IEC 62433-2

Edition 1.0 2008-10

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

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

Modèles de circuits intégrés pour la CEM –
Partie 2: Modèles de circuits intégrés pour la simulation du comportement lors de perturbations électromagnétiques – Modélisation des émissions conduites (ICEM-CE)

IEC 62433-2:2008

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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

PRICE CODE
CODE PRIX
X

ICS 31.200

ISBN 978-2-83220-593-8

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

EMC IC MODELLING –

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FOREWORD

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International Standard IEC 62433-2 has been prepared by subcommittee 47A: Integrated circuits, of IEC technical committee 47: Semiconductor devices.

This bilingual version (2013-01) corresponds to the monolingual English version, published in 2008-10.

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

FDIS	Report on voting
47A/794/FDIS	47A/799/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.

The French version of this standard has not been voted upon.

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

A list of all the parts in 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 publication will remain unchanged until the maintenance result 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

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- withdrawn,
- replaced by a revised edition, or
- amended.

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EMC IC MODELLING –

Part 2: Models of integrated circuits for EMI behavioural simulation – Conducted emissions modelling (ICEM-CE)

1 Scope

This part of IEC 62433 specifies macro-models for ICs to simulate conducted electromagnetic emissions on a printed circuit board. The model is commonly called Integrated Circuit Emission Model - Conducted Emission (ICEM-CE).

The ICEM-CE model can also be used for modelling an IC-die, a functional block and an Intellectual Property block (IP).

The ICEM-CE model can be used to model both digital and analogue ICs.

Basically, conducted emissions have two origins:

- conducted emissions through power supply terminals and ground reference structures;
- conducted emissions through input/output (I/O) terminals.

The ICEM-CE model addresses those two types of origins in a single approach.

This standard defines structures and components of the macro-model for EMI simulation taking into account the IC's internal activities.

This standard gives general data, which can be implemented in different formats or languages such as IBIS, IMIC, SPICE, VHDL-AMS and Verilog. SPICE is however chosen as default simulation environment to cover all the conducted emissions.

This standard also specifies requirements for information that shall be incorporated in each ICEM-CE model or component part of the model for model circulation, but description syntax is not within the scope of this standard.

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 61967 (all parts), *Integrated Circuits – Measurement of electromagnetic emissions, 150 KHz to 1 GHz*

IEC 61967-4, *Integrated circuits – Measurement of electromagnetic emissions, 150 kHz to 1 GHz – Part 4: Measurement of conducted emissions – 1 Ω/150 Ω direct coupling method*

3 Terms and definitions

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

3.1
external terminal
terminal of an IC macro-model, which interfaces the model to the external environment of the IC, such as power supply pins and I/O pins

NOTE In this document, the name of each external terminal starts with "ET".

3.2
internal terminal
terminal of an IC macro-model's component, which interfaces the component to other components of the IC macro-model

NOTE In this document, the name of each internal terminal starts with "IT".

4 Philosophy

4.1 General

Integrated circuits will have more and more gates on silicon and technical progress will develop faster. To predict the electromagnetic behaviour of equipment, it is required to model the switching of the input and output interface and the internal activities of an integrated circuit effectively.

Figure 1 depicts an example of decomposition of an IC to enable conducted emissions analysis. The internal digital activity (culprit) is a source of electromagnetic noise that originates in switching of active devices. The coupling path propagates the emissions to the IC's external terminals: pins/pads. The coupling path is the power distribution network or I/O lines inside the IC.

