TECHNICAL REPORT

CISPR 16-4-5

First edition
2006-10

INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

Specification for radio disturbance and immunity measuring apparatus and methods –

Part 4-5: Uncertainties, statistics and limit modelling – Conditions for the use of alternative test methods

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SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY MEASURING APPARATUS AND METHODS –

Part 4-5: Uncertainties, statistics and limit modelling – Conditions for the use of alternative test methods

FOREWORD

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CISPR 16-4-5, which is a technical report, has been prepared by CISPR subcommittee A: Radio-interference measurements and statistical methods.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
CISPR/A/665/DTR	CISPR/A/685/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 list of all parts of the CISPR 16-4 series, published under the general title *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4: Uncertainties, statistics and limit 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

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- withdrawn,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

A bilingual version of this publication may be issued at a later date.

SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY MEASURING APPARATUS AND METHODS –

Part 4-5: Uncertainties, statistics and limit modelling – Conditions for the use of alternative test methods

1 Scope

This part of CISPR 16-4 specifies a method to enable product committees to develop limits for alternative test methods, using conversions from established limits. This method is generally applicable for all kinds of disturbance measurements, but focuses on radiated disturbance measurements (i.e. field strength), for which several alternative methods are presently specified. These limits development methods are intended for use by product committees and other groups responsible for defining emissions limits in situations where it is decided to use alternative test methods and the associated limits in product standards.

2 Normative references

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

CISPR 16-4-1:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-1: Uncertainties, statistics and limit modelling – Uncertainty in standardized EMC tests*

CISPR 16-4-2:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-2: Uncertainties, statistics and limit modelling – Uncertainty in EMC measurements*

3 Terms and definitions

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

3.1
established test method
test method described in a basic standard with established emissions limits defined in corresponding product or generic standards. An established test method consists of a specific test procedure, a specific test set-up, a specific test facility or site, and an established emissions limit

NOTE The following test methods have been considered to be established test methods in CISPR:

– conducted disturbance measurements: test method defined in CISPR 16-2-1:2003, Clause 7;

– radiated disturbance measurements up to 1 GHz: the test method defined in CISPR 16-2-3, 7.2.1;

– radiated disturbance measurements up to 18 GHz: the test method defined in CISPR 16-2-3, 7.3.

3.2
alternative test method
test method described in a basic standard without established emissions limits. The alternative test method is designed for the same purpose as the established test method. An alternative test method consists of a specific test procedure, a specific test set-up, a specific test facility or site, and a derived emissions limit that was determined by the application of the proposed method stated in this document

3.3
established limit
limit having “many years” of good protection of radio services.

NOTE An example is radiated field strength measured on OATS, developed to protect radio services as described in CISPR 16-3.

3.4
derived limit
limit applicable for the alternative test method, derived by appropriate conversion from the established limit and expressed in terms of the misbrands

3.5
conversion factor *K*
for a given EUT or type of EUT, the relation of the measured value of the established test method to the measured value of the alternative test method

NOTE The terms measured and calculated are used interchangeably at various places in this document to describe actual laboratory tests and computer simulations.

3.6
reference quantity *X*
the basic parameter which determines the interference potential to radio reception. It may be independent of the parameters presently used in established standards

NOTE The goal for both the established and alternative test methods is to determine the reference quantity (X) for all frequencies of interest. For both established and alternative test methods, the test results may deviate from the reference quantity values. The specification of the reference quantity when applying methods of this document should include applicable procedures and conditions to calculate (or measure) this quantity

3.7
inherent uncertainty
u_{inherent}
uncertainty caused solely by the difference in EUT characteristics and the ability of the measurement procedure to cope with them. It is specific to each test method and remains, even if the measurement is performed perfectly, i.e., the standards compliance uncertainty is zero and the measurement instrumentations uncertainty is zero

3.8
intrinsic uncertainty of the measurand
$u_{\text{intrinsic}}$
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 negligible measurement instrumentation uncertainty.

[CISPR 16-4-1, definition 3.6]

3.9
EUT type
grouping of products with sufficient similarity in electromagnetic characteristics to allow testing with the same test installation and the same test protocol.

