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INTERNATIONAL STANDARD

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INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE
COMITÉ INTERNATIONAL SPÉCIAL DES PERTURBATIONS RADIOÉLECTRIQUES

BASIC EMC PUBLICATION
PUBLICATION FONDAMENTALE EN CEM

Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-2: Uncertainties, statistics and limit modelling – Measurement instrumentation uncertainty

Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Partie 4-2: Incertitudes, statistiques et modélisation des limites – Incertitudes de mesure de l'instrumentation

CISPR 16-4-2:2011

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SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY MEASURING APPARATUS AND METHODS –

Part 4-2: Uncertainties, statistics and limit modelling – Measurement instrumentation uncertainty

FOREWORD

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International Standard CISPR 16-4-2 has been prepared by CISPR subcommittee A: Radio-interference measurements and statistical methods.

This second edition cancels and replaces the first edition published in 2003. It constitutes a technical revision.

This edition includes the following significant technical additions with respect to the previous edition:

– Methods of conducted disturbance measurements
  - on the mains port using a voltage probe,
  - on the telecommunication port using an AAN (ISN),

  - on the telecommunication port using a CVP, and
  - on the telecommunication port using a current probe.
- Methods of radiated disturbance measurements
  - in the frequency range 30 MHz to 1 000 MHz using a FAR, and
  - in the frequency range 1 GHz to 18 GHz using a FAR.

This publication has the status of a basic EMC standard in accordance with IEC Guide 107:2009, *Electromagnetic compatibility – Guide to the drafting of electromagnetic compatibility publications*.

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

FDIS	Report on voting
CISPR/A/942/FDIS	CISPR/A/952/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.

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

A list of all parts of the CISPR 16 series can be found, under the general title *Specification for radio disturbance and immunity measuring apparatus and methods*, 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

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

The contents of the corrigendum of April 2013 have been included in this copy.

IMPORTANT – The “colour inside” logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this publication using a colour printer.

INTRODUCTION

The CISPR 16-4 series, *Specification for radio disturbance and immunity measuring apparatus and methods – Uncertainties, statistics and limit modelling, contains information related to uncertainties, statistics and limit modelling*, and consists of the following five parts:

- Part 4-1: Uncertainties in standardized EMC tests,
- Part 4-2: Measurement instrumentation uncertainty,
- 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 the protection of radio services, and
- Part 4-5: Conditions for the use of alternative test methods.

For practical reasons, standardized electromagnetic compatibility (EMC) tests are simplified representations of possible electromagnetic interference (EMI) scenarios that a product may encounter in practice. Consequently, in an EMC standard, the measurand, the limit, measurement instruments, measurement set-up, measurement procedure and measurement conditions are simplified but are still meaningful (representative). Here meaningful means that there is a statistical correlation between compliance of the product with a limit, based on a standardized EMC test using standardized test equipment, and a high probability of actual EMC of the same product during its life cycle. Part 4-4 provides methods based on statistics to derive meaningful disturbance limits to protect radio services.

In general, a standardized EMC test should be developed such that reproducible results are obtained if different parties perform the same test with the same EUT. However, various uncertainty sources limit the reproducibility of a standardized EMC.

Part 4-1 is a technical report that consists of a collection of informative reports that address all relevant uncertainty sources that may be encountered during EMC compliance tests. Typical examples of uncertainty sources are the EUT itself, the measurement instrumentation, the set-up of the EUT, the test procedures and the environmental conditions.

Part 4-2 describes a specific category of uncertainties, i.e. measurement instrumentation uncertainties. In this part, examples of MIU budgets are given for most of the CISPR measurement methods. Also in this part, normative requirements are given on how to apply the MIU when determining compliance of an EUT with a disturbance limit (i.e. conformity assessment decision).

Part 4-3 is a technical report that describes the statistical treatment of test results when compliance tests are performed on samples of mass-produced products. This treatment is known as the 80 %/80 % rule.

Part 4-4 is a technical report that contains CISPR recommendations for the collation of statistical data on interference complaints and for the classification of interference sources. Also, models for the calculation of limits for various modes of interference coupling are given.