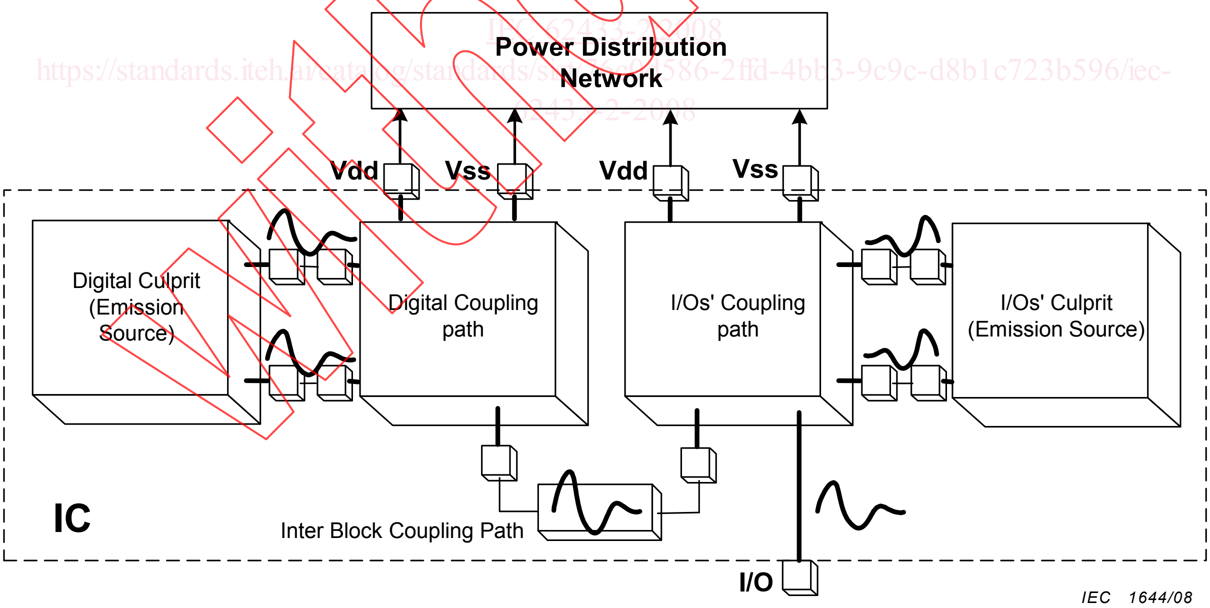


Figure 1 – Decomposition example of a digital IC for conducted emissions analysis

4.2 Conducted emission from core activity (digital culprit)

The current transients are created in the core area on the IC-die. Due to the characteristics of the digital coupling paths, the passive distribution network on printed circuit board (PCB) and the availability of on-chip decoupling, a portion of these current transients will occur at the power supply pins of the IC.

NOTE These off-chip power supply currents can be measured according to the IEC 61967 series.

4.3 Conducted emission from I/O activity

I/Os activities may create voltage fluctuations of power and ground levels, and conducted emissions appear at power and ground pins through the I/Os' coupling path. And the output signals at output pins themselves are sources of conducted emissions to the printed circuit boards.

NOTE The measurement set-up is done according to the IEC 61967 series.

5 Basic components

5.1 General

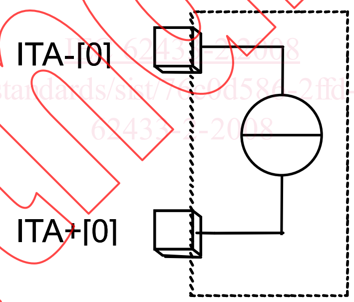
The basic components are component parts of the IC macro-model or block component or sub-model component. The following subclauses define the basic components.

NOTE The block component and the sub-model component are defined in 6.3.1 and 6.4.1 respectively.

5.2 Internal Activity (IA)

The Internal Activity (IA) component is the electromagnetic noise source that originates in switching of active devices in the IC or in a portion of the IC. This component is applicable for both analogue and digital circuitry.

The IA is described using an independent current source or an independent voltage source with two internal terminals as shown in Figure 2.



IEC 1645/08

Figure 2 – IA component

The characteristics of IA component are typically described in the time domain, and the characteristics can also be described in the frequency domain.

The description of an IA component shall contain the following information.

