TECHNICAL REPORT

CISPR 16-4-1

2003

AMENDMENT 2
2007-04

INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

Amendment 2

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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FOREWORD

This amendment has been prepared by CISPR subcommittee A: Radio-interference measurements and statistical methods.

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

DTR	Report on voting
CISPR/A/713/DTR	CISPR/A/729/RVC

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

The committee has decided that the contents of this amendment and the base 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- withdrawn,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.

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2 Normative references

Add the following new references:

CISPR 16-1-4:2007, *Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-4: Radio disturbance and immunity measuring apparatus - Ancillary equipment - Radiated disturbances*

CISPR 16-2-3:2006, *Specification for radio disturbance and immunity measuring apparatus and methods - Part 2-3: Methods of measurement of disturbances and immunity - Radiated disturbance measurements*

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3 Terms and definitions

Replace the existing heading of Clause 3 by the following:

3 Terms, definitions, and acronyms

Add new subclause 3.1 as follows, and renumber terms 3.1 to 3.20 as 3.1.1 to 3.1.20:

3.1 Terms and definitions

Add, on page 14, the following new subclause:

3.2 Acronyms

AF antenna factor

EUT equipment under test

GUM *ISO/IEC Guide to the expression of uncertainty in measurement*

ILC interlaboratory comparison

LPDA log-periodic dipole array

MIU measurement instrumentation uncertainty

OATS open-area test site

RRT round-robin test

SAC semi-anechoic chamber

SCU standards compliance uncertainty

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8 Radiated emission measurements

Replace the existing title and text of Clause 8 by the following:

8 Radiated emission measurements using a SAC or an OATS in the frequency range of 30 MHz to 1 000 MHz

8.1 General

8.1.1 Objective

This clause provides information and guidance for the determination of uncertainties associated with measurement equipment and the measurement method used for radiated emission measurements in the frequency range of 30 MHz to 1 000 MHz in a SAC or on an OATS. Furthermore, a rationale is provided for the various uncertainty aspects described in several parts of CISPR 16 that are related to the radiated emission measurement method (see Clause 7 of CISPR 16-2-3).

In CISPR 16-4-2, the uncertainty considerations for SAC/OATS-based radiated emission measurements are limited to measurement instrumentation uncertainties (MIU). This part addresses all uncertainties that are relevant for compliance testing, i.e. the standards compliance uncertainty (SCU), which also includes the MIU.

The rationale for the methods of uncertainty estimation provided in this Clause 8 is intended to serve as background information for the parts of CISPR 16 that are related to the SAC/OATS-based emission measurement method. This background information may be used by the CISPR subcommittees to improve the existing standards as far as uncertainties are concerned. In addition, this clause provides information for those who apply the radiated emission measurement method and who have to establish their own uncertainty estimates.

8.1.2 Introduction

Clause 8 provides information on the uncertainties associated with the SAC/OATS-based radiated emission measurement method as described in CISPR 16-2-3. The uncertainty estimates for the SAC/OATS radiated emission measurement method described in CISPR 16-4-2, or for example in LAB 34 [11], address only some of the uncertainty components present in actual compliance tests performed in accordance with CISPR 16-2-3. Uncertainty estimates in the aforementioned documents account only for the measurement instrumentation uncertainties (MIUs), whereas uncertainties due to the set-up of the EUT including its cables, and due to the measurement procedure itself, are not taken into account. In this clause, all uncertainty sources that are relevant for the measurement uncertainty of the compliance test, termed as the standards compliance uncertainty (SCU), are considered. One basic assumption for these SCU estimations is that the EUT does not change. In other words, the uncertainty of the SAC/OATS radiated emission measurement method is considered based on using the same EUT as measured by different test laboratories. The laboratories will use different measurement instrumentation, a different test site, different measurement procedures, and different operators. Often the laboratories may also apply different measurement set-ups or different EUT operating modes. The latter EUT-related sources of uncertainty may become significant, and can contribute to poor reproducibility.

The uncertainty estimation described in this clause is done in accordance with the basic considerations on uncertainties in emission measurements given in Clause 4.

