be able to deliver the required impulse current to the induction coils specified in 6.3.

The waveform is specified as a short-circuit current and therefore shall be measured without the induction coil connected.

This generator is intended to generate a surge having:

- a short-circuit current front time of 8 μs;
- a short-circuit current duration of 20 μs.

A simplified circuit diagram of the generator is given in Figure 1. The values for the different components R_{S1}, R_{S2}, R_m, L_r, and C_c are selected so that the generator delivers an 8/20 μs current surge into a short-circuit.



Key

U	High-voltage source
R_c	Charging resistor
C_c	Energy storage capacitor
R_s	Impulse duration shaping resistors
R_m	Impedance matching resistor
L_r	Rise time shaping inductor
C_o	Internal or external 18 μF capacitor

Figure 1 – Simplified circuit diagram of the combination wave generator

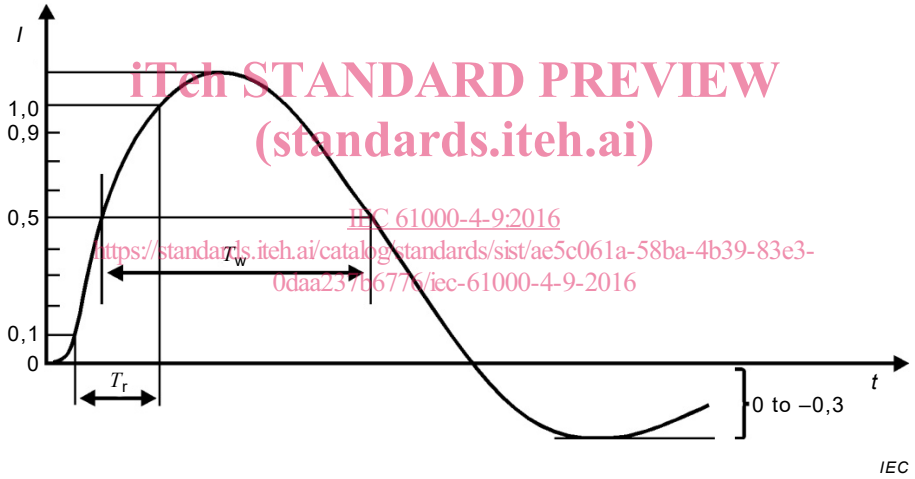
6.2.2 Performance characteristics of the generator

Polarity	positive and negative
Phase shifting	in a range between 0° to 360° relative to the phase angle of the a.c. line voltage to the EUT with a tolerance of ± 10°
Repetition rate	1 per minute or faster
Short-circuit peak output current	100 A to 1 000 A or the required test level divided by the coil factor
Waveform of the surge current	see Table 2 and Figure 2
Short-circuit peak output current tolerance	± 10 %

Table 2 – Definitions of the waveform parameters 8/20 µs

	Front time T_f µs	Duration T_d µs
Short-circuit current	T_f = 1,25 × T_r = 8 ± 20 %	T_d = 1,18 × T_w = 20 ± 20 %

A generator with floating output shall be used.



Front time: T_f= 1,25 × T_r = 8 µs ± 20 %

Duration: T_d = 1,18 × T_w = 20 µs ± 20 %

NOTE 1 The value 1,25 is the reciprocal of the difference between the 0,9 and 0,1 thresholds.

NOTE 2 The value 1,18 is derived from empirical data.

Figure 2 – Waveform of short-circuit current (8/20 µs) at the output of the generator with the 18 µF capacitor in series

6.2.3 Calibration of the generator

If a current transformer (probe) is used to measure short-circuit current, it should be selected so that saturation of the magnetic core does not take place. The lower (-3 dB) corner frequency of the probe should be less than 100 Hz. The calibration shall be carried out with a current probe and oscilloscope or other equivalent measurement instrumentation with a bandwidth of not less than 1 MHz. The calibration shall be performed for all test levels, which are applied for testing.