TECHNICAL REPORT

CISPR 16-4-1

First edition
2003-11

INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

Specification for radio disturbance and immunity measuring apparatus and methods –

Part 4-1: Uncertainties, statistics and limit modelling – Uncertainties in standardized EMC tests

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International Electrotechnical Commission, 3, rue de Varembé, PO Box 131, CH-1211 Geneva 20, Switzerland
Telephone: +41 22 919 02 11 Telefax: +41 22 919 03 00 E-mail: inmail@iec.ch Web: www.iec.ch

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FOREWORD

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The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

CISPR 16-4-1, which is a technical report, has been prepared by CISPR subcommittee A: Radio interference measurements and statistical methods.

This first edition of CISPR 16-4-1, together with CISPR 16-4-3, CISPR 16-4-4 and the second edition of CISPR 16-3, cancels and replaces the first edition of CISPR 16-3, published in 2000, and its amendment 1 (2002). It contains the relevant clauses of CISPR 16-3 without technical changes.

The text of this technical report is based on the first edition of CISPR 16-3 and on the following documents:

Enquiry draft	Report on voting
CISPR/A/450/DTR	CISPR/A/466/RVC

Full information on the voting for the approval of this technical report 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 bilingual version of this publication may be issued at a later date.

The committee has decided that the contents of this publication will remain unchanged until 2004. At this date, the publication will be

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- withdrawn;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

INTRODUCTION

CISPR 16-1, CISPR 16-2, CISPR 16-3 and CISPR 16-4 have been reorganised into 14 parts, to accommodate growth and easier maintenance. The new parts have also been renumbered. See the list given below.

Old CISPR 16 publications		New CISPR 16 publications	
CISPR 16-1	Radio disturbance and immunity measuring apparatus	CISPR 16-1-1	Measuring apparatus
		CISPR 16-1-2	Ancillary equipment – Conducted disturbances
		CISPR 16-1-3	Ancillary equipment – Disturbance power
		CISPR 16-1-4	Ancillary equipment – Radiated disturbances
		CISPR 16-1-5	Antenna calibration test sites for 30 MHz to 1 000 MHz
CISPR 16-2	Methods of measurement of disturbances and immunity	CISPR 16-2-1	Conducted disturbance measurements
		CISPR 16-2-2	Measurement of disturbance power
		CISPR 16-2-3	Radiated disturbance measurements
		CISPR 16-2-4	Immunity measurements
CISPR 16-3	Reports and recommendations of CISPR	CISPR 16-3	CISPR technical reports
		CISPR 16-4-1	Uncertainties in standardised EMC tests
		CISPR 16-4-3	Statistical considerations in the determination of EMC compliance of mass-produced products
		CISPR 16-4-4	Statistics of complaints and a model for the calculation of limits
CISPR 16-4	Uncertainty in EMC measurements	CISPR 16-4-2	Measurement instrumentation uncertainty

More specific information on the relation between the 'old' CISPR 16-3 and the present 'new' CISPR 16-4-1 is given in the table after this introduction (TABLE RECAPITULATING CROSS REFERENCES).

Measurement instrumentation specifications are given in five new parts of CISPR 16-1, while the methods of measurement are covered now in four new parts of CISPR 16-2. Various reports with further information and background on CISPR and radio disturbances in general are given in CISPR 16-3. CISPR 16-4 contains information related to uncertainties, statistics and limit modelling.

CISPR 16-4 consists of the following parts, under the general title *Specification for radio disturbance and immunity measuring apparatus and methods - Uncertainties, statistics and limit modelling:*

- Part 4-1: Uncertainties in standardised EMC tests,
- Part 4-2: Uncertainty in EMC measurements,
- Part 4-3: Statistical considerations in the determination of EMC compliance of mass-produced products,
- Part 4-4: Statistics of complaints and a model for the calculation of limits.

For practical reasons, standardised EMC tests are drastic simplifications of all possible EMI scenarios that a product may encounter in practice. Consequently, in an EMC standard the measurand, the limit, measurement instruments, set-up, measurement procedure and measurement conditions shall be simplified but still meaningful. Meaningful means that there is a statistical correlation between compliance of the product with a standardized EMC test and a high probability of actual EMC of the same product during its life cycle. Part 4-4 provides statistical based methods to derive meaningful disturbance limits to protect the radio services.