8.2 Uncertainties related to the SAC/OATS radiated emission measurement method

This subclause describes the preparation of the uncertainty estimates for the SAC/OATS-based radiated emission measurement method described in Clause 7 of CISPR 16-2-3. For reference, a schematic overview of the radiated emission measurement method is given in Figure 8-1. This figure shows an EUT set up on a positioning table in a SAC. The receive antenna measures the sum of the direct and reflected emission from the EUT.

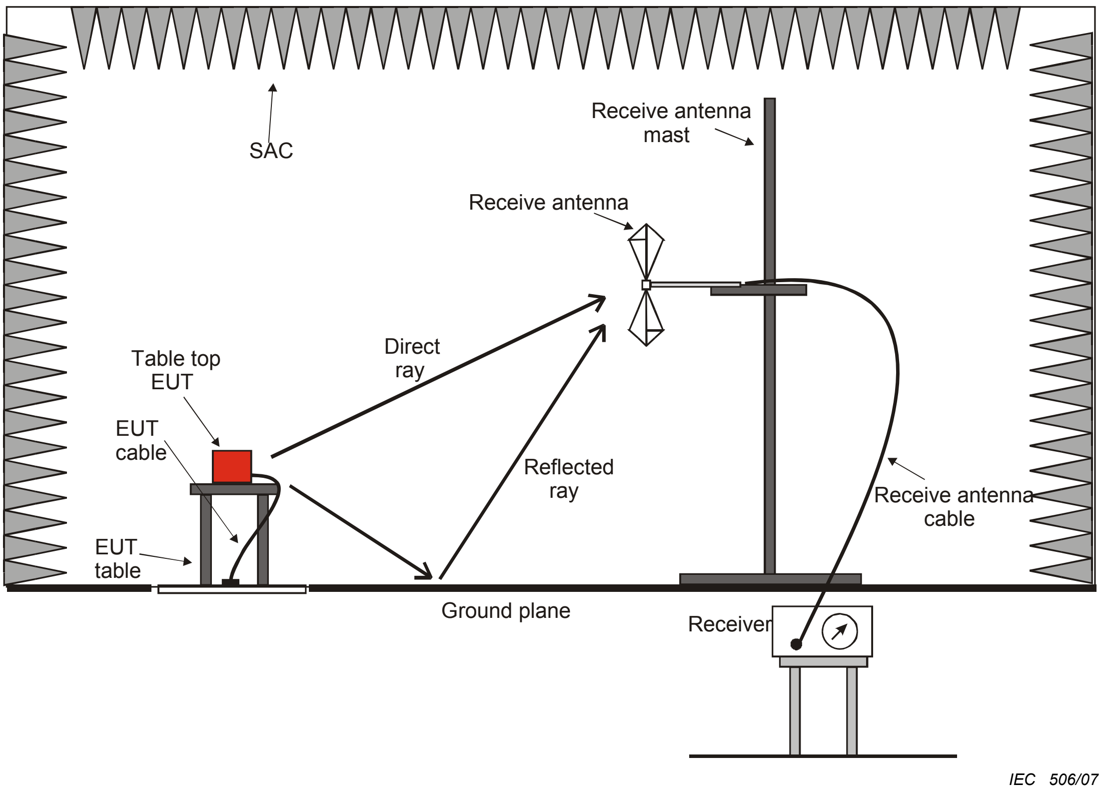

Figure 8-1 – Schematic of a radiated emission measurement set-up in a SAC

8.2.1 The measurand

Previously, the measurand for the SAC/OATS-based radiated emission measurement method in CISPR 16-2-3 was only incompletely defined. In Clause 4 of CISPR 16-1-4, which covers the frequency range 9 kHz to 18 GHz, a reference antenna (balanced dipole) was specified in the range 30 MHz to 300 MHz. For convenience, this measurand was called the reference electric field strength (E-field), i.e. the E-field measured by the CISPR reference antenna. In the frequency range 300 MHz to 1 000 MHz, a reference antenna was not defined, and the measurand is the electric field strength.

