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TECHNICAL SPECIFICATION

SPÉCIFICATION TECHNIQUE

EMC IC modelling – Part 1: General modelling framework

Modèles de circuits intégrés pour la CEM – Partie 1: Cadre de modèle général

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CONTENTS

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EMC IC MODELLING –

Part 1: General modelling framework

FOREWORD

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Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC 62433-1, which is a technical specification, has been prepared by subcommittee 47A: Integrated circuits, of IEC technical committee 47: Semiconductor devices.

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

Enquiry draft	Report on voting
47A/840/DTS	47A/850A/RVC

Full information on the voting for the approval of this technical specification 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.

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 publication 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

- transformed into an International standard,
- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

INTRODUCTION

The International Standards of IEC 62433 series provide specifications for EMC IC modelling. EMC IC model is the model of integrated circuits for electro-magnetic compatibility.

IC models that are built in conformity with these International Standards can be applied to simulations for EMC and/or evaluations of EMI (electro-magnetic interference) as well as EMS (electro-magnetic susceptibility) of electronic systems.

EMC IC MODELLING –

Part 1: General modelling framework

1 Scope

This part of the IEC 62433 series provides specifications for model-categories of EMC IC modelling, definitions of terms that are commonly used in IEC 62433 series, modelling approaches that can be used, and requirements for each modelling that is standardized in this series.

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 60050-131, *International Electrotechnical Vocabulary (IEV) – Chapter 131: Circuit theory*

IEC 60050-161, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-131, IEC 60050-161 and the following apply.

3.1
reference node
node of a network where the voltages of other nodes, which belong to the network, are determined by reference to the node

NOTE In many cases the voltage of the reference node is set as zero for descriptive purposes.

3.2
reference terminal
terminal of a circuit block where the voltages of other terminals, which belong to the block, are determined by reference to the terminal

3.3
internal activity
IA
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 IA is applicable for both analogue and digital circuitry.

3.4
passive distribution network
PDN
component of an IC model that represents the characteristics of propagation path of electromagnetic noises such as power distribution network

3.5
inter-block coupling
IBC
network of passive elements that presents a coupling effect between circuit blocks

4 Definition of models

4.1 General

Four EMC IC models presented in IEC 62433 series are defined in 4.2 through 4.5.

These models can be used for

– device-to-device comparison,
– risk assessment for the disturbance among devices involved in multi-chip technology (such as MCM, SiP), and
– evaluation of the coupling between a device and PCB tracks.

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.

The 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 a form of a black box and/or an equivalent circuit. The model can include sub-models of inter-block coupling (IBC) if needed.

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

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).

The 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.

4.4 Conducted immunity model

A conducted immunity (CI) 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 victim of conducted RF disturbances applied from outside.

The CI model shall be described as a multi-terminal or a multi-port circuit in a form of a black box and/or an equivalent circuit which may be linear or nonlinear.

The CI model provides measures or criteria of malfunctions caused by RF disturbances injected at external terminals as voltage, current, or RF power.

4.5 Radiated immunity model

A radiated immunity (RI) 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 victim of radiated RF disturbances from outside.

The RI model is described as equivalent circuits which can express electric or magnetic coupling between the IC or dies and external circuits or enclosures.

The RI model provides measures or criteria of malfunctions caused by RF disturbances applied as electric or magnetic fields in near-field or electromagnetic field.

5 Modelling approaches

5.1 General

Description of an EMC IC model, such as equivalent circuit parameters, can be derived from design data of the device, or extracted from data obtained by measurement. Each of the models shall contain information of an internal integrated circuit (IC) or multiple dies as well as that of a package.

The conducted emission (CE) or conducted immunity (CI) model can be expressed in either a form of a black box model, or an equivalent circuit model. The model shall be expressed with a circuit concept including terminals and/or nodes.

The radiated emission (RE) or radiated immunity (RI) model can be expressed with either an electromagnetic model or an equivalent circuit model. The electromagnetic RE model expresses near field or far field which causes electromagnetic interference (EMI). The electromagnetic RI model expresses electromagnetic coupling induced in the device. The equivalent circuit model for RE/RI describes electric or magnetic coupling with capacitive or inductive circuit elements. The equivalent circuit model for RE/RI may include a black-box model as a sub-model.

The following sub-clauses describe modelling approach for possible expressions of each model. Some of the expressions can be combined and used in one model.

5.2 Black box modelling approach

The expression of a black box model is essentially an N-port circuit, whose characteristics are expressed in a matrix form or with some circuit equations. When a black box model is used to express a CE or RE model, some voltage and/or current sources are connected to the black box as noise sources to express internal activities (IAs). The following matrix expressions are available for black-box models.

For a linear circuit, or a circuit which can be approximated as linear, the following matrices can be used; these matrices are the functions of frequency and time-variant, disregarding non-linear elements.

- impedance (Z) matrix
- admittance (Y) matrix
- fundamental (F) matrix
- scattering (S) matrix

Elements of these matrices can be expressed with formulas with some parameters, or tables which provide frequency characteristics of the circuit.

In the definition of a model, internal terminals/ports and external terminals/ports shall be clearly defined and noted as prerequisite information for the matrices.

Characteristics of a distributed constant circuit, such as transmission lines, can be expressed with a scattering (S) matrix as a multi-port circuit. For these circuits, definition of ports and their locations shall be described with port impedance for each. Particularly when a differential port is used, it is desirable to define a common-mode port as a counterpart of a differential signal port.

5.3 Equivalent circuit modelling approach

Equivalent circuit models, both lumped element circuits and distributed constant circuits, can be used to express electrical characteristics of CE/CI and RE/RI models. In the circuit expression, non-linear circuits can be included as well as linear circuits.

A linear circuit which is described with a black box model, or a matrix model, may be converted to an equivalent circuit model. Particularly when a model is constructed by measurement, characteristics of the circuit are first expressed in a matrix form, and then converted to an equivalent circuit.

Some of non-linear characteristics of a device can be obtained by measurement, and can be included in an equivalent circuit model. Additionally, model simplification is possible using a complex circuit model and generating information of the circuit by simulation.

In the description of a model which can be determined by measurement or simulation, the method of model parameter extraction shall be described in each part of this series of standard. An equivalent circuit model of a particular device shall contain all the information of the circuit structure, values of circuit parameters, and its applicable conditions.

5.4 Other modelling approaches

Other modelling approaches are possible to obtain an EMC IC macro-model. The followings are possible approaches.

5.4.1 Electromagnetic modelling approach

Distribution of sources of electromagnetic fields can be used as a radiated emission (RE) model. Possible sources are as follows.

- Electric current distribution
- (Virtual) magnetic current distribution
- Electric charge distribution
- Electrical and/or magnetic scalar and/or vector potentials
- (To be defined)

5.4.2 Statistical modelling approach

Some of the electromagnetic interferences in digital systems are evaluated statistically. Particularly, performance degradation of wireless digital communication systems has strong correlation to statistical characteristics of radiated emission. A statistical model such as below is one possible model.

- amplitude probability distribution (APD).

6 Requirements of model description

It is necessary to provide the following information with IC model (see Annex A).