4 Symbols and abbreviated terms

The following abbreviations are used in this technical report:

ATM alternative test method (e.g. subscript in D_{ATM})

D deviation

ETM established test method (e.g. subscript in D_{ETM})

i index of one individual (e.g., of a number of EUTs)

K	conversion factor
k	coverage factor
L	limit
M	measurement (or calculation) result
N	number of EUTs
s	standard deviation
U	expanded uncertainty
u	standard uncertainty
v	volume
X	reference quantity
Δ	difference of two values or quantities
$\bar{x}$	mean value of a set of values x (e.g., $\bar{D}$)

5 Introduction

Over the years, several test procedures and test set-ups for radiated emissions testing have been described in basic standards. One particular combination of test method and test set-up also having defined emissions limits is the open area test site (OATS) method, which has proven to be successful for the protection of radio services. In general limits have not been defined for the other, alternative test methods, e.g., fully anechoic room, TEM waveguide, reverberation chamber.

Each alternative method can be used to get measurement results related to emission of the EUT. Although each method gives an emission level from the EUT, the different methods may capture the EUT emission differently. For example, considering radiated emission measurements, different methods may capture different EUT radiation pattern lobes, differing numbers of lobes, or the test facility may alter the EUT radiation pattern producing a different apparent emission level. Therefore the limits defined for the established test method cannot be applied directly to the alternative test methods. Consequently, a procedure is needed for how to derive limits to use for the results of alternative test methods.

The specification for such a procedure should consider the general goal of disturbance measurements. The aim of the disturbance measurement is to verify whether the EUT satisfies or violates certain compliance criteria. Past experience has shown that using the present system of the established test method and the associated limits yields a situation without many cases of interference due to conducted or radiated emissions. Applying the established test method with the associated limits will fulfill the protection requirement with a high probability. To preserve this situation, the most important requirement for the use of alternative test methods is as follows.

– Use of an alternative test method in a normative standard shall provide the same protection of radio services as the established test method.

This requirement can be met by developing a procedure for deriving emission limits for the alternative test method from the existing limits of the established test method. Such a procedure shall relate the results of the alternative test method to those of the established test method. Using this relation the limits of the established test method can be converted into limits for the alternative test method. The measured values of the alternative test method can then easily be evaluated against the converted limits. Such a procedure will provide a similar amount of protection, even though an alternative test method is used.

The limits conversion procedure should consider the goal of emissions measurements as described above. The results of standard emissions tests can be considered as an approximation of the interference potential of an EUT. Depending on the characteristics of the EUT (e.g., radiation pattern characteristics for radiated disturbance test methods), and on the measurement set-up, the measured value differs from the actual interference potential of the EUT. This deviation can be divided into two parts: a systematic deviation, which can be interpreted as a bias of the test method, and a random deviation depending on the characteristics of different EUTs, which can be interpreted as an uncertainty of the test method. Each emissions test method contains both quantities, and consequently the established test method does too. In the following clauses, a procedure based on these two quantities for comparing an alternative test method with the established test method is described. To determine these quantities, the abstract term “interference potential” needs to be expressed in terms of a physical quantity. For the purposes of this report, this quantity is called the “reference quantity,” *X*. More details about correlation of test methods using a reference quantity can be found in [1][1)].

6 Procedure to derive limits for an alternative test method

6.1 Overview

A procedure to derive limits for an alternative test method based on the limits of an established test method is described in the following paragraphs. Figure 1 shows a summary of the estimated quantities needed for the correlation process. Figure 2 shows a flowchart for the correlation process using these quantities. The nine-step conversion process below can be accomplished using numerical simulations, measurements, or a combination of simulations and measurements. Calculable or reference EUTs are invaluable for this conversion procedure. In the following subclauses, as part of the conversion process the quantities shown in Figure 1 and Figure 2 are combined into several equations. A summary of the equations is given in Table 2. A summary of the steps in the conversion procedure is shown in Table 1.