In general, a standardized EMC test must be developed such that reproducible results are obtained if different parties perform the same test with the same product. However, various uncertainty sources and influence quantities cause that the reproducibility of a standardized EMC test is limited. Part 4-1 consists of a collection of informative reports that deal with all relevant uncertainty sources that may be encountered during EMC compliance tests. Typical examples of uncertainty sources are the product itself, the measurement instrumentation, the set-up of the product, the test procedures and the environmental conditions.

Part 4-2, deals with a limited and specific category of uncertainties (i.e. the measurement instrumentation uncertainties). In Part 4-2, examples of measurement instrumentation uncertainty budgets are given for most of the CISPR test methods. In this part also requirements are given on how to incorporate the measurement instrumentation uncertainty in the compliance criterion.

If a compliance test is performed using different samples of the same product, then the spread of the EMC performance of the product samples shall be incorporated also in the compliance criterion. Part 4-3 deals with the statistical treatment of test results in case compliance test are performed using samples of mass-produced products. This treatment is well known as the 80 %-80 % rule.

Many important decisions are based on the results of EMC tests. The results are used, for example, to judge compliance against specifications or statutory requirements. Whenever decisions are based on EMC tests, it is important to have some indication of the quality of the results, that is, the extent to which they can be relied on for the purpose in hand. Confidence in test results obtained outside the user's own organisation is a prerequisite to meeting this objective. In the sector of EMC it is often times a formal (frequently legislative) requirement for test laboratories to introduce quality assurance measures to ensure that they are capable of and are providing results of the required quality. Such measures include: the valid use of standardized test methods; the use of defined internal quality control procedures; participation in proficiency testing schemes; accreditation to ISO 17025; and establishing traceability of the results of the tests.

As a consequence of these requirements, EMC test laboratories are, for their part, coming under increasing pressure to demonstrate the quality of their test results. This includes the degree to which a test result would be expected to agree with other test results (reproducibility using the same test method), normally irrespective of the methods used (reproducibility using alternative test methods). A useful means to demonstrate the quality of standardized EMC tests is the evaluation of the associated uncertainty.

Although the concept of measurement uncertainty has been recognised by EMC specialists for many years, it was the publication of the 'Guide to the Expression of Uncertainty in Measurement' (the GUM) by ISO in 1993, and the publication of the EMC specific NAMAS publication NIS 81 on 'The treatment of Uncertainty in EMC measurements' in 1994, which established general and EMC specific rules for evaluating and expressing uncertainty of EMC measurements.

In contrast to classical metrology problems, in EMC there has been great emphasis on precision of results obtained using a specified and standardized method, rather than on their traceability to a defined standard or SI unit. This has led to the use of standardized test methods, such as the CISPR standards, to fulfil legislative and trading requirements. Furthermore, in EMC tests the magnitude of the intrinsic uncertainty (mainly due to reproducibility problems of the set-up of products and their cabling) is large compared to the uncertainties induced by the measurement instrumentation and test procedure. These two important differences between EMC test methods and classical metrology tests, makes it necessary to give specific guidance for evaluating uncertainties of EMC tests, in addition to the generic uncertainty guides like the aforementioned ISO Guide (GUM) on measurement uncertainties.

CISPR 16-4-1 consists of a collection of informative reports that deal with all relevant uncertainty sources that may be encountered during EMC compliance tests. Typical examples of uncertainty sources are the product itself, the measurement instrumentation, the product set-up, the test procedures and the environmental conditions. This CISPR document shows how the concepts given in the ISO Guide may be applied in standardised EMC tests. The EMC-specific basic uncertainty aspects of both emission and immunity tests are outlined in Clauses 4 and 5 respectively. These basic concepts include the introduction of the different types of uncertainties relevant in EMC tests and also the various typical categories of uncertainty sources encountered. This is followed by a description of the steps involved in the evaluation and application of uncertainties in EMC tests.

