

CONSOLIDATED VERSION

VERSION CONSOLIDÉE



BASIC EMC PUBLICATION

PUBLICATION FONDAMENTALE EN CEM

**Electromagnetic compatibility (EMC) –
Part 4-5: Testing and measurement techniques – Surge immunity test**

**Compatibilité électromagnétique (CEM) –
Partie 4-5: Techniques d'essai et de mesure – Essai d'immunité aux ondes
de choc**



THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2017 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

IEC Central Office
3, rue de Varembe
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
Fax: +41 22 919 03 00
info@iec.ch
www.iec.ch

About the IEC

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue

The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - www.iec.ch/searchpub

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,...). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org

The world's leading online dictionary of electronic and electrical terms containing 20 000 terms and definitions in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

65 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: csc@iec.ch.

A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Catalogue IEC - webstore.iec.ch/catalogue

Application autonome pour consulter tous les renseignements bibliographiques sur les Normes internationales, Spécifications techniques, Rapports techniques et autres documents de l'IEC. Disponible pour PC, Mac OS, tablettes Android et iPad.

Recherche de publications IEC - www.iec.ch/searchpub

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études,...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et aussi une fois par mois par email.

Electropedia - www.electropedia.org

Le premier dictionnaire en ligne de termes électroniques et électriques. Il contient 20 000 termes et définitions en anglais et en français, ainsi que les termes équivalents dans 16 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

Glossaire IEC - std.iec.ch/glossary

65 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: csc@iec.ch.

CONSOLIDATED VERSION

VERSION CONSOLIDÉE



BASIC EMC PUBLICATION
PUBLICATION FONDAMENTALE

**Electromagnetic compatibility (EMC) –
Part 4-5: Testing and measurement techniques – Surge immunity test**

**Compatibilité électromagnétique (CEM) –
Partie 4-5: Techniques d'essai et de mesure – Essai d'immunité aux ondes
de choc**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 33.100.20

ISBN 978-2-8322-4706-8

**Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

REDLINE VERSION

VERSION REDLINE



BASIC EMC PUBLICATION

PUBLICATION FONDAMENTALE

Electromagnetic compatibility (EMC) –

Part 4-5: Testing and measurement techniques – Surge immunity test

Compatibilité électromagnétique (CEM) –

Partie 4-5: Techniques d'essai et de mesure – Essai d'immunité aux ondes de choc

CONTENTS

FOREWORD.....	7
INTRODUCTION.....	9
INTRODUCTION to the amendment.....	10
1 Scope and object.....	11
2 Normative references	11
3 Terms, definitions and abbreviations	12
3.1 Terms and definitions.....	12
3.2 Abbreviations	15
4 General	16
4.1 Power system switching transients.....	16
4.2 Lightning transients.....	16
4.3 Simulation of the transients.....	16
5 Test levels.....	16
6 Test instrumentation	17
6.1 General.....	17
6.2 1,2/50 µs combination wave generator	17
6.2.1 General	17
6.2.2 Performance characteristics of the generator.....	18
6.2.3 Calibration of the generator	20
6.3 Coupling/decoupling networks.....	21
6.3.1 General	21
6.3.2 Coupling/decoupling networks for a.c./d.c. power port rated up to 200 A per line	22
6.3.3 Coupling/decoupling networks for interconnection lines	26
6.4 Calibration of coupling/decoupling networks.....	29
6.4.1 General	29
6.4.2 Calibration of CDNs for a.c./d.c. power port rated up to 200 A per line	30
6.4.3 Calibration of CDNs for interconnection lines.....	30
7 Test setup	33
7.1 Test equipment.....	33
7.2 Verification of the test instrumentation	33
7.3 Test setup for surges applied to EUT power ports	34
7.4 Test setup for surges applied to unshielded unsymmetrical interconnection lines	34
7.5 Test setup for surges applied to unshielded symmetrical interconnection lines.....	34
7.6 Test setup for surges applied to shielded lines.....	35
8 Test procedure	36
8.1 General.....	36
8.2 Laboratory reference conditions	36
8.2.1 Climatic conditions	36
8.2.2 Electromagnetic conditions	36
8.3 Execution of the test	37
9 Evaluation of test results	38
10 Test report.....	38