Table 1 – Summary of steps in conversion procedure

1	Select the reference quantity
2	Describe the test methods and measurands
3	Determine the deviations of the measured quantities from the reference quantity
4	Determine the average values of the deviations
5	Determine the standard uncertainties of the test methods
6	Verify the calculated values
7	Apply the conversion

1) Figures in square brackets refer to the Bibliography.

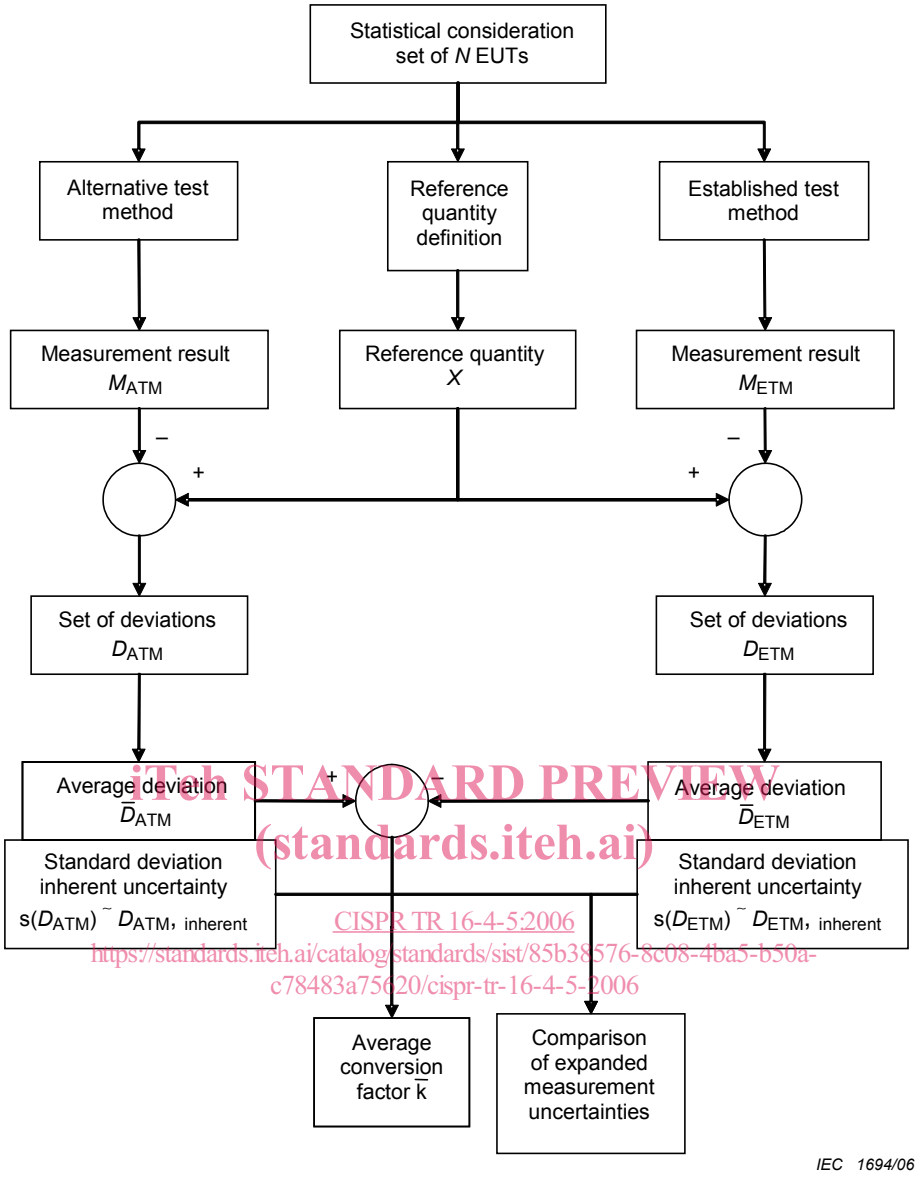

Figure 1 – Overview of quantities to estimate for use in conversion procedure

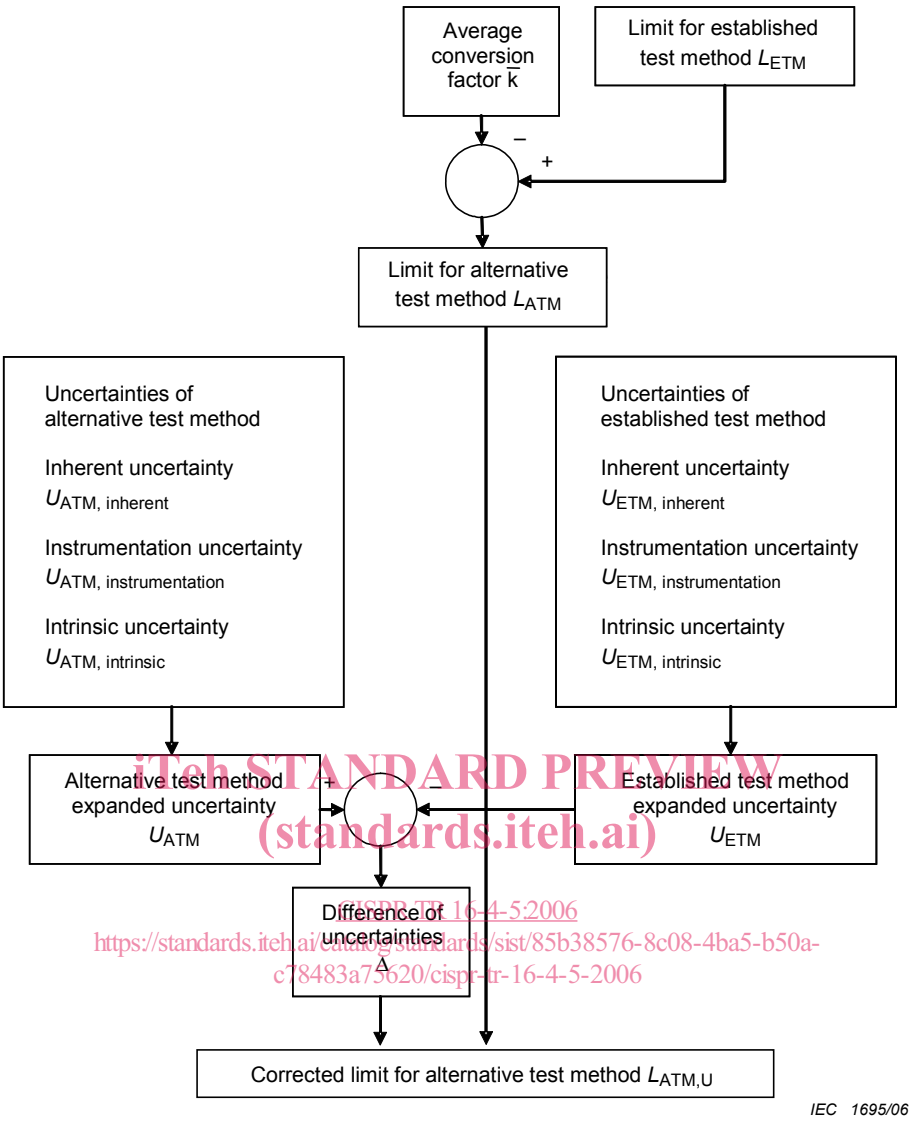

Figure 2 – Overview of limit conversion procedure using estimated quantities

Table 2 – Overview of quantities and defining equations for conversion process

Quantity	Meaning	Equation no.
$D_{ATMi}(f)$	the deviation from the reference quantity of the measurement result of EUT *i* as produced by the alternative test method	(1)
$D_{ETMi}(f)$	the deviation from the reference quantity of the measurement result of EUT *i* as produced by the established test method	(2)
$\overline{D}_{ATM}$	the average deviation of the alternative test method	(3)
$\overline{D}_{ETM}$	the average deviation of the established test method	(4)
$u_{ATM,inherent}$	the inherent uncertainty of the alternative test method	(5)
$u_{ETM,inherent}$	the inherent uncertainty of the established test method	(6)
u_{ATM}	combined standard uncertainty of the alternative test method	(7)
U_{ATM}	the expanded uncertainty of the alternative test method	(8)
u_{ETM}	combined standard uncertainty of the established test method	(9)
U_{ETM}	the expanded uncertainty of the established test method	(10)
$K_i(f)$	frequency dependent conversion factor for EUT *i*	(11)
$\overline{K}(f)$	the average of the conversion factors	(12), (13), (14)
$L_{ATM}(f)$	the limit line of the alternative test method equivalent to the limit of the established test method, without consideration of the uncertainties	(15)
Δ	difference of expanded uncertainties	(16)
$L_{ATM,U}$	the limit to be used for alternative measurements	(17)