Part 4-5 is a technical report describing a method to enable product committees to develop limits for alternative test methods, using conversions from established limits.

SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY MEASURING APPARATUS AND METHODS –

Part 4-2: Uncertainties, statistics and limit modelling – Measurement instrumentation uncertainty

1 Scope

This part of CISPR 16-4 specifies the method of applying Measurement Instrumentation Uncertainty (MIU) when determining compliance with CISPR disturbance limits. The material is also relevant to any EMC test when interpretation of the results and conclusions reached will be impacted by the uncertainty of the measurement instrumentation used during testing.

NOTE In accordance with IEC Guide 107, CISPR 16-4-2 is a basic EMC standard for use by product committees of the IEC. As stated in Guide 107, product committees are responsible for determining the applicability of the EMC standard. CISPR and its sub-committees are prepared to co-operate with technical committees and product committees in the evaluation of the applicability of this standard for specific products.

The annexes contain the background material used in providing the amount of MIU found in generating the CISPR values shown in Clauses 4 through 8 and hence provide valuable background material for those needing both initial and further information on MIU and how to take individual uncertainties in the measurement chain into account. The annexes, however, are not intended to be a tutorial or user manual or to be copied when making uncertainty calculations. For that purpose, the references shown in the bibliography, or other widely recognized documents, may be used.

Measurement instrumentation specifications are given in the CISPR 16-1 series, while the methods of measurement are covered in the CISPR 16-2 series. Further information and background on CISPR and radio disturbances is given in CISPR 16-3. The other parts of the CISPR 16-4 series contain further information on uncertainties in general, statistics and limit modelling. See the introduction of this part for more information on the background and on the content of the CISPR 16-4 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.

CISPR 11, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*

CISPR 12, *Vehicles, boats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of off-board receivers*

CISPR 13, *Sound and television broadcast receivers and associated equipment – Radio disturbance characteristics – Limits and methods of measurement*

CISPR 16-1-1, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus*

CISPR 16-1-2, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-2: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Conducted disturbances*

CISPR 16-1-3, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-3: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Disturbance power*

CISPR 16-1-4, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-4: Radio disturbance and immunity measuring apparatus – Antennas and test sites for radiated disturbance measurements*

CISPR 16-2-1, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-1: Methods of measurement of disturbances and immunity – Conducted disturbance measurements*

CISPR 16-2-2, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-2: Methods of measurement of disturbances and immunity – Measurement of disturbance power*

CISPR 16-2-3:2010, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-3: Methods of measurement of disturbances and immunity – Radiated disturbance measurements*

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

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

CISPR 16-4-3, *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 22:2008, *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement*

ISO/IEC Guide 98-3, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

ISO/IEC Guide 99, *International vocabulary of metrology – Basic and general concepts and associated terms (VIM)*

3 Terms, definitions, symbols and abbreviations

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC Guide 98-3 and ISO/IEC Guide 99, as well as the following apply.

NOTE General terms and definitions used in the expression of uncertainty are contained in ISO/IEC Guide 98-3. General metrology definitions are contained in ISO/IEC Guide 99. Relevant basic definitions are not repeated here.

3.1.1
measurement instrumentation uncertainty
MIU
parameter, associated with the result of a measurement, that characterises the dispersion of the values that could reasonably be attributed to the measurand, induced by all relevant input quantities that are related to the measurement instrumentation

3.2 Symbols

For the purposes of this document, the symbols given in Clauses 3, 5, 6, 7 and 8 apply, as well as the following.