TABLE RECAPITULATING CROSS-REFERENCES

First edition of CISPR 16-4-1 Clauses	First edition of CISPR 16-3 Clauses
1	1 (of document CISPR/A/450/DTR)
2	2 (of document CISPR/A/450/DTR)
3	3 (of document CISPR/A/450/DTR)
4	4 (of document CISPR/A/450/DTR)
5	Reserved
6	6.3
7	Reserved
8	Reserved
9	Reserved
10	Reserved
Annexes	Annexes
A	A (of document CISPR/A/450/DTR)
B	B (of document CISPR/A/450/DTR)

SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY MEASURING APPARATUS AND METHODS –

Part 4-1: Uncertainties, statistics and limit modelling – Uncertainties in standardized EMC tests

1 General

1.1 Scope

This part of CISPR 16-4 gives guidance on the treatment of uncertainties to those who are involved in the development or modification of CISPR electromagnetic compatibility (EMC) standards. In addition, this part provides useful background information for those who apply the standards and the uncertainty aspects in practice.

The objectives of this part are:

a) to identify the parameters or sources governing the uncertainty associated with the statement that a given product complies with the requirement specified in a CISPR recommendation. This uncertainty will be called 'standards compliance uncertainty' (abbreviated as SCU, see 3.16);

b) to give guidance on the estimation of the magnitude of the standards compliance uncertainty;

c) to give guidance for the implementation of the standards compliance uncertainty into the compliance criterion of a CISPR standardised compliance test.

As such, this part can be considered as a handbook that can be used by standards writers to incorporate and harmonise uncertainty considerations in existing and future CISPR standards. This part also gives guidance to regulatory authorities, accreditation bodies and test engineers to judge the performance quality of an EMC test-laboratory carrying out CISPR standardised compliance tests. The uncertainty considerations given in this part can also be used as guidance when comparing test results (and its uncertainties) obtained by using different alternative test methods.

The uncertainty of a compliance test also relates to the probability of occurrence of an electromagnetic interference (EMI) problem in practice. This aspect is recognized and introduced briefly in this part. However, the problem of relating uncertainties of a compliance test to the occurrence of EMI in practice is not considered within the scope of this part.

The scope of this part is limited to all the relevant uncertainty considerations of a standardized EMC compliance test.

1.2 Structure of clauses related to standards compliance uncertainties

The result of the application of basic considerations (Clauses 4 and 5) in this part to existing or new CISPR standards will lead to proposals to improve and harmonise the uncertainty aspects of those CISPR standards. Such proposals will also be published as a report within this part and will give the background and rationale for improvement of certain CISPR standards. Clause 6 is an example of such a report.

The structure of clauses related to the CISPR standards compliance uncertainty work is depicted in Table 1. Clause 3 deals with the basic considerations of standards compliance uncertainties in emission measurements. Clause 6 contains the uncertainty considerations related to voltage measurements. Clauses 7 and 8 are reserved for SCU considerations of absorbing clamp and radiated emission measurements, respectively.

Uncertainty work is also considered for immunity compliance tests in the future. Clauses 5, 9 and 10 are reserved for this material. SCU considerations of immunity tests differ from the emission SCU considerations in particular points. For instance, in an immunity test, the measurand is often a functional attribute of the EUT and not an isolated quantity. This may cause additional specific SCU considerations. Priority is given to the uncertainty evaluations for emission measurements at this stage of the work.

Table 1 – Structure of clauses related to the subject of standards compliance uncertainty

STANDARDS COMPLIANCE UNCERTAINTY			
Clause 1, 2 and 3: General			
EMISSION		**IMMUNITY**	
Clause 4	Basic considerations	Clause 5	Basic considerations
Clause 6	Voltage measurements	Clause 9	Conducted immunity tests
Clause 7	Absorbing clamp measurements	Clause 10	Radiated immunity tests
Clause 8	Radiated emission measurements		

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 60050-161:1990, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic Compatibility*
Amendment 1 (1997)
Amendment 2 (1998)

IEC 60050-300:2001, *International Electrotechnical Vocabulary (IEV) – Electrical and electronic measurements and measuring instruments – Part 311: General terms relating to measurements – Part 312: General terms relating to electrical measurements – Part 313: Types of electrical measuring instruments – Part 314: Specific terms according to the type of instrument*

IEC 60359:2001, *Electrical and electronic measurement equipment – Expression of performance*

CISPR 16-1 (all parts), *Specification for radio disturbance and immunity measuring apparatus and methods – Radio disturbance and immunity measuring apparatus*