Annex A (normative) Surge testing for unshielded outdoor symmetrical communication lines intended to interconnect to widely dispersed systems	40
A.1 General.....	40
A.2 10/700 μ s combination wave generator	40
A.2.1 Characteristics of the generator	40
A.2.2 Performances of the generator	41
A.2.3 Calibration of the generator	43
A.3 Coupling/decoupling networks.....	43
A.3.1 General	43
A.3.2 Coupling/decoupling networks for outdoor communication lines	44
A.4 Calibration of coupling/decoupling networks.....	44
A.5 Test setup for surges applied to outdoor unshielded symmetrical communication lines	45
Annex B (informative) Selection of generators and test levels	47
B.1 General.....	47
B.2 The classification of environments	47
B.3 The definition of port types.....	47
B.4 Generators and surge types	48
B.5 Tables.....	48
Annex C (informative) Explanatory notes	50
C.1 Different source impedance	50
C.2 Application of the tests.....	50
C.2.1 Equipment level immunity	50
C.2.2 System level immunity	50
C.3 Installation classification	51
C.4 Minimum immunity level of ports connected to the a.c./d.c. mains supply.....	52
C.5 Equipment level immunity of ports connected to interconnection lines.....	52
Annex D (informative) Considerations for achieving immunity for equipment connected to low voltage power distribution systems	54
Annex E (informative) Mathematical modelling of surge waveforms	56
E.1 General.....	56
E.2 Normalized time domain voltage surge (1,2/50 μ s).....	57
E.3 Normalized time domain current surge (8/20 μ s)	58
E.4 Normalized time domain voltage surge (10/700 μ s).....	60
E.5 Normalized time domain current surge (5/320 μ s)	62
Annex F (informative) Measurement uncertainty (MU) considerations	65
F.1 Legend	65
F.2 General.....	65
F.3 Uncertainty contributors to the surge measurement uncertainty	66
F.4 Uncertainty of surge calibration.....	66
F.4.1 General	66
F.4.2 Front time of the surge open-circuit voltage	66
F.4.3 Peak of the surge open-circuit voltage	68
F.4.4 Duration of the surge open-circuit voltage.....	69
F.4.5 Further MU contributions to time and amplitude measurements	70
F.4.6 Rise time distortion due to the limited bandwidth of the measuring system.....	70