Recently work was begun in CISPR/A to implement E-field as the quantity to be measured over the frequency range of 30 MHz to 1 000 MHz, with an amendment under development at the time of writing.

In this subclause it is assumed that the quantity to be measured is the E-field. However, this is not a complete description of the measurand, because as described in the ISO GUM the measurand definition also requires statements about the influence quantities.

From a metrological viewpoint, a more appropriate description of the measurand associated with the SAC/OATS-based radiated emission measurement, is as follows:

The quantity to be measured is the maximum field strength emitted by the EUT as a function of horizontal and vertical polarisation and at heights between 1 m and 4 m, and at a horizontal distance of 10 m from the EUT, over all angles in the azimuth plane. This quantity shall be determined with the following provisions:

a) the frequency range of interest is 30 MHz to 1 000 MHz;

b) the quantity shall be expressed in terms of field strength units that correspond with the units used to express the limit levels for this quantity;

c) a SAC/OATS measurement site and positioning table shall be used that complies with the applicable CISPR validation requirements;

d) a CISPR-compliant EMI receiver shall be used;

e) the application of alternative measurement distances, such as 3 m or 30 m rather than the nominal distance of 10 m (see 8.2.3.3a), is considered to be an alternative measurement method; correlation factors shall be used to translate results obtained at these measurement distances to 10 m results (see 8.2.3.3a for the consequences in terms of uncertainties);

f) the measurement distance is the horizontal projection onto the ground plane of the distance between the boundary of the EUT and the antenna reference point;

g) the EUT is configured and operated in accordance with the CISPR specifications;

h) free-space-antenna factors shall be used.

The measurand E is derived from the maximum voltage reading V_r by using the free-space antenna factor AF:

$$E = V_r + L_c + F_A + \sum_i C_i^{IQ} \qquad (8\text{-}1)$$

where

E is the field strength in dB(μV/m) as described in the measurand description;

V_r is the maximum voltage reading in dB(μV) using the procedure as described in the measurand description;

L_c is the loss in dB of the measuring cable between antenna and receiver;

F_A is the free-space antenna factor [1)] of the receive antenna in dB(m^{-1});

$\sum_i C_i^{IQ}$ is the sum of the correction factors C_i^{IQ} that may be applicable for the various influence quantities as described in 8.2.3.

8.2.2 Uncertainty sources

This subclause summarises the sources of uncertainty associated with the SAC/OATS-based measurement method. From Equation (8-1) it can be seen that the uncertainty is determined by the uncertainty of the measured voltage, the uncertainty of the cable loss, and the uncertainty of the antenna factor.

The uncertainty of the measured voltage is determined by the uncertainties induced by the EUT, the set-up, the measurement procedure, the measurement instrumentation and the environment. Figure 8-2 gives a schematic overview of all the relevant uncertainty sources. This fish-bone diagram indicates the categories of uncertainty sources that contribute to the overall uncertainty of the measurand. An important set-up uncertainty source is the reproducibility of the set-up of the EUT.

