

INTERNATIONAL STANDARD



EMC IC modelling – Part 1: General modelling framework



THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2019 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.

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 It also gives information on projects, replaced and withdrawn publications.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.



IEC 62433-1

Edition 1.0 2019-03

INTERNATIONAL STANDARD



EMC IC modelling – Part 1: General modelling framework

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 31.200

ISBN 978-2-8322-6601-4

Warning! Make sure that you obtained this publication from an authorized distributor.

CONTENTS

FOREWORD.....	5
1 Scope.....	7
2 Normative references	7
3 Terms, definitions, abbreviated terms and conventions.....	7
3.1 Terms and definitions.....	7
3.2 Abbreviated terms.....	10
3.3 Conventions.....	11
4 Definition of models.....	11
4.1 General.....	11
4.2 Conducted emission model	11
4.3 Radiated emission model	11
4.4 Conducted immunity model	12
4.5 Radiated immunity model.....	12
4.6 Conducted pulse immunity model.....	12
5 Modelling approaches.....	12
5.1 General.....	12
5.2 Black box modelling approach.....	13
5.3 Equivalent circuit modelling approach	13
5.4 Other modelling approaches	14
5.4.1 General	14
5.4.2 Electromagnetic modelling approach	14
5.4.3 Statistical modelling approach	14
6 Requirements of model description.....	14
7 Model data exchange format.....	14
7.1 General.....	14
7.2 IC EMCML structure.....	15
7.3 IC EMCML components.....	16
7.3.1 Root element.....	16
7.3.2 Global element	16
7.3.3 Header section	16
7.3.4 Lead element.....	17
7.3.5 Lead_definitions section	17
7.3.6 Macromodels section	17
7.3.7 Frequency section	18
7.3.8 Validity section	19
7.3.9 Pdn section	20
7.3.10 Nlb section	21
7.3.11 lbc section	21
7.3.12 la section.....	21
7.3.13 lb section.....	22
7.3.14 Fb section.....	22
7.3.15 Voltage, Current and Power sections	23
7.3.16 Table section.....	23
7.3.17 Coordinate_system section.....	24
7.3.18 Reference section.....	24
Annex A (normative) Requirements for EMC IC models	25

Annex B (normative) Preliminary definitions for XML representation	26
B.1 XML basics	26
B.1.1 XML declaration.....	26
B.1.2 Basic elements	26
B.1.3 Root element.....	26
B.1.4 Comments	26
B.1.5 Line terminations	27
B.1.6 Element hierarchy.....	27
B.1.7 Element attributes	27
B.2 Keyword requirements	27
B.2.1 General	27
B.2.2 Keyword characters	27
B.2.3 Keyword syntax	28
B.2.4 File structure	28
B.2.5 Values	30
Annex C (normative) IC EMCML valid keywords and usage	32
C.1 Root element keywords.....	32
C.2 Global keywords	33
C.3 File header keywords	33
C.4 <i>Lead</i> keyword attributes	35
C.5 <i>Submodel</i> element attributes.....	36
C.6 <i>Vector</i> element keywords	36
C.7 <i>Lead_definitions</i> section attributes	37
C.7.1 General	37
C.7.2 <i>Lead</i> element attributes	38
C.8 <i>Validity</i> section keywords	38
C.9 <i>Subckt</i> section attributes	38
C.10 <i>Netlist</i> section keywords	39
C.11 <i>Pdn and lbc</i> section keywords.....	39
C.11.1 General	39
C.11.2 <i>Lead</i> element attributes in the <i>Pdn</i> section	40
C.11.3 <i>Lead</i> element attributes in the <i>lbc</i> section.....	42
C.12 <i>la</i> section keywords	44
C.12.1 General	44
C.12.2 <i>Lead</i> element attributes	44
C.12.3 <i>Voltage</i> section keywords	45
C.12.4 <i>Current</i> section keywords	46
C.12.5 <i>Pulse</i> element keywords	48
C.13 <i>lb</i> section keywords	50
C.13.1 <i>Lead</i> element keywords	50
C.13.2 <i>Max_power_level</i> section keywords	51
C.13.3 <i>Voltage</i> section keywords	51
C.13.4 <i>Current</i> section keywords	52
C.13.5 <i>Power</i> section keywords	53
C.13.6 <i>Test_criteria</i> section keywords.....	54
C.14 <i>Nlb</i> section keywords	55
C.15 <i>Fb</i> section keywords	56
C.15.1 <i>Lead</i> element keywords	56
C.15.2 Table element keywords	57