CISPR 16-2 (all parts), *Specification for radio disturbance and immunity measuring apparatus and methods – Methods of measurement of disturbances and immunity*

CISPR 16-3:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 3: CISPR technical reports*

CISPR 16-4-2:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-2: Uncertainties, statistics and limit modelling – Measurement instrumentation uncertainties*

CISPR 16-4-3:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-3: Uncertainties, statistics and limit modelling – Statistical considerations in the determination of EMC compliance of mass-produced products*

CISPR 16-4-4:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-4: Uncertainties, statistics and limit modelling – Statistics of complaints and a model for the calculation of limits*

ISO/IEC 17025:1999, *General requirements for the competence of testing and calibration laboratories*

ISO Guide:1995, *Guide to the expression of uncertainty in measurement* (GUM)

ISO:1993, *International vocabulary of basic and general terms in metrology*, 1993 (the VIM)

3 Terms and definitions

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

NOTE 1 Wherever possible, existing terminology, from the normative standards of Clause 2 is used. Additional terms and definitions not included in those standards are listed below.

NOTE 2 Terms shown in **bold** are defined in this clause.

3.1
electromagnetic (EM) disturbance
any electromagnetic phenomenon which may degrade the performance of a device, equipment or system, or adversely affect living or inert matter

[IEV 161-01-05]

3.2
emission level
the **level** of a given **EM disturbance** emitted from a particular device, equipment or system, measured in a specified way

[IEV 161-03-11]

3.3
emission limit
the specified maximum **emission level** of a source of **EM disturbance**

NOTE In IEC this limit has been defined as 'the maximum permissible emission level'

[IEV 161-03-12]

3.4
influence quantity
quantity that is not the **measurand** but that affects the result of the measurement

NOTE 1 In a standardised compliance test an influence quantity may be specified or non-specified. Specified influence quantities preferably include **tolerance** data.

NOTE 2 An example of a specified influence quantity is the measurement impedance of an artificial mains network. An example of a non-specified influence quantity is the internal impedance of an EM disturbance source.

[ISO GUM, B.2.10]

3.5
interference probability
the probability that a product complying with the EMC requirements will function satisfactorily (from an EMC point of view) in its normal use electromagnetic environment

3.6
intrinsic uncertainty of the measurand
minimum uncertainty that can be assigned in the description of a measured quantity. In theory, the intrinsic uncertainty of the measurand would be obtained if the measurand was measured using a measurement system having a negligible **measurement instrumentation uncertainty**

NOTE 1 No quantity can be measured with continually lower uncertainty, inasmuch as any given quantity is defined or identified at a given level of detail. If one tries to measure a given quantity at an uncertainty lower than its own intrinsic uncertainty one is compelled to redefine it with higher detail, so that one is actually measuring another quantity. See also GUM D.1.1.

NOTE 2 The result of a measurement carried out with the intrinsic uncertainty of the measurand may be called the best measurement of the quantity in question.

[IEC 60359, definition 3.1.11]

3.7
intrinsic uncertainty of the measurement instrumentation
uncertainty of a measurement instrumentation when used under **reference conditions**. In theory, the intrinsic uncertainty of the measurement instrumentation would be obtained if the **intrinsic uncertainty of the measurand** would be negligible

NOTE Application of a reference EUT is a means to create reference conditions in order to obtain the intrinsic uncertainty of the measurement instrumentation (4.5.5)

[IEC 60359, definition 3.2.10, modified]

3.8
level
value of a quantity, such as a power or a field quantity, measured and/or evaluated in a specified manner during a specified time interval

NOTE The level may be expressed in logarithmic units, for example in decibels with respect to a reference value.

[IEV 161-03-01]

3.9
measurand
particular quantity subject to measurement

EXAMPLE –Electric field, measured at a distance of 3 m, of a given sample.

NOTE The specification of a measurand may require statements about influence quantities (see GUM, B.2.9)

[ISO VIM 2.6]

3.10
measurement instrumentation uncertainty
MIU
parameter, associated with the result of a measurement which characterises the dispersion of the values that could reasonably be attributed to the **measurand**, induced by all relevant influence quantities that are related to the measurement instrumentation

[ISO VIM 3.9 and IEC 60359, definition 3.1.4, modified]

3.11
measuring chain
series of elements of a measuring instrument or system that constitutes the path of the measuring signal from input to the output