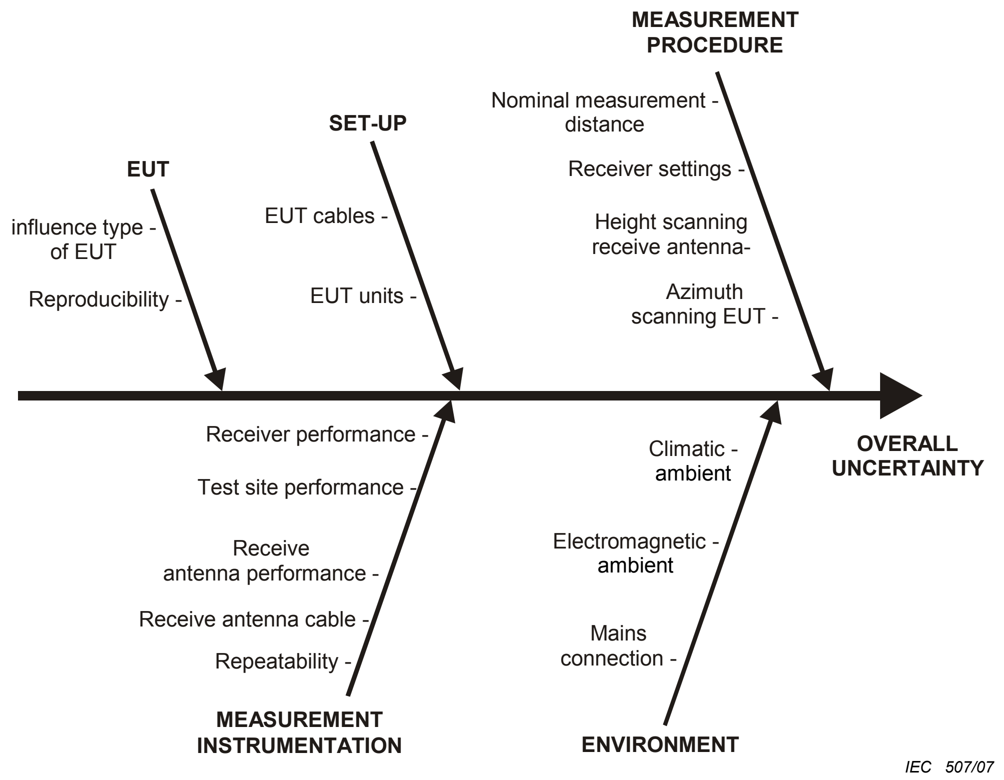

Figure 8-2 – Uncertainty sources associated with the SAC/OATS radiated emission measurement method

1) Free-space antenna factors are used as a figure of merit for the antenna. It should be noted the field strength is not measured in a free-space environment but over a ground plane. See 8.2.3.5 h) for further information.

8.2.3 Influence quantities

For most of the qualitative uncertainty sources given in Figure 8-2, one or more influence quantities can be used to "translate" the uncertainty source in question. Table 8-1 shows the relationship between the uncertainty sources and the influence quantities. If an influence quantity cannot be identified, the original uncertainty source will be used in the uncertainty estimate. For each of the uncertainty sources and influence quantities, details are provided below.

NOTE The uncertainty sources and influence quantities terms used in this subclause and in the remainder of Clause 8 may deviate from similar terms used in CISPR 16-4-2. This is justified for the following reasons: a) Some of the influence quantities are specifically applicable for SCU, and are not applicable for the MIU-only estimates of CISPR 16-4-2; b) Some of the influence-quantity terms used in CISPR 16-4-2 are not quantified or are not clearly identified. For instance the term "site imperfection" is a qualitative term used in CISPR 16-4-2. The term "NSA deviation" used in Table 8-1 is more appropriate because it reflects a specific and well-known quantity. Furthermore, the term "noise floor proximity" is not clearly defined, while the term "signal-to-noise ratio" is a well-known and quantifiable term.

Therefore it is intended to harmonise with the terms used in this document in future maintenance of CISPR 16-4-2.

Table 8-1 – Influence quantities for the SAC/OATS radiated emission measurement method associated with the uncertainty sources of Figure 8-2

Subclause no.	Uncertainty source	Influence quantity
8.2.3.1	**EUT-RELATED**	
a)	Influence of type EUT on other uncertainty sources	Size of EUT
b)		Type of disturbance
c)	Reproducibility of EUT	Product sampling
d)		Modes of operation
8.2.3.2	**SET-UP-RELATED**	
a)	EUT set-up	Layout of EUT unit(s) and cable(s)
b)		Termination of cable(s)
c)		Measurement distance tolerance
d)		EUT height above ground plane tolerance
8.2.3.3	**MEASUREMENT-PROCEDURE-RELATED**	
a)	Nominal measurement distance	Nominal measurement distance
b)	Receiver settings	Receiver settings
c)	Height-scanning of receive antenna	Height-scanning step size
d)		Start and stop position tolerance
e)	Azimuth-scanning of EUT	Azimuth step size
8.2.3.4	**ENVIRONMENT-RELATED**	
a)	Climatic, ambient	Temperature and humidity tolerances
b)	Electromagnetic ambient signals	Signal-to-ambient-signal ratio
c)	Mains connection	Mains voltage variation
d)		Application of mains coupling devices
8.2.3.5	**MEASUREMENT-INSTRUMENTATION-RELATED**	
a)	Receiver performance	Receiver accuracy
b)		Mismatch at the receiver input
c)		Measuring system reading
d)		Signal–to-noise ratio
e)	Test-site performance	NSA deviation
f)		EUT positioning table
g)		Influence receive-antenna mast
h)	Receive-antenna performance	Free-space antenna factor uncertainty
i)		Type of receive antenna (directivity)
j)		Antenna-factor height dependence
k)		Antenna-factor frequency interpolation
l)		Antenna phase-centre variation
m)		Antenna unbalance
n)		Cross-polarisation performance
o)	Receive antenna cable	Cable loss uncertainty
p)		Mismatch [a]
q)	Measurement system repeatability	Measurement system repeatability