- Name of the IA component
- Names of its internal terminals
- Operational mode or test vector
- Domain (time or frequency)
- Definition of origin of time, and cycle-time for the operational mode (for time domain)
- Definition of origin of phase (for frequency domain)
- Operational conditions and applicable ranges
  a) Power supply voltage ranges
  b) Temperature range

c) Frequency range

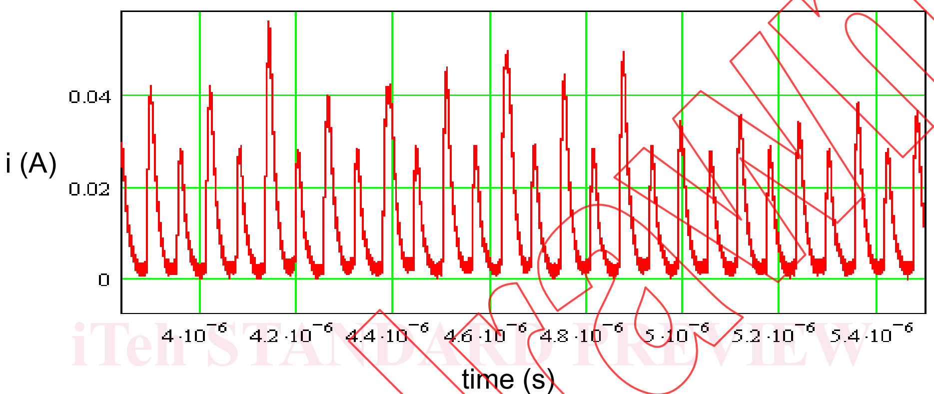
- Characteristics of the IA

a) Current or voltage waveform over the whole cycle-time (for time domain)

b) Current or voltage amplitude and phase, versus frequency over the whole frequency range (for frequency domain)

EXAMPLE 1

Figure 3 shows an example of characteristics of IA in the time domain. The waveform depends on the specific operational mode of function. A simple waveform such as a triangular waveform can be used for the component description.

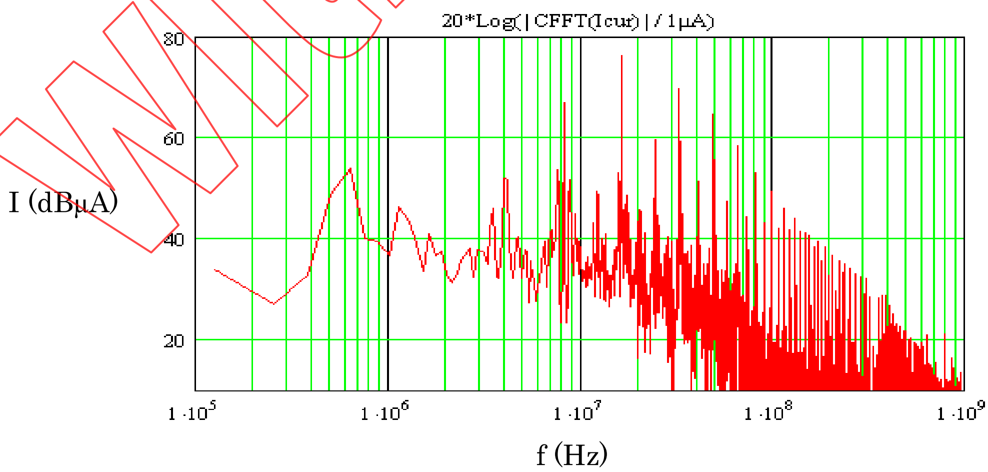


IEC 1646/08

Figure 3 – Example of IA characteristics in the time domain

EXAMPLE 2

Figure 4 shows an example of characteristics of IA in the frequency domain.



IEC 1647/08

Figure 4 – Example of IA characteristics in the frequency domain

5.3 Passive Distribution Network (PDN)

The Passive Distribution Network component (PDN) presents the characteristics of propagation path of electromagnetic noises such as power distribution network (part of the PDN). The PDN can be linear or non-linear.

