IEC 62433-4

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INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

EMC IC modelling – Part 4: Models of integrated circuits for RF immunity behavioural simulation – Conducted immunity modelling (ICIM-CI)

Modèles de circuits intégrés pour la CEM – Partie 4: Modèles de circuits intégrés pour la simulation du comportement d'immunité aux radiofréquences – Modélisation de l'immunité conduite (ICIM-CI)

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EMC IC MODELLING –

Part 4: Models of integrated circuits for RF immunity behavioural simulation – Conducted immunity modelling (ICIM-CI)

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The text of this standard is based on the following documents:

FDIS	Report on voting
47A/988/FDIS	47A/989/RVD

Full information on the voting for the approval of this standard can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

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EMC IC MODELLING –

Part 4: Models of integrated circuits for RF immunity behavioural simulation – Conducted immunity modelling (ICIM-CI)

1 Scope

This part of IEC 62433 specifies a flow for deriving a macro-model to allow the simulation of the conducted immunity levels of an integrated circuit (IC). This model is commonly called Integrated Circuit Immunity Model – Conducted Immunity, ICIM-CI. It is intended to be used for predicting the levels of immunity to conducted RF disturbances applied on IC pins.

In order to evaluate the immunity threshold of an electronic device, this macro-model will be inserted in an electrical circuit simulation tool.

This macro-model can be used to model both analogue and digital ICs (input/output, digital core and supply). This macro-model does not take into account the non-linear effects of the IC.

The added value of ICIM-CI is that it could also be used for immunity prediction at board and system level through simulations.

This part of IEC 62433 has two main parts:

- the electrical description of ICIM-CI macro-model elements;
- a universal data exchange format called CIML based on XML. This format allows ICIM-CI to be encoded in a more useable and generic form for immunity simulation.

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 62132-1, *Integrated circuits – Measurement of electromagnetic immunity – Part 1: General conditions and definitions*

IEC 62132-4, *Integrated circuits – Measurement of electromagnetic immunity 150 kHz to 1 GHz – Part 4: Direct RF power injection method*

IEC 62433-2, *EMC IC modelling – Part 2: Models of integrated circuits for EMI behavioural simulation – Conducted emissions modelling (ICEM-CE)*

ISO 8879: 1986, *Information processing – Text and office systems – Standard Generalized Markup Language (SGML)*

ISO/IEC 646: 1991, *Information technology – ISO 7-bit coded character set for information interchange (7-Bit ASCII)*

CISPR 17, *Methods of measurement of the suppression characteristics of passive EMC filtering devices*

3 Terms, definitions, abbreviations and conventions

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1
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

3.1.2
parent
keyword which is one level above another keyword

3.1.3
child
keyword which is one level below another keyword

3.1.4
external terminal
terminal of an integrated circuit macro-model which interfaces the model to the external environment of the integrated circuit

EXAMPLE Power supply pins and input/output pins.

Note 1 to entry: In this part of IEC 62433, a terminal is by default considered as external unless otherwise stated.

[SOURCE: IEC 62433-2:2008, 3.1, modified – Note 1 to entry has been changed, Example has been added]

3.1.5
internal terminal
terminal of an integrated circuit macro-model's component which interfaces the component to other components of the integrated circuit macro-model

[SOURCE: IEC 62433-2:2008, 3.2]

3.1.6
parser
tool for syntactic analysis of data that is encoded in a specified format

3.1.7
CIML
Conducted Immunity Markup Language
data exchange format for ICIM-CI model

3.1.8
CIMLBase
Conducted Immunity Markup Language Base
abstract type from which all CIML model components are directly or indirectly derived in the ICIM-CI model definition

3.1.9
DI
Disturbance Input
input terminal for the injection of RF disturbances

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

3.1.10
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

3.1.11
OO
Observable Output
output terminal where the immunity criteria are monitored during the test

3.1.12
GND
Ground terminal
terminal that is used as reference for return path

3.1.13
PDN
Passive Distribution Network
block that describes the impedance network of one or more ports of the integrated circuit

3.1.14
IB
Immunity Behaviour
block that describes the internal immunity behaviour of the IC

3.1.15
IBC
Inter Block Coupling
block that describes the coupling network between different PDN blocks within an IC

[SOURCE: IEC TS 62433-1:2011, 3.3]

3.1.16
VNA
Vector Network Analyzer
instrument to measure complex network parameters such as S-, Y- or Z- parameters in the frequency domain

3.1.17
RFIP
Radio Frequency Injection Probe
probe for injecting RF disturbances into a pin of an IC allowing measurement of voltage and current

3.2 Abbreviations

CIM	Conducted Immunity Model
XML	eXtensible Markup Language
SPICE	Simulation Program with Integrated Circuit Emphasis
ESD	ElectroStatic Discharge

3.3 Conventions

For the sake of clarity, but with some exceptions, the writing conventions of XML have been used in text and tables.

