IEC 61000-4-18

Edition 2.0 2019-05

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

Electromagnetic compatibility (EMC) –
Part 4-18: Testing and measurement techniques – Damped oscillatory wave immunity test

Compatibilité électromagnétique (CEM) –
Partie 4-18: Techniques d'essai et de mesure – Essai d'immunité à l'onde oscillatoire amortie

IEC 61000-4-18:2019-05(en-fr)

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ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 4-18: Testing and measurement techniques – Damped oscillatory wave immunity test

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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International Standard IEC 61000-4-18 has been prepared by subcommittee 77B: High frequency phenomena, of IEC Technical Committee 77: Electromagnetic compatibility.

It forms Part 4-18 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 2006 and its Amendment 1:2010. 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 damped oscillatory wave waveform;
b) new Annex B on measurement uncertainty;
c) addition high speed CDN;

d) addition of calibration procedures for CDNs;

e) addition of the use of the capacitive coupling clamp on interconnection lines for fast damped oscillatory waves;

f) addition of a test procedure for DC/DC converters in case the CDN does not work;

g) new Annex C on issues relating to powering EUTs having DC/DC converters at the input.

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

FDIS	Report on voting
77B/797/FDIS	77B/799/RVD

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 document 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 document will remain unchanged until the stability date indicated on the IEC website under "http://webstore.iec.ch" in the data related to the specific document. At this date, the document will be

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- withdrawn,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

The contents of the corrigendum of August 2019 have been included in this copy.

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 document 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

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 damped oscillatory waves.

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 4-18: Testing and measurement techniques – Damped oscillatory wave immunity test

1 Scope

This part of IEC 61000 focuses on the immunity requirements and test methods for electrical and electronic equipment, under operational conditions, with regard to:

a) repetitive slow damped oscillatory waves occurring mainly in power, control and signal cables installed in high voltage and medium voltage (HV/MV) substations;

b) repetitive fast damped oscillatory waves occurring mainly in power, control and signal cables installed in gas insulated substations (GIS) and in some cases also air insulated substations (AIS) or in any installation due to high-altitude electromagnetic pulse (HEMP) phenomena.

The object of this document is to establish a common and reproducible reference for evaluating the immunity of electrical and electronic equipment when subjected to damped oscillatory waves on supply, signal, control and earth ports. 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. [1]

The document defines:

– test voltage and current waveforms;
– ranges of test levels;
– test equipment;
– calibration and verification procedures of test equipment;
– test setups;
– test procedure.

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 60050-161, *International Electrotechnical Vocabulary (IEV) – Part 161: Electromagnetic compatibility* (available at www.electropedia.org)

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[1] 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.

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-161 and 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

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

3.1.1
air insulated substation
AIS
substation which is made up with only air insulated switchgear

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

3.1.2
auxiliary equipment
AE
equipment necessary to provide the equipment under test (EUT) with the signals required for normal operation and to verify the performance of the EUT

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

3.1.3
burst
sequence of a limited number of distinct pulses or an oscillation of limited duration

[SOURCE: IEC 60050-161:1990, 161-02-07]

3.1.4
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]

3.1.5
capacitive 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

3.1.6
coupling
interaction between circuits, transferring energy from one circuit to another

3.1.7
coupling network
electrical circuit for the purpose of transferring energy from one circuit to another

3.1.8
decoupling network
electrical circuit for the purpose of preventing test voltages applied to the EUT from affecting other devices, equipment, or systems which are not under test

3.1.9
degradation (in performance)
undesired departure in the operational performance of any device, equipment or system from its intended performance

Note 1 to entry: The term "degradation" can apply to temporary or permanent failure.

[SOURCE: IEC 60050-161:1990, 161-01-19]

3.1.10
gas insulated substation
GIS
substation which is made up with only gas insulated metal enclosed switchgear

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

[SOURCE: IEC 60050-605:1983,605-02-14, modified – "metal-enclosed" has been removed from the term.]

3.1.11
high-altitude electromagnetic pulse
HEMP

electromagnetic pulse produced by a nuclear explosion outside the earth's atmosphere

Note 1 to entry: Typically above an altitude of 30 km.

3.1.12
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

[SOURCE: IEC 60050-161:2018,161-01-07]

3.1.13
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]

3.1.14
port
particular interface of the EUT with the external electromagnetic environment

3.1.15
reference ground plane
RGP
flat conductive surface that is at the same electric potential as reference ground, which is used as a common reference, and which contributes to a reproducible parasitic capacitance with the surroundings of the equipment under test (EUT)

Note 1 to entry A reference ground plane is needed for the measurements of conducted disturbances, and serves as reference for the measurement of unsymmetrical and asymmetrical disturbance voltages.

Note 2 to entry In some regions, the term 'earth' is used in place of 'ground'.

Note 3 to entry: This note applies to the French language only.

[SOURCE: IEC 60050-161:1990,161-04-36]

3.1.16
rise time
interval of time between the instants at which the instantaneous value of a pulse first reaches the 10 % value and then the 90 % value

[SOURCE: IEC 60050-161:1990, 161-02-05, modified – The note has been included in the definition]

3.1.17
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 with the time-scale of interest

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

3.1.18
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 to entry: The methods used for verification can be different from those used for calibration.

Note 2 to entry: The procedure of 6.2.1.3 and 6.2.2.3 is meant as a guide to ensure the correct operation of the test generator and other items making up the test setup so that the intended waveform is delivered to the EUT.