The PDN consists of passive elements, and is equipped with internal terminals. And the PDN can have external terminals.

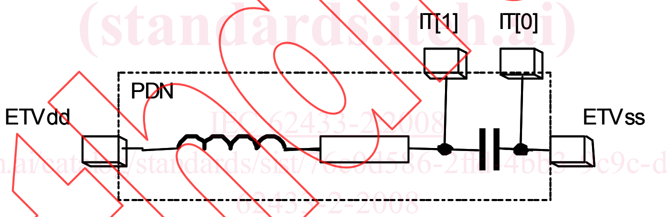
The PDN can be described using a netlist. In the case the PDN can be assumed to be linear, some matrix formats such as the S-parameter can also present the PDN characteristics.

The description of a PDN component shall contain the following information.

- Name of the PDN component
- Names of its internal terminals and external terminals
- Applicable ranges
  a) Power supply voltage range
  b) Temperature range
  c) Applicable load conditions if the PDN is for output
  d) Applicable frequency range
- Characteristics of the PDN

EXAMPLE 1

Figure 5 shows an example of a four-terminal PDN using lumped elements. The ETVdd and ETVss are two external terminals of the PDN. The IT[1] and the IT[0] are two internal terminals.

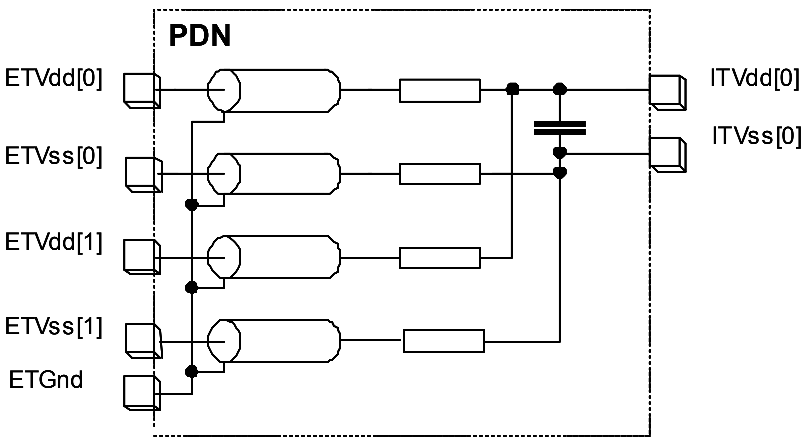


IEC 1648/08

Figure 5 – Example of a four-terminal PDN using lumped elements

EXAMPLE 2

Figure 6 depicts the seven-terminal PDN structure using distributed elements such as transmission lines. The ETVxx are the four external terminals, the ITVxx are two internal terminals and the ETGnd is the common ground of the four transmission lines, connected to the PCB ground.



IEC 1649/08

Figure 6 – Example of a seven-terminal PDN using distributed elements

EXAMPLE 3

Figure 7 shows an example of a twelve-terminal PDN using scattering parameters in a matrix format (black box). The ET[x] are external terminals. The IT[1] to IT[6] are internal terminals. A ground plane below the modelled IC is taken as an ideal reference ground for these terminals.

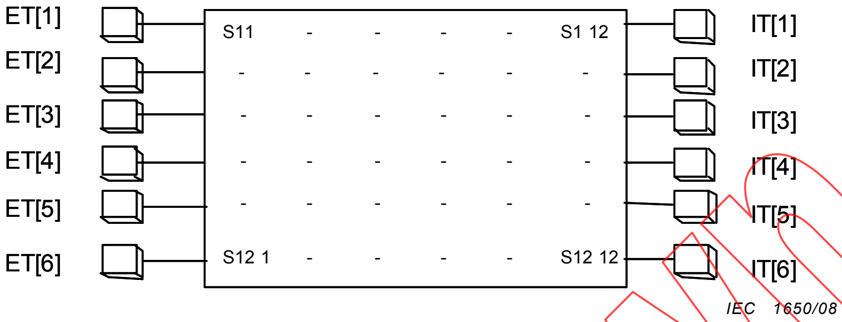


Figure 7 – Example of a twelve-terminal PDN using matrix representation

6 IC macro-models

6.1 General

An IC is modelled as an IC macro-model. Three types of IC macro-models, general model, block-based model and sub-model-based model, are possible. These IC macro-models are defined in this subclause.