4 Philosophy

Integrated circuits contain more and more gates, the integration density of technologies is increasing and supply voltages are becoming lower. The reduction of distance between on-chip signals, die geometry size reduction and the increase of unwanted currents in parasitic structures, such as isolation capacitances, leads to increased internal crosstalk. Consequently, the immunity of integrated circuits is becoming more and more critical.

Due to this increased risk of lower IC immunity, the use of models and simulation tools is required to optimize the immunity behaviour of both the IC and the application.

This part of IEC 62433 describes such macro-models for simulating immunity behaviour at the IC level. The model, called ICIM-CI, will be used to predict electromagnetic immunity at the application level. This model is based on files describing the PDN and the IB containing data on electromagnetic disturbances leading to a variation of one or more observable signals. The PDN is considered to be linear, while the inherent non-linearity of the IC is taken into account in the IB. This assumption is shown in 8.2 (see Figure 25). Users of the model should apply a failure criterion to the observable signal depending on their requirements.

ICIM-CI model data is arranged in a decipherable nested manner using XML format. The objective of this exchange format, called Conducted Immunity Markup Language (CIML), is to create simple and practical universal access to the ICIM-CI model. The preliminary definitions for XML representation are given in Annex A.

5 ICIM-CI model description

5.1 General

The internal structure of an IC can be broken down into two parts:

a) Passive parts (parasitic elements of pins, bondings and tracks, ESD protection), which conduct the disturbances from the external environment to the internal IC blocks,

b) Active parts (CPU core, clock system, memory, analogue blocks). It is these active internal blocks which are sensitive to the incoming disturbances.

The ICIM-CI model consists of a set of data describing these two parts:

- PDN: the Passive Distribution Network is a multi-port circuit. It is composed of four different terminals:
  - DI: Terminals to which disturbances are applied,
  - DO: Terminals that can influence the impedance of the DI terminals and consequently receive a part of the disturbance applied on the DI terminals,
  - GND: PDN shall have one or more ground terminals (such as digital ground, analogue ground),
  - Internal terminals: Terminals that can influence the impedance of the DI terminals and are internal to the IC (at chip-level).
- IB: The Immunity Behaviour component that describes how the IC reacts to the applied disturbances (referenced to one ground terminal of the PDN). The immunity criterion is set on terminals that are called Observable Output (OO). These OO could be associated or not to the various DI, depending on the configuration of the IC.

NOTE 1 DI, DO, OO and GND terminals are external terminals and are interfaced at pin level. These pins connect to the external environment of the IC.

NOTE 2 OO terminals link the PDN to the IB. Though these terminals are external on the IC and are used to obtain the IB by monitoring the immunity criterion, they are virtually represented (internally) on the PDN of the ICIM-CI macro-model.

Figure 1 represents an example of ICIM-CI model structure.

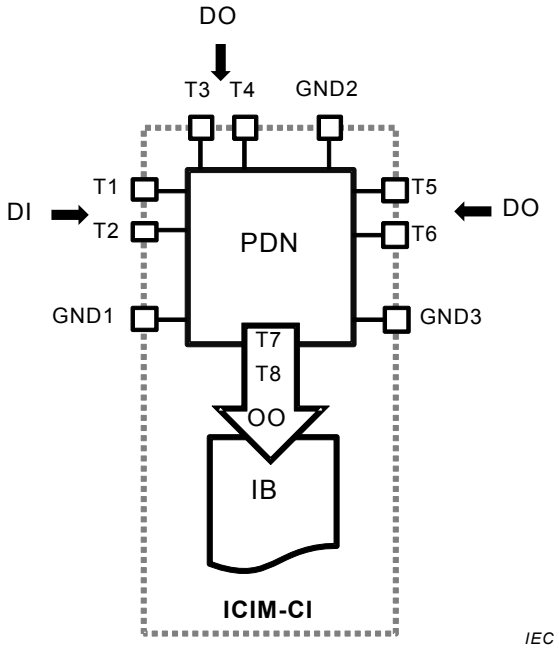

Figure 1 – Example of ICIM-CI model structure

There is no direct electrical connection between the PDN block and IB block. The PDN represents the input impedance of the DI. The power entering the DI is calculated by simulation based on the PDN and the external environment. IB links the power entering the DI to an immunity criterion monitored at OO. The IB is obtained by an immunity measurement of the IC, by means of monitoring the OO terminal.

Depending on the IC's operating conditions and stability, DO terminals may be present. One such example is illustrated in Annex B.

Different ICIM-CI models can be combined to model and describe a full electronic system such as an electronic board. That proposed structure can also be used to model an item of equipment. The DO terminal of one ICIM-CI model can be used to connect with the different terminals of neighbouring ICIM-CI blocks

Figure 2 gives an example of a complete ICIM-CI model of an electronic board. The board is fully described by three stand-alone ICIM-CI models. T12 and T21 are connected together and they receive the same disturbance. The ICIM-CI_1 propagates a fraction of its disturbance to the ICIM-CI_3 model through its T14 (DO) terminal, which is connected to the T31 (DI) terminal of the ICIM-CI_3 model.