F.4.7	Impulse peak and width distortion due to the limited bandwidth of the measuring system	71
F.5	Application of uncertainties in the surge generator compliance criterion	72
Annex G (informative)	Method of calibration of impulse measuring systems	73
G.1	General	73
G.2	Estimation of measuring system response using the convolution integral	73
G.3	Impulse measuring system for open-circuit voltage (1,2/50 μ s, 10/700 μ s)	74
G.4	Impulse measuring system for short-circuit current (8/20 μ s, 5/320 μ s)	74
Annex H (informative)	Coupling/decoupling surges to lines rated above 200 A	76
H.1	General	76
H.2	Considerations of coupling and decoupling	76
H.3	Additional precautions	77
Annex I (informative)	Issues relating to powering EUTs having DC/DC converters at the input	78
I.1	General	78
I.2	Considerations for remediation	79
Bibliography		80
Figure 1	– Simplified circuit diagram of the combination wave generator	18
Figure 2	– Waveform of open-circuit voltage (1,2/50 μ s) at the output of the generator with no CDN connected	19
Figure 3	– Waveform of short-circuit current (8/20 μ s) at the output of the generator with no CDN connected	20
Figure 4	– Selection of coupling/decoupling method	22
Figure 5	– Example of coupling network and decoupling network for capacitive coupling on a.c./d.c. lines line-to-line coupling	24
Figure 6	– Example of coupling network and decoupling network for capacitive coupling on a.c./d.c. lines: line-to-ground coupling	25
Figure 7	– Example of coupling network and decoupling network for capacitive coupling on a.c. lines (3 phases): line L2-to-line L3 coupling	25
Figure 8	– Example of coupling network and decoupling network for capacitive coupling on a.c. lines (3 phases): line L3-to-ground coupling	26
Figure 9	– Example of coupling network and decoupling network for unshielded unsymmetrical interconnection lines: line-to-line and line-to-ground coupling	27
Figure 10	– Example of coupling and decoupling network for unshielded symmetrical interconnection lines: lines-to-ground coupling	28
Figure 11	– Example of coupling and decoupling network for unshielded symmetrical interconnection lines: lines-to-ground coupling via capacitors	29
Figure 12	– Example of test setup for surges applied to shielded lines	36
Figure A.1	– Simplified circuit diagram of the combination wave generator (10/700 μ s – 5/320 μ s)	41
Figure A.2	– Waveform of open-circuit voltage (10/700 μ s)	42
Figure A.3	– Waveform of the 5/320 μ s short-circuit current waveform	42
Figure A.4	– Example of test setup for unshielded outdoor symmetrical communication lines: lines-to-ground coupling, coupling via gas arrestors (primary protection fitted)	44
Figure E.1	– Voltage surge (1,2/50 μ s): width time response T_W	57
Figure E.2	– Voltage surge (1,2/50 μ s): rise time response T	58
Figure E.3	– Voltage surge (1,2/50 μ s): spectral response with $\Delta f = 3,333$ kHz	58

Figure E.4 – Current surge (8/20 μ s): width time response T_W	59
Figure E.5 – Current surge (8/20 μ s): rise time response T_r	60
Figure E.6 – Current surge (8/20 μ s): spectral response with $\Delta f = 10$ kHz	60
Figure E.7 – Voltage surge (10/700 μ s): width time response T_W	61
Figure E.8 – Voltage surge (10/700 μ s): rise time response T_r	62
Figure E.9 – Voltage surge (10/700 μ s): spectral response with $\Delta f = 0,2$ kHz	62
Figure E.10 – Current surge (5/320 μ s): width time response T_W	63
Figure E.11 – Current surge (5/320 μ s): rise time response T_r	64
Figure E.12 – Current surge (5/320 μ s): spectral response with $\Delta f = 0,4$ kHz	64
Figure G.1 – Simplified circuit diagram of the current step generator	75
Figure I.1 – Example of adding a damping circuit to the CDN for DC/DC converter EUTs	79
Table 1 – Test levels	17
Table 2 – Definitions of the waveform parameters 1,2/50 μ s and 8/20 μ s	19
Table 3 – Relationship between peak open-circuit voltage and peak short-circuit current	19
Table 4 – Voltage waveform specification at the EUT port of the CDN	23
Table 5 – Current waveform specification at the EUT port of the CDN	23
Table 6 – Relationship between peak open-circuit voltage and peak short-circuit current at the EUT port of the CDN	24
Table 7 – Summary of calibration process for CDNs for unsymmetrical interconnection lines	31
Table 8 – Surge waveform specifications at the EUT port of the CDN for unsymmetrical interconnection lines	31
Table 9 – Summary of calibration process for CDNs for symmetrical interconnection lines	32
Table 10 – Surge waveform specifications at the EUT port of the CDN for symmetrical interconnection lines	33
Table A.1 – Definitions of the waveform parameters 10/700 μ s and 5/320 μ s	42
Table A.2 – Relationship between peak open-circuit voltage and peak short-circuit current	43
Table A.3 – Summary of calibration process for CDNs for unshielded outdoor symmetrical communication lines	45
Table A.4 – Surge waveform specifications at the EUT port of the CDN for unshielded outdoor symmetrical communication lines	45
Table B.1 – Power ports: selection of the test levels (depending on the installation class)	48
Table B.2 – Circuits/lines: selection of the test levels (depending on the installation class)	49
Table F.1 – Example of uncertainty budget for surge open-circuit voltage front time (T_{fV})	67
Table F.2 – Example of uncertainty budget for surge open-circuit voltage peak value (V_P)	68
Table F.3 – Example of uncertainty budget for surge open-circuit voltage duration (T_d)	69
Table F.4 – α factor, Equation (F.5), of different unidirectional impulse responses corresponding to the same bandwidth of the system B	71

