

INTERNATIONAL STANDARD

NORME INTERNATIONALE



EMC IC modelling –

**Part 6: Models of integrated circuits for pulse immunity behavioural simulation –
Conducted pulse immunity modelling (ICIM-CPI)**

Modèles de circuits intégrés pour la CEM –

**Partie 6: Modèles de circuits intégrés pour la simulation du comportement
d'immunité aux impulsions – Modélisation de l'immunité aux impulsions
conduites (ICIM-CPI)**



THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2020 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
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 corrigendum or an amendment might have been published.

IEC publications search - webstore.iec.ch/advsearchform

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 It also gives information on projects, replaced and withdrawn publications.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 once a month by email.

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: sales@iec.ch.

Electropedia - www.electropedia.org

The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries 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

67 000 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.

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.

Recherche de publications IEC - webstore.iec.ch/advsearchform

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 une fois par mois par email.

Service Clients - webstore.iec.ch/csc

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

Electropedia - www.electropedia.org

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 000 articles terminologiques 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

67 000 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.

INTERNATIONAL STANDARD

NORME INTERNATIONALE



EMC IC modelling –

**Part 6: Models of integrated circuits for pulse immunity behavioural simulation –
Conducted pulse immunity modelling (ICIM-CPI)**

Modèles de circuits intégrés pour la CEM –

**Partie 6: Modèles de circuits intégrés pour la simulation du comportement
d'immunité aux impulsions – Modélisation de l'immunité aux impulsions
conduites (ICIM-CPI)**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 31.200

ISBN 978-2-8322-8813-9

**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.**

CONTENTS

FOREWORD	5
1 Scope	7
2 Normative references	7
3 Terms, definitions, abbreviated terms and conventions	8
3.1 Terms and definitions	8
3.2 Abbreviated terms	11
3.3 Conventions	11
4 Philosophy	11
5 ICIM-CPI model structure	12
5.1 General	12
5.2 PPN	14
5.2.1 Typical structure of a PPN	14
5.2.2 PDN description	15
5.2.3 NLB description	16
5.3 FB description	16
6 CPIML format	18
6.1 General	18
6.2 CPIML structure	19
6.3 Global elements	20
6.4 Header section	20
6.5 Lead_definitions section	20
6.6 Macromodels section	21
6.7 Validity section	22
6.8 PDN	22
6.9 NLB	22
6.9.1 General	22
6.9.2 Attribute definition	23
6.9.3 Data description	24
6.10 FB	25
6.10.1 General	25
6.10.2 Attribute definitions	26
6.10.3 Data description	30
Annex A (informative) Extraction of model components	34
A.1 General	34
A.2 PPN description	34
A.3 PDN Extraction	34
A.3.1 General	34
A.3.2 S/Z/Y-parameter measurement	34
A.3.3 Conventional one-port method	35
A.3.4 Two-port method for low impedance measurement	35
A.3.5 Two-port method for high impedance measurement	36
A.4 NLB extraction	36
A.4.1 General	36
A.4.2 TLP test method	37
A.5 FB extraction	39
A.5.1 General	39

A.5.2	Example of FB data in case of test criteria type = Class E_IC	39
A.5.3	Example of FB data in case of test criteria type = Class C_IC	41
Annex B (informative)	NLB implementation techniques in a circuit simulator	42
B.1	General	42
B.2	NLB modelling based on a R/I table	42
B.3	NLB modelling based on a switch based model	42
B.4	NLB modelling based on physical device model	43
Annex C (informative)	Example of ICIM-CPI model	45
C.1	General	45
C.2	Example of Power switch ICIM-CPI model	45
C.2.1	General	45
C.2.2	CPI model	45
C.2.3	ICIM-CPI model use	48
C.3	Example of 32-bit microcontroller ICIM-CPI model	50
C.3.1	General	50
C.3.2	CPI model	51
Bibliography	54
Figure 1	– Structure of the ICIM-CPI model	13
Figure 2	– Example of an ICIM-CPI model of an electronic board	14
Figure 3	– Structure of a typical PPN	15
Figure 4	– Characteristics of a voltage pulse entering the DUT during a TLP test	17
Figure 5	– Example of defect monitored at the OOV when a disturbance is applied to the DI	18
Figure 6	– CPIML inheritance hierarchy	19
Figure 7	– Example of a NLB external file	25
Figure 8	– Example of an external FF file	33
Figure A.1	– Conventional one-port S-parameters measurement	35
Figure A.2	– Two-port method for low impedance measurement	35
Figure A.3	– Two-port method for high impedance measurement	36
Figure A.4	– Example of V/I measurements to extract NLB	37
Figure A.5	– TLP method set-up (not powered IC)	38
Figure A.6	– Example of NLB extraction using standard TLP pulse	38
Figure A.7	– Graphs for identification of IC failure mechanism for destruction prediction	40
Figure B.1	– NLB model based on a R/I table	42
Figure B.2	– Example of a generic model architecture based on switches for NLB behavioural modelling	43
Figure B.3	– Example of core MOS large signal model of the GGNMOS	43
Figure C.1	– Use of the ICIM-CPI model for simulation	45
Figure C.2	– Power switch V/I curve for 50 ns-pulse width	46
Figure C.3	– Power switch ICIM-CPI model	46
Figure C.4	– Power switch ICIM-CPI model use for ESD protection design	49
Figure C.5	– Calculated voltage at Power switch pin for different ESD protection capacitor values	49
Figure C.6	– Voltage at Power switch pin for fog lamp left and right sides	50
Figure C.7	– Example of 32-bit microcontroller protection devices	50