C.15.3 Test_characteristics element attributes	58
Bibliography.....	59
Figure B.1 – Multiple XML files	29
Figure B.2 – XML files with data files (*.dat)	29
Figure B.3 – XML files with additional files.....	30
Figure C.1 – Pulse signal as defined using the Pulse element.....	50
Table 1 – Attributes of <i>Lead</i> keyword in the <i>Lead_definitions</i> section.....	17
Table 2 – General definition of the <i>Subckt</i> attributes	18
Table 3 – Definition of the <i>Validity</i> section	19
Table A.1 – Requirements for model description	25
Table B.1 – Valid logarithmic units	31
Table C.1 – <i>Root</i> element keywords.....	32
Table C.2 – Global keywords	33
Table C.3 – <i>Header</i> element keywords.....	34
Table C.4 – <i>Lead</i> element keywords	35
Table C.5 – <i>Submodel</i> element keywords	36
Table C.6 – <i>Vector</i> element keywords	37
Table C.7 – Valid elements in the <i>Lead_definitions</i> section.....	37
Table C.8 – Attributes of the <i>Lead</i> element in the <i>Lead_definitions</i> section	38
Table C.9 – <i>Validity</i> element keywords.....	38
Table C.10 – <i>Subckt</i> element keywords	39
Table C.11 – <i>Netlist</i> element keywords	39
Table C.12 – <i>Pdn</i> element keywords	40
Table C.13 – Attributes of the <i>Lead</i> element in the <i>Pdn</i> section	41
Table C.14 – Attributes of the <i>Lead</i> element in the <i>Ibc</i> section	43
Table C.15 – Valid keywords in the <i>Ia</i> section.....	44
Table C.16 – Attributes of the <i>Lead</i> element in the <i>Ia</i> section.....	44
Table C.17 – <i>Voltage</i> element keywords	45
Table C.18 – <i>Current</i> element keywords	47
Table C.19 – Attributes of the <i>Pulse</i> element	48
Table C.20 – <i>Lead</i> element keywords in the <i>Ib</i> section.....	50
Table C.21 – <i>Max_power_level</i> section keywords	51
Table C.22 – <i>Voltage</i> section keywords	52
Table C.23 – <i>Current</i> section keywords.....	53
Table C.24 – <i>Power</i> section keywords.....	54
Table C.25 – <i>Test_criteria</i> section keywords	55
Table C.26 – <i>Lead</i> element keywords in the <i>Nlb</i> section	55
Table C.27 – <i>Lead</i> element keywords in the <i>Fb</i> section.....	56
Table C.28 – <i>Table</i> element keywords in the <i>Fb</i> section.....	57
Table C.29 – <i>Test_characteristics</i> element keywords in the <i>Fb</i> section	58

INTERNATIONAL ELECTROTECHNICAL COMMISSION

EMC IC MODELLING –**Part 1: General modelling framework**

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.

International Standard IEC 62433-1 has been prepared by subcommittee 47A: Integrated circuits, of IEC technical committee 47: Semiconductor devices.

IEC 62433-1 cancels and replaces IEC TS 62433-1 published in 2011. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to IEC TS 62433 1:2011:

Incorporation of a data exchange format for an integrated circuit's model representation.