6.2 Select the reference quantity *X*

The first step is to select the reference quantity *X*. It should be selected on the basis of a quantity that can possibly cause interference to a radio service, and selection of a reference quantity also depends on the type of EUT.

For the types of EUTs investigated in Annex B, as an example the maximum electric field strength determined on a sphere of a certain radius around the EUT has been selected as the reference quantity for radiated emission measurements in the frequency range of 30 MHz to 1 GHz. In the frequency range below 30 MHz, depending on the frequency subrange and the coupling model, the reference quantity may be the vertical component of the electric field strength, the magnetic field strength, or the asymmetric voltage. In general, the reference quantity and the actual measurands will not necessarily have the same units.

6.3 Describe the test methods and measurands

The measurand shall be described for both the alternative and the established test methods. In addition, the test set-up geometry, the methods of measurement for EUT emissions, and any analysis methods producing the final measurement results shall be described. This description is necessary for an understanding about how the test method works and to give a basis for comparison of the two test methods. In most cases this description is explicit or implicit in the standards that specify the test methods.

6.4 Determine the deviations of the measured quantities from the reference quantity

Each test method provides results, each of which deviate from the reference quantity X. The deviation depends on the characteristics of the test set-up as well as on the characteristics of the EUT. Considering a certain EUT i, a frequency dependent deviation can be determined for both alternative and established test method.

For a given EUT i the deviation of the alternative test method, in a logarithmic scale, is given as

$$D_{\mathrm{ATM}i}(f) = X_i(f) - M_{\mathrm{ATM}i}(f) \qquad (1)$$

where

i is the index of the EUT;

f is the frequency;

$D_{\mathrm{ATM}i}(f)$ is the deviation from the reference quantity of the measurement result of EUT i as produced by the alternative test method;

$X_i(f)$ is the reference quantity defined in 6.2 for the EUT i, and

$M_{\mathrm{ATM}i}(f)$ is the measurement result given by the alternative test method for the EUT i.

The results of the established test method will deviate from the reference quantity as well. The deviation of the established test method is analogously given by the equation

$$D_{\mathrm{ETM}i}(f) = X_i(f) - M_{\mathrm{ETM}i}(f) \qquad (2)$$

where

$X_i(f)$, f, i are the same as in Equation (1);

$D_{\mathrm{ETM}i}(f)$ is the deviation from the reference quantity of the measurement result of EUT i as produced by the established test method;

$M_{\mathrm{ETM}i}(f)$ is the measurement result given by the established test method for the EUT i.

6.5 Determine the average values of the deviations

The deviations given by Equations (1) and (2) will differ for different EUTs. In order to obtain more universal results, varying characteristics of EUTs shall be considered, for example as shown in Annex A. Considering a range of N EUTs leads to a set of N values for the deviation D for both alternative and established test methods. From this set of D the average can be easily determined. See Annex A for more details about EUT considerations and variations.

An estimate of the mean of the deviation of the alternative test method is given by

$$\overline{D}_{\mathrm{ATM}} = \frac{1}{N}\sum_{i=1}^{N} D_{\mathrm{ATM}i} \qquad (3)$$

where

D_{ATM} is the set of deviations of the alternative test method;

$\overline{D}_{\mathrm{ATM}}$ is the average deviation of the alternative test method;

N is the number of EUTs considered, and shall be as large as possible for statistical reasons;

i is the index of any one EUT;

$D_{\mathrm{ATM}i}$ is the deviation from the reference quantity of the measurement result of EUT i, as produced by the alternative test method [Equation (1)].