The description of an IC macro-model shall contain the following information for model circulation.

- Name of the IC macro-model
- Type of the model, general model or block-based model or sub-model-based model
- Names of components that are included in the IC macro-model
- Names of its external terminals
- Connections of the internal terminals of its components

6.2 General IC macro-model

The general model consists of a single PDN and one or more IAs as shown in Figure 8. The PDN shall include both the whole PDN on the IC die(s) and the whole PDN of the package. An on-chip decoupling capacitor shall also be included in the PDN if it exists.

NOTE This structure is suitable for the model circulation to IC users because of the least disclosure of proprietary information of the IC vendor.

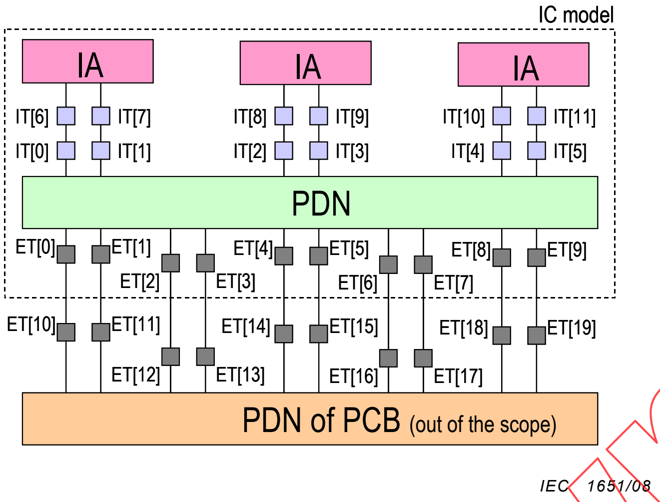


Figure 8 – General IC macro-model

6.3 Block-based IC macro-model

6.3.1 Block component

The block component represents EMC properties of a specific functional block of IC such as embedded memory.

The block component consists of a single PDN and one or more IAs. The PDN includes PDN of the specific functional block, a portion of global power/ground network and a portion of package PDN, which are directly involved into the block's functionality. The on-chip decoupling capacitor is a part of the PDN. The component is equipped with external terminals and internal terminals.

The description of a block component shall include the following information.

- Name of the block component
- Names of the basic components that make up the block component
- Connections of the internal terminals of its basic components

EXAMPLE 1

Figure 9 shows an example of block component. The block consists of an IA and a PDN. The internal terminals of the IA are connected to the internal terminals of the PDN.

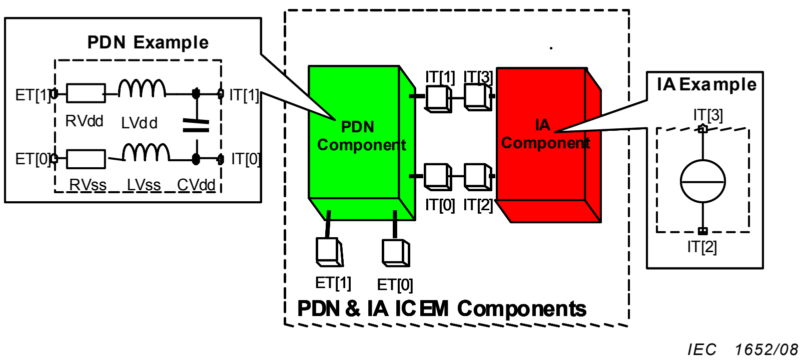


Figure 9 – Example of block component