3.2.1 General symbols

X_i	input quantity
x_i	estimate of X_i
δX_i	correction for input quantity
$u(x_i)$	standard uncertainty of x_i
c_i	sensitivity coefficient
y	result of a measurement (the estimate of the measurand), corrected for all recognised significant systematic effects, in logarithmic units, e.g. dB(μV/m)
$u_c(y)$	(combined) standard uncertainty of y, in dB
$U(y)$	expanded uncertainty of y, in dB
U_{cispr}	CISPR criterion for the expanded MIU evaluated in this standard for each specific measurement method, in dB
U_{lab}	expanded MIU determined by the test laboratory, in dB
k	coverage factor
a^+	upper abscissa of a probability distribution
a^-	lower abscissa of a probability distribution

3.2.2 Symbols for measured quantities

E	disturbance electric field strength, in dB(μV/m)
I	disturbance current, in dB(μA)
P	disturbance power, in dB(pW)
V	disturbance voltage, in dB(μV)

3.2.3 Symbols for input quantities common to all disturbance measurements

a_c	attenuation of the connection between the receiver and the ancillary equipment (e.g. AMN, antenna etc.), in dB
δM	correction for the error caused by mismatch, in dB
V_r	receiver voltage reading, in dB(μV)
δV_{sw}	correction for receiver sine wave voltage inaccuracy, in dB
δV_{pa}	correction for imperfect receiver pulse amplitude response, in dB
δV_{pr}	correction for imperfect receiver pulse repetition rate response, in dB
δV_{nf}	correction for the effect of the receiver noise floor, in dB

3.3 Abbreviations

For the purposes of this document, the following abbreviations apply.

NOTE Abbreviations not shown here are defined at their first occurrence in this document.

AAN	asymmetric artificial network
AE	associated equipment (equipment connected to the AE port of the ancillary equipment; ancillary equipment is a transducer, e.g. an AAN; see definitions in CISPR 16-2-1)
AF	antenna factor
AMN	artificial mains network
CP	current probe
CVP	capacitive voltage probe
EUT	equipment under test
FAR	fully anechoic room
FSOATS	free-space OATS (refer to CISPR16-1-4)
LCL	longitudinal conversion loss
LPDA	logarithmic periodic (log-periodic) dipole array
MIU	measurement instrumentation uncertainty
OATS	open area test site
PRF	pulse repetition frequency
RF	radio frequency
SAC	semi-anechoic chamber
S/N	signal to noise ratio
VDF	voltage division factor
VP	voltage probe
VSWR	voltage standing wave ratio

4 Compliance criterion for the MIU

4.1 General

MIU shall be taken into account, as described in this clause, when determining compliance or non-compliance of an EUT with a disturbance limit.

The MIU for a test laboratory shall be evaluated for the measurements addressed in Clauses 5 through 8, taking into consideration each of the input quantities listed there. The standard uncertainty $u(x_i)$ in dB, and the sensitivity coefficient c_i, shall be evaluated for the estimate x_i of each quantity. The combined standard uncertainty $u_c(y)$ of the estimate y of the measurand shall be calculated using

$$u_c(y) = \sqrt{\sum_i c_i^2\, u^2(x_i)} \tag{1}$$

The expanded MIU U_{lab} for a test laboratory shall be calculated for each type of measurement using

$$U_{\text{lab}} = U(y) = 2\, u_{\text{c}}(y) \quad (2)$$

If U_{lab} is less than or equal to U_{cispr} in Table 1, then the test report may either state the value of U_{lab} or state that U_{lab} is less than U_{cispr}.

If U_{lab} exceeds U_{cispr} of Table 1, then the test report shall contain the value of U_{lab} (in dB) for the measurement instrumentation actually used for the measurements.

NOTE Equation (2) means that a coverage factor k = 2 is applied that yields approximately a 95 % level of confidence for the near-normal distribution typical of most measurement results.

