

Electromagnetic compatibility (EMC) —

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

ICS 33.100.20

National foreword

This British Standard is the UK implementation of EN 61000-4-18:2007+A1:2010, incorporating corrigendum September 2007. It is identical with IEC 61000-4-18:2006 incorporating amendment 1:2010. It supersedes BS EN 61000-4-18:2007 which is withdrawn.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to ISO text carry the number of the ISO amendment. For example, text altered by ISO amendment 1 is indicated by **A1** **A1**.

The UK participation in its preparation was entrusted by Technical Committee GEL/210, EMC — Policy committee, to Subcommittee GEL/210/12, EMC — Basic, generic and low frequency phenomena Standardization.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

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**Electromagnetic compatibility (EMC) -
Part 4-18: Testing and measurement techniques -
Damped oscillatory wave immunity test
(IEC 61000-4-18:2006)**

Compatibilité électromagnétique (CEM) -
Partie 4-18: Techniques d'essai
et de mesure -
Essai d'immunité
à l'onde oscillatoire amortie
(CEI 61000-4-18:2006)

Elektromagnetische Verträglichkeit (EMV) -
Teil 4-18: Prüf- und Messverfahren -
Prüfung der Störfestigkeit
gegen gedämpft schwingende Wellen
(IEC 61000-4-18:2006)

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CENELEC

European Committee for Electrotechnical Standardization
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Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of document 77B/517/FDIS, future edition 1 of IEC 61000-4-18, prepared by SC 77B, High frequency phenomena, of IEC TC 77, Electromagnetic compatibility, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61000-4-18 on 2007-03-01.

This European Standard deals with the immunity test against oscillatory waves which was formerly covered by EN 61000-4-12:1995 + A1:2001, now superseded by EN 61000-4-12:2006. It constitutes a technical revision by extending the frequency range.

The following dates were fixed:

- latest date by which the EN has to be implemented
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Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard IEC 61000-4-18:2006 was approved by CENELEC as a European Standard without any modification.

Foreword to amendment A1

The text of document 77B/604/CDV, future amendment 1 to IEC 61000-4-18:2006, prepared by SC 77B, High frequency phenomena, of IEC TC 77, Electromagnetic compatibility, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A1 to EN 61000-4-18:2007 on 2010-07-01.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN and CENELEC shall not be held responsible for identifying any or all such patent rights.

The following dates were fixed:

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The text of amendment 1:2010 to the International Standard IEC 61000-4-18:2006 was approved by CENELEC as an amendment to the European Standard without any modification.

CONTENTS

INTRODUCTION.....	5
1 Scope and object.....	6
2 Normative references	6
3 Terms and definitions	7
4 General	8
4.1 Information on the slow damped oscillatory wave phenomenon.....	8
4.2 Information on the fast damped oscillatory wave phenomenon	9
5 Test levels.....	11
6 Test equipment.....	13
6.1 Generator.....	13
6.2 Specifications of the coupling/decoupling network	15
7 Test setup	17
7.1 Earthing connections	17
7.2 Ground reference plane	18
7.3 Equipment under test.....	18
7.4 Coupling/decoupling networks.....	19
7.5 Generators	19
8 Test procedure	19
8.1 Laboratory reference conditions	20
8.2 Execution of the test	20
9 Evaluation of test results	21
10 Test report	22
Annex A (informative) Information on test levels for the damped oscillatory wave	34
Annex ZA (normative) Normative references to international publications with their corresponding European publications	36
Bibliography	35
Figure 1 – Waveform of the damped oscillatory wave (open circuit voltage).....	23
Figure 2 – Example of schematic circuit of the test generator for the damped oscillatory wave	23
Figure 3 – Example of test setup for table-top equipment using the ground reference plane .	24
Figure 4 – Example of test setup for floor-standing equipment using the ground reference plane	24
Figure 5 – AC/DC power supply port, single phase, line-to-ground tests	25
Figure 6 – AC power supply port, three phases, line-to-ground test.....	26
Figure 7 – Input/output port, single circuit, line-to-ground test	27
Figure 8 – Input/output port, group of circuits with common return, line-to-ground test.....	28
Figure 9 – AC/DC power supply port, single phase, line-to-line test.....	29

Figure 10 – AC power supply port, three phases, line-to-line test	30
Figure 11 – Input/output port, single circuit, line-to-line test	31
Figure 12 – Input/output port, group of circuits with common return, line-to-line test	32
Figure 13 – Test of a system with communication ports with fast operating signals (generator output earthed)	33
Table 1 – Test levels for the slow damped oscillatory wave (100 kHz or 1 MHz)	12
Table 2 – Test levels for the fast damped oscillatory wave (3 MHz, 10 MHz or 30 MHz)	12

INTRODUCTION

This standard is part of the IEC 61000 series, 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: 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 and object

This part of IEC 61000-4 relates to the immunity requirements and test methods for electrical and electronic equipment, under operational conditions, with regard to:

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

The object of this basic standard is to establish the immunity requirements and a common reference for evaluating in a laboratory the performance of electrical and electronic equipment intended for residential, commercial and industrial applications, as well as of equipment intended for power stations and substations, as applicable.

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 purpose of this standard is to define:

- test voltage and current waveforms;
- ranges of test levels;
- test equipment;
- test setup;
- test procedure.

The object of this standard is to establish a common reference for evaluating the immunity of electrical and electronic equipment when subjected to damped oscillatory 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.