Table 1 – Attributes of <i>Lead</i> tag in the <i>Lead_definitions</i> section	20
Table 2 – Compatibility between the <i>Mode</i> and <i>Type</i> fields for correct CPIML annotation.....	21
Table 3 – Definition of the <i>Lead</i> tag for <i>Nlb</i> section	22
Table 4 – Default values of <i>Unit_voltage</i> and <i>Unit_current</i>	24
Table 5 – Allowed file extensions for <i>Data_files</i>	24
Table 6 – Definition of the <i>Lead</i> tag in <i>Fb</i> section	26
Table 7 – <i>Table</i> sub-attributes definition	27
Table 8 – <i>Pulse_characteristics</i> parameters definition.....	27
Table 9 – <i>Test_criteria</i> parameters definition	28
Table A.1 – Example of FB data corresponding to Class E _{IC} failure.....	41
Table A.2 – Example of FB data corresponding to Class C _{IC} failure	41
Table C.1 – Synthesis Peak voltage and Energy for different pulse widths	46

Currently in preview, click buy full version.

INTERNATIONAL ELECTROTECHNICAL COMMISSION

EMC IC MODELLING –

Part 6: Models of integrated circuits for pulse immunity behavioural simulation – Conducted pulse immunity modelling (ICIM-CPI)

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, accept 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.

International Standard IEC 62433-6 has been prepared by subcommittee 47A: Integrated circuits, of IEC technical committee 47: Semiconductor devices.

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

CDV	Report on voting
47A/1090/CDV	47A/1098/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 document has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts in the IEC 62433 series, published under the general title *EMC IC modelling*, 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.

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.

EMC IC MODELLING –

Part 6: Models of integrated circuits for pulse immunity behavioural simulation – Conducted pulse immunity modelling (ICIM-CPI)

1 Scope

The objective of this part of IEC 62433 is to describe the extraction flow for deriving an immunity macro-model of an Integrated Circuit (IC) against conducted Electrostatic Discharge (ESD) according to IEC 61000-4-2 and Electrical Fast Transients (EFT) according to IEC 61000-4-4.

The model addresses physical damages due to overvoltage, thermal damage and other failure modes. Functional failures can also be addressed.

This model allows the immunity simulation of the IC in an application. This model is commonly called "Integrated Circuit Immunity Model Conducted Pulse Immunity", ICIM-CPI.

The described approach is suitable for modelling analogue, digital and mixed-signal ICs. Several terminals of an IC can be part of a single model (e.g. input, output and supply pins). The implementation of the model is capable of representing the non-linear behaviour of overvoltage protection circuits.

The model can be implemented for the use in different software tools for circuit simulation in time-domain. The described modelling approach allows simulating device failure due to ESD or EFT at component and system level considering all components necessary for the immunity simulation of an IC, such as a PCB or external protection elements.

This document demonstrates, in detail, the construction of models in a defined XML-based format which is suitable for the exchange of models without any deeper knowledge of the semiconductor circuit. However, the model functionality can be implemented in different formats including, but not limited to, tables, SPICE[1]¹ netlists, hardware description languages such as VHDL-AMS [2] and Verilog-AMS [3].

This document provides:

- the description of ICIM-CPI macro-model elements representing electrical, thermal or logical behaviour of the IC.
- a universal data exchange format based on XML.

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 61000-4-2, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

¹ Numbers in square brackets refer to the bibliography.