3.2 Abbreviated terms

AE	auxiliary equipment
AIS	air insulated substation
CDN	coupling/decoupling network
EFT/B	electrical fast transient/burst
EMC	electromagnetic compatibility
EUT	equipment under test
FDOW	fast damped oscillatory wave
FDOWG	fast damped oscillatory wave generator
GDT	gas discharge tube
GIS	gas insulated substation
HEMP	high-altitude electromagnetic pulse
HV	high voltage
MU	measurement uncertainty

MV medium voltage
PE protective earth
PWM pulse width modulation
RGP reference ground plane
SDOW slow damped oscillatory wave
SDOWG slow damped oscillatory wave generator

4 General

4.1 Types of damped oscillatory waves

The damped oscillatory wave phenomena are divided into two parts. The first part is referred to as the slow damped oscillatory wave and includes oscillation frequencies between 100 kHz and 1 MHz. The second part is referred to as the fast damped oscillatory wave, and it includes oscillation frequencies above 1 MHz.

The formula of the ideal waveform of Figure 1, $w(t)$ (open circuit voltage or short circuit current), is as follows:

$$w(t) = A \cdot K \cdot \frac{\left(\frac{t}{t_1}\right)^n}{1+\left(\frac{t}{t_1}\right)^n} \cdot \exp\left(-\frac{t}{t_2}\right) \cdot \cos(2\pi f \cdot t + \varphi)$$

The values of the parameters of $w(t)$ for the open circuit voltage are given in Table 1 for each standard oscillation period $T = 1/f$.

Table 1 – Values of the parameters of $w(t)$ for each standard oscillation frequency

Waveform	A	K	n	t_1	f	t_2	ϕ
Fast 30 MHz	Pk_1	1,19	1,67	2,26 ns	30 MHz	126 ns	-π/2
Fast 10 MHz	Pk_1	1,04	2,65	1,69 ns	10 MHz	377 ns	-π/4
Fast 3 MHz	Pk_1	1,07	2,30	2,89 ns	3 MHz	1,26 µs	0
Slow 1 MHz	Pk_1	1,12	2,45	49,8 ns	1 MHz	3,77 µs	-π/4
Slow 100 kHz	Pk_1	1,04	1,96	32,7 ns	100 kHz	37,7 µs	0

The causes of these two types of damped oscillatory waves are described below.

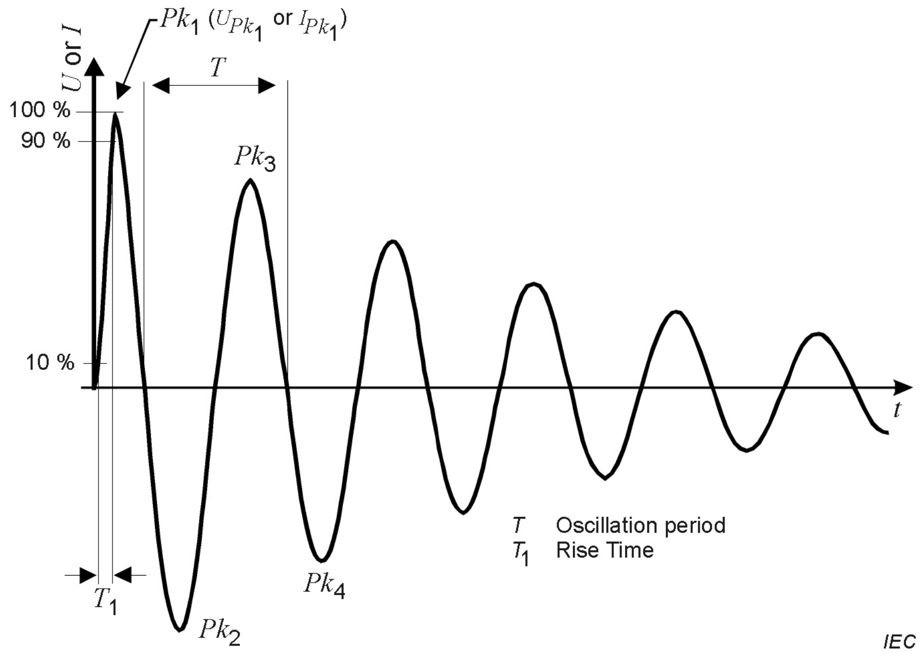

Figure 1 – Example of waveform of the damped oscillatory wave

4.2 Slow damped oscillatory wave phenomenon

This phenomenon is representative of the switching of disconnectors in HV/MV open-air substations, and is particularly related to the switching of HV busbars.

In substations, the opening and closing operations of HV disconnectors give rise to sharp front-wave transients, with rise times of the order of some tens of nanoseconds.

The voltage front-wave includes reflections due to the mismatch of the characteristic impedance of HV circuits involved. In this respect, the resulting transient voltage and current in HV busbars are characterized by a fundamental oscillation frequency that depends on the length of the circuit and on the propagation time.

The oscillation frequency ranges from about 100 kHz to a few megahertz for open-air sub-stations, depending on the influence of the parameters mentioned above and the length of the busbars, which can vary from some tens of metres to hundreds of metres (400 m can occur).

In this respect, the oscillation frequency of 1 MHz can be considered representative of most situations, but 100 kHz has been considered appropriate for large HV substations.

The repetition frequency is variable between a few hertz and a few kilohertz depending on the distance between the switching contacts. For contacts in close proximity, the repetition frequency is at its maximum, while for contact distances close to allowing re-ignitions between the contacts, the repetition rate is at its minimum and is equivalent to twice the power frequency with respect to each phase (100/s per phase for 50 Hz grids and 120/s per phase for 60 Hz grids).

The repetition rates of 40/s and 400/s represent a compromise, taking into account the different durations of the phenomena, different frequencies considered and the energy to which the circuits under test are subjected.

Repetitive oscillatory transients can be generated by switching transients and the injection of impulsive currents in power systems (networks and electrical equipment).