Table F.5 – β factor, Equation (F.9), of the standard surge waveforms	72
Table H.1 – Recommended inductance values for decoupling lines (> 200 A)	76

This document is a preview generated by EVS

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 4-5: Testing and measurement techniques – Surge 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.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

DISCLAIMER

This Consolidated version is not an official IEC Standard and has been prepared for user convenience. Only the current versions of the standard and its amendment(s) are to be considered the official documents.

This Consolidated version of IEC 61000-4-5 bears the edition number 3.1. It consists of the third edition (2014-05) [documents 77B/711/FDIS and 77B/715/RVD] and its amendment 1 (2017-08) [documents 77B/762/CDV and 77B/773/RVC]. The technical content is identical to the base edition and its amendment.

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendment 1. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

International Standard IEC 61000-4-5 has been prepared by subcommittee 77B: High frequency phenomena, of IEC technical Committee 77: Electromagnetic compatibility.

It forms Part 4-5 of IEC 61000. It has the status of a basic EMC publication in accordance with IEC Guide 107.

This third edition constitutes a technical revision.

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

- a) new Annex E on mathematical modelling of surge waveforms;
- b) new Annex F on measurement uncertainty;
- c) new Annex G on method of calibration of impulse measuring systems;
- d) new Annex H on coupling/decoupling surges to lines rated above 200 A;
- e) moreover while surge test for ports connected to outside telecommunication lines was addressed in 6.2 of the second edition (IEC 61000-4-5:2005), in this third edition (IEC 61000-4-5:2014) the normative Annex A is fully dedicated to this topic. In particular it gives the specifications of the 10/700 μ s combined wave generator.

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 the base publication and its amendment 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 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 (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 surge voltages and surge currents.

INTRODUCTION to the amendment

Rationale:

The method for testing DC products in the current revision of IEC61000-4-5 is causing many field related problems for test labs and manufacturers. Many products will not power up through the power CDN in the standard and in some cases may be damaged by the inductance that is necessary to apply the surge (see 77B/734/DC for further information).

The DC./DC converter problem is related to the switching of the converter which produces a voltage drop at the decoupling inductors on one hand and oscillations produced by the EUT impedance in combination with the source on the other hand. Measurements were performed using different brands of CDNs with a device known to show that problem as an EUT. The result shows different oscillations and signal forms of the voltage at the EUT for different CDNs. According to the outcome, the use of a CDN with a higher current rating (i.e. smaller decoupling inductivity) can solve the problem. At the meeting of SC77B/MT12 in Akishima, Japan on August 26, 2016, it was decided to add a statement into 7.3 allowing surge tests with higher current rated CDNs and to add a new Annex I to explain the problem in detail.

ELECTROMAGNETIC COMPATIBILITY (EMC) –

Part 4-5: Testing and measurement techniques – Surge immunity test

1 Scope and object

This part of IEC 61000 relates to the immunity requirements, test methods, and range of recommended test levels for equipment with regard to unidirectional surges caused by over-voltages from switching and lightning transients. Several test levels are defined which relate to different environment and installation conditions. These requirements are developed for and are applicable to electrical and electronic equipment.

The object of this standard is to establish a common reference for evaluating the immunity of electrical and electronic equipment when subjected to surges. 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 surge voltages caused by switching and lightning effects.

It is not intended to test the capability of the EUT's insulation to withstand high-voltage stress. Direct injections of lightning currents, i.e. direct lightning strikes, are not considered in this standard.

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)