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

CDV	Report on voting
47A/1042/CDV	47A/1055/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 of the IEC 62433 series, 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 1: General modelling framework

1 Scope

This part of IEC 62433 specifies the framework and methodology for EMC IC macro-modelling. Terms that are commonly used in IEC 62433 (all parts), different modelling approaches, requirements and data-exchange format for each model category that is standardized in this series are defined in this document.

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 62433 (all parts), *EMC IC modelling*

ISO 8879, *Information processing – Text and office systems – Standard Generalized Markup Language (SGML)*

ANSI INCITS 4:1986, *Information Systems – Coded Character Sets – 7-Bit American National Standard Code for Information Interchange (7-Bit ASCII)*

3 Terms, definitions, abbreviated terms and conventions

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions 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>

3.1.1

ICEM-CE

Integrated Circuit Emission Model – Conducted Emissions
macro-model of an integrated circuit (IC) to simulate the conducted electromagnetic emissions

Note 1 to entry: An ICEM-CE macro-model can be used for modelling an IC-die, a functional block and an Intellectual Property (IP) block.

3.1.2

ICEM-RE

Integrated Circuit Emission Model – Radiated Emissions
macro-model of an integrated circuit (IC) to simulate the radiated electromagnetic emissions

3.1.3**ICIM-CI**

Integrated Circuit Immunity Model – Conducted Immunity
macro-model of an integrated circuit (IC) to simulate the susceptibility levels of the IC to conducted disturbances applied on the IC pins

3.1.4**ICIM-RI**

Integrated Circuit Immunity Model – Radiated Immunity
macro-model of an integrated circuit (IC) to simulate the susceptibility levels of the IC to external radiated disturbances

3.1.5**ICIM-CPI**

Integrated Circuit Immunity Model – Conducted Pulse Immunity
macro-model of an integrated circuit (IC) to simulate the susceptibility levels of the IC to conducted pulse disturbances applied on the IC pins

3.1.6**IA**

Internal Activity
component of an IC model represented by a current or voltage source, which originates in activity of active devices in an IC or in a portion of the IC

Note 1 to entry: The component is applicable for both analogue and digital circuitry.

3.1.7**IB**

Immunity Behaviour
block that describes the internal immunity behaviour of the IC

3.1.8**FB**

Failure Behaviour
block that describes the internal failure behaviour of the IC

3.1.9**PDN**

Passive Distribution Network
component of an IC model that represents the characteristics of propagation path of electromagnetic noises such as power distribution network

Note 1 to entry: The propagation path can be represented either as an electrical network or as an equivalent network of electromagnetic sources such as electric and magnetic dipoles.

3.1.10**NLB**

Non-Linear Block
component of the IC model that represents the non-linear characteristics of the propagation path of the electromagnetic noises such as power distribution network

EXAMPLE ESD diodes, clamping diodes, back-to-back diodes.

3.1.11**IBC**

Inter-Block Coupling
network of passive elements that presents a coupling effect between circuit blocks within an IC

3.1.12**DI**

Disturbance Input

input terminal for the injection of RF and transient disturbances

Note 1 to entry: It could be any pin of IC, an input, supply or an output.

3.1.13**DO**

Disturbance Output

terminal whose load influences the impedance of DI terminal, and/or the transfer characteristics of PDN, and that outputs a part of the disturbance received on the DI terminals

3.1.14**OO**

Observable Output

output terminal where the immunity criteria are monitored during the test

3.1.15**section**

XML element placed one level below the root element or within another section and that contains one or more XML elements, but no value

3.1.16**parent**

keyword which is one level above another keyword

3.1.17**child**

keyword which is one level below another keyword

3.1.18**parser**

tool for syntactic analysis of data that is encoded in a specified format

3.1.19**S-parameter**

scattering parameter

S_{ij}

element of the S-matrix expressing the transmission and reflection coefficients of a device

Note 1 to entry: As most commonly used, each S-parameter relates the complex electric field strength of a reflected or transmitted wave to that of an incident wave; the subscripts of a typical S-parameter S_{ij} refer to the output and input ports related by the S-parameter, which may vary with frequency.