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): *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electro-magnetic compatibility*

IEC 61000-4-4: *Electromagnetic compatibility (EMC) – Part 4-4: Testing and measurement techniques – Electrical fast transient/burst immunity test*

IEC 61000-6-6: *Electromagnetic compatibility (EMC) – Part 6-6: Generic standards – HEMP immunity for indoor equipment*

3 Terms and definitions

For the purposes of this document, the terms and definitions contained in IEC 60050-161, some of which are repeated here for convenience, and the following terms and definitions apply.

NOTE These terms are applicable to the restricted field of oscillatory transients.

3.1

air insulated substation

AIS

substation which is made up with only air insulated switchgear

3.2

burst

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

[IEV 161-02-07]

3.3

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]

3.4

coupling

interaction between circuits, transferring energy from one circuit to another

3.5

coupling network

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

3.6

decoupling network

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

3.7

gas insulated (metal-enclosed) substation

GIS

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

[IEV 605-02-14]

3.8

high-altitude electromagnetic pulse

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

NOTE Typically above an altitude of 30 km

3.9

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]

3.10

port

particular interface of the EUT with the external electromagnetic environment

3.11

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]

3.12

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

[IEV 161-02-01]

3.13

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 6.1.3 and 6.2 is meant as a guide to insure 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.

[IEV 311-01-13, modified]

4 General

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

4.1 Information on the 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, as well as to the background disturbance in industrial plants.

In electrical stations, 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 has an evolution that includes reflections, due to the mismatching 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 substations, depending on the influence of the parameters mentioned above and the length of the busbars, which may vary from some tens of metres to hundreds of metres (400 m may occur).

In this respect, the oscillation frequency of 1 MHz may 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: that is, for close contacts, there is a maximum repetition frequency, while for distances between the contacts near to the extinction of the arc, the minimum repetition frequency, in respect of each phase, is twice the power frequency (100/s per phase for 50 Hz and 120/s per phase for 60 Hz HV systems).

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

In industrial plants, repetitive oscillatory transients may be generated by switching transients and the injection of impulsive currents in power systems (networks and electrical equipment).

The systems have a local response in a frequency band well covered by the rise time and the fundamental frequency of oscillation of the damped oscillatory wave selected for testing purposes.

4.2 Information on the fast damped oscillatory wave phenomenon

The fast damped oscillatory wave immunity test should cover phenomena present in two specific environments:

- substations of the power network (produced by switchgear and controlgear);
- all installations exposed to the high-altitude electromagnetic pulse (HEMP).

4.2.1 Disturbances produced by switchgear and controlgear

During opening or closing disconnector operations, between both contacts of the operated device, a large number of restrikes take place due to the slow speed of the contacts. Therefore, disconnector switch operations generate very fast transients, which propagate as travelling waves in the busbars of the substation. The electrical length of the shielded conductors and the length of the open circuit busbars determine the oscillation frequencies of the transient overvoltages.

For air insulated substations (AIS) these transients will radiate an electromagnetic field in the substation environment. Recent measurements have been performed in air insulated

substations using instruments with a large frequency bandwidth [1])¹. These measurements have shown that transient phenomena with frequencies higher than 1 MHz can also take place in these substations.

For gas insulated substations (GIS), these transients propagate inside the metallic enclosure, which contains the SF₆ gas. Due to the skin effect, high frequency transients are confined inside the enclosure and cause no problems. At the enclosure discontinuities however, a part of transients is transferred to the external surface of the enclosure tube. As a consequence, the enclosure potential rises and the current flowing on the enclosure surface radiates an electromagnetic field in the substation environment. The transient ground potential rise is a direct source of transient common mode currents in the secondary circuits. The radiated electromagnetic field also induces common mode currents in the secondary circuits.

Measurements have shown that the maximum frequency of significant components in the spectral density of these currents can be as high as 30 MHz to 50 MHz (see Figures 1 and 2) [2].

In Figures 1 and 2, it can be seen that several peaks occur in the current spectral density characteristic and important spectral components are observed at frequencies of some tens of MHz.

As summarized in [1], the frequency environment of HV substations (GIS, but also AIS) has become more severe than it was in the past, due to a reduction in distances as a consequence of the reduction of the overall sizes of substations, the use of gas insulated substations (GIS) and the installation of electronic equipment nearer to switching devices.

Therefore, the oscillation frequencies of 3 MHz, 10 MHz and 30 MHz for the fast damped oscillatory waves seem to be suitable to better take into account a more realistic environment both in some AIS and in all GIS.

The repetition frequency is variable between a few hertz and many kilohertz depending on the distance between the switching contacts: that is, with close contacts, there is a maximum repetition frequency, while for distances between the contacts near to the extinction of the arc, the minimum repetition frequency, in respect of each phase, is twice the power frequency (100/s per phase for 50 Hz and 120/s per phase for 60 Hz HV systems).

The repetition rate selected, 5 000/s, is set to consider the higher repetition rates measured in GIS. That rate still represents a compromise (as higher rates have been measured), taking into account the different duration of the phenomena, the suitability of the different frequencies considered and the problem related to the energy to which the circuits under test are subjected.

4.2.2 Disturbances produced by the high-altitude electromagnetic pulse (HEMP)

The high-altitude electromagnetic pulse (HEMP) as presented in IEC 61000-2-9 [4] describes an intense, plane wave electromagnetic pulsed field which has a rise time of 2,5 ns and a pulse width of approximately 25 ns. This field interacts with exposed cables and wiring to produce an oscillating voltage and current depending on the length of the line (see IEC 61000-2-10 [5]). For most external lines such as power and communications, these lines are long enough (often greater than 1 km) that the coupled currents and voltages are usually impulsive in nature.

¹) Figures in square brackets refer to the bibliography.