[a] When a single cable is used, there are two sources of mismatch between the antenna and the receiver:

a) between the antenna and the cable;

b) between the cable and the receiver (=mismatch at receiver input).

If a test lab uses several cables to interconnect the antenna and the receiver, additional mismatches may be present. In the estimation of MIU, typically only a single mismatch influence quantity is included.

8.2.3.1 EUT-related influence quantities

a) Size of EUT

Various influence quantities depend on the type of the EUT, i.e. large EUTs, small EUTs, EUTs with single or multiple attached cables. The electromagnetic behaviour of these different EUT types may cause different contributions to uncertainty. Influence quantities that are affected by the size of the EUT are included as part of the EUT set-up-related influence quantities in 8.2.3.2. For the EUT-related uncertainty source, no specific uncertainty value will be assigned to the size of the EUT, to avoid double counting of uncertainties. Instead, the size of the EUT shall be considered as an influence quantity for the uncertainties of the set-up-related uncertainty sources discussed in 8.2.3.2.

b) Type of disturbance

The type of the disturbance (broadband, narrowband or intermittent) radiated by the EUT may affect the magnitudes of the uncertainties induced by the receiver and by the measurement method applied (e.g. probability of intercept of broadband signals).

c) Product sampling (if applicable)

This influence quantity is especially important if the measurement is repeated by the manufacturer for quality assurance reasons, or if the 80 %/80 % rule is to be applied. If the manufacturer performs a type test, the manufacturer may repeat the measurement using different samples of the same type of EUT. In case of market surveillance that involves measurements on different samples by another test laboratory, the 80 %/80 % rule may also be applied.

d) Modes of operation of the EUT

During the measurement, meaningful modes of operation shall be selected such that representative and worst case radiated emissions are obtained. In cases that the modes of operation are not specified, different operators and/or test laboratories could select different modes in conjunction with different receiver settings and scan speeds, which may induce significant reproducibility uncertainties, and therefore affecting SCU.

8.2.3.2 Set-up-related influence quantities

a) Layout of EUT unit(s) and cable(s)

Despite the specification of the EUT set-up in product standards, this influence quantity may cause significant uncertainties when different operators and different test laboratories configure a given EUT. Especially for an EUT that consists of several enclosures and interconnecting cables, the uncertainty due to the many degrees of freedom allowed for setting up the EUT may be significant. This influence quantity contributes to the SCU. Results of the CISPR/A RRT in the frequency range 30 MHz to 300 MHz [f3] revealed that the uncertainty induced by the set-up for the specific EUT was approximately 7 dB. The uncertainty associated with the set-up of an EUT depends largely on the type of the EUT. Table 8-2 provides qualitative guidance for the set-up uncertainty as a function of EUT type. Above 200 MHz, the effect of different cable layouts is reduced.

Table 8-2 – Relation between and type of EUT and set–up-related uncertainties

Type of EUT	Set-up uncertainty
Table-top battery fed	Very low
Table-top: single unit, single cable to mains	Low
Table-top: multiple units, multiple cables to mains and auxiliary equipment	High
Floor-standing equipment, single cable to mains	Low
Floor standing equipment, multiple cables to mains and auxiliary equipment	High