[SOURCE: CISPR 17:2011, 3.1.13, modified – The example has been removed.]

3.1.20**IC EMCML**

Integrated Circuit ElectroMagnetic Compatibility Markup Language

data exchange format for EMC IC model description

3.1.21**CAML**

Conducted Emissions Markup Language

data exchange format for conducted emissions macro-model

3.1.22**REML**

Radiated Emissions Markup Language

data exchange format for radiated emissions macro-model

3.1.23**CIML**

Conducted Immunity Markup Language

data exchange format for conducted immunity macro-model

3.1.24**RIML**

Radiated Immunity Markup Language

data exchange format for radiated immunity emissions macro-model

3.1.25**CPIML**

Conducted Pulse Immunity Markup Language

data exchange format for conducted pulse immunity macro-model

3.1.26**CEMLBase**

Conducted Emissions Markup Language Base

abstract type from which all CEML model components are directly or indirectly derived in the conducted emissions macro-model definition

3.1.27**REMLBase**

Radiated Emissions Markup Language Base

abstract type from which all REML model components are directly or indirectly derived in the radiated emissions macro-model definition

3.1.28**CIMLBase**

Conducted Immunity Markup Language Base

abstract type from which all CIML model components are directly or indirectly derived in the conducted immunity macro-model definition

3.1.29**RIMLBase**

Radiated Immunity Markup Language Base

abstract type from which all RIML model components are directly or indirectly derived in the radiated immunity macro-model definition

3.1.30**CPIMLBase**

Conducted Pulse Immunity Markup Language Base

abstract type from which all CPIML model components are directly or indirectly derived in the conducted pulse immunity macro-model definition

3.2 Abbreviated terms**3.2.1****XML**

eXtensible Markup Language

markup language that defines a set of rules for encoding data or files in a format that is both human-readable and machine-readable

3.2.2 SPICE

Simulation Program with Integrated Circuit Emphasis
general purpose analogue and mixed signal circuit simulator

3.3 Conventions

For the sake of clarity, but with some exceptions, the writing conventions of XML have been used within the text and tables. The following print types are used throughout this standard:

- XML keywords are defined in *Italics*
- The symbol "μ" is used in the text part to define micro = 1e-6. The symbol "u" is used in the XML parts to define the micro = 1e-6.

4 Definition of models

4.1 General

Different categories of EMC IC models are defined in IEC 62433 (all parts). IC models that are built in conformity with these guidelines can be applied to simulations for EMC. The models can be used for EMI (Electromagnetic Interference) and/or EMS (Electromagnetic Susceptibility) evaluation of electronic systems.

Each model is presented in a separate part of the IEC 62433 series and classified in one of the following categories (see 4.2 to 4.6 included).

4.2 Conducted emission model

A conducted emission (CE) model is a macro-model which describes an Integrated Circuit (IC) or multiple dies in a package or module (System in Package, SiP) as a source of conducted RF disturbances.

A CE model shall be described as a multi-terminal or a multi-port circuit which can be linear or nonlinear. Each CE model consists of internal activities (IAs) as noise sources and passive distribution networks (PDNs) which express characteristics of internal circuits in the form of a black box and/or an equivalent circuit. The model can also include sub-models of inter-block coupling (IBC).

The model describes RF disturbances at external terminals of an IC as voltage and/or current which are generated by its internal operations.

The model is described in CEML format.

4.3 Radiated emission model

A radiated emission (RE) model is a macro-model which describes radiated RF disturbances generated by an integrated circuit (IC) or multiple dies in a package or module (System in Package, SiP).

A RE model shall be described as equivalent sources of electric or magnetic fields, which cause near-field coupling or far-field radiation, or an equivalent circuit which express electric or magnetic coupling between the IC or dies and external circuits or enclosures. Each RE model consists of internal activities (IAs) as noise sources and passive distribution network (PDNs) that define the radiating elements (as equivalent antennas) of the internal circuits in the form of a black box.

The model is described in REML format.