Table 1 – Values of U_{cispr}

Measurement		U_{cispr}	Table
Conducted disturbance at mains port using AMN	(9 kHz to 150 kHz)	3,8 dB	B.1
	(150 kHz to 30 MHz)	3,4 dB	B.2
Conducted disturbance at mains port using voltage probe	(9 kHz to 30 MHz)	2,9 dB	B.3
Conducted disturbance at telecommunication port using AAN	(150 kHz to 30 MHz)	5,0 dB	B.4
Conducted disturbance at telecommunication port using CVP	(150 kHz to 30 MHz)	3,9 dB	B.5
Conducted disturbance at telecommunication port using CP	(150 kHz to 30 MHz)	2,9 dB	B.6
Disturbance power	(30 MHz to 300 MHz)	4,5 dB	C.1
Radiated disturbance (electric field strength at an OATS or in a SAC)	(30 MHz to 1 000 MHz)	6,3 dB	D.1 to D.4
Radiated disturbance (electric field strength in a FAR)	(30 MHz to 1 000 MHz)	5,3 dB	D.5 to D.6
Radiated disturbance (electric field strength in a FAR)	(1 GHz to 6 GHz)	5,2 dB	E.1
Radiated disturbance (electric field strength in a FAR)	(6 GHz to 18 GHz)	5,5 dB	E.2

NOTE 1 The values of U_{cispr} are based on the expanded uncertainties in the annexes that were evaluated by considering uncertainties associated with the quantities listed in the measurement-specific subclause. If there are different values in the annexes, then the value taken as U_{cispr} is the maximum value (e.g. maximum of Tables D.1 through D.4).

NOTE 2 In the frequency range below 1 GHz, the values of U_{cispr} were calculated for measurements using the quasi-peak detector, assuming that values for the average detector and r.m.s.-average detector would not exceed these values. Above 1 GHz, the value of U_{cispr} was calculated for measurements using the peak detector.

Nothing in this clause supersedes the requirement for measurement instrumentation to comply with specifications of the CISPR 16-1 series. Also, this clause does not replace the requirement to comply with CISPR 16-4-3.

4.2 Compliance assessment

Compliance or non-compliance with a disturbance limit shall be determined in the following manner.

If U_{lab} is less than or equal to U_{cispr} of Table 1, then:

– compliance is deemed to occur if no measured disturbance level exceeds the disturbance limit;
– non-compliance is deemed to occur if any measured disturbance level exceeds the disturbance limit.

If U_{lab} is greater than U_{cispr} of Table 1, then:

– compliance is deemed to occur if no measured disturbance level, increased by (U_{lab} – U_{cispr}), exceeds the disturbance limit;

– non-compliance is deemed to occur if any measured disturbance level, increased by (U_{lab} – U_{cispr}), exceeds the disturbance limit.

NOTE For the compliance assessment procedure described in this subclause, both the measured disturbance level and the disturbance limit are expressed in logarithmic units, e.g. dB(μV/m).

5 Conducted disturbance measurements

5.1 Conducted disturbance measurements at a mains port using an AMN (see also B.1)

5.1.1 Measurand for measurements using an AMN

V Unsymmetric voltage, in dB(μV), measured at the EUT port of the AMN relative to the reference ground plane

5.1.2 Symbols of input quantities specific to measurements using an AMN

F_{AMN} Voltage division factor of the AMN, in dB

δF_{AMNf} Correction for voltage division factor (VDF) frequency interpolation error, in dB

δD_{mains} Correction for the error caused by mains disturbances, in dB

δV_{env} Correction for the effect of the environment, in dB

δZ_{AMN} Correction for imperfect AMN impedance, in dB

5.1.3 Input quantities to be considered for conducted disturbance measurements at a mains port using an AMN

– Receiver reading
– Attenuation of the connection between AMN and receiver
– AMN voltage division factor
– AMN VDF frequency interpolation
– Receiver related input quantities:
  - Receiver sine-wave voltage accuracy
  - Receiver pulse amplitude response
  - Receiver pulse response variation with repetition frequency
  - Receiver noise floor
– Mismatch effects between AMN receiver port and receiver
– AMN impedance
– Effect of mains disturbances
– Effect of environment

5.2 Conducted disturbance measurements at a mains port using a VP (see also B.2)

5.2.1 Measurand for measurements using a VP

V Unsymmetric voltage, in dB(μV), measured at the EUT power port – loaded with an impedance of 1 500 Ω – relative to the reference ground

5.2.2 Symbols of input quantities specific to measurements using a VP

F_{VP} Voltage division factor (VDF) of the voltage probe, in dB

$\delta F_{\mathrm{VP}f}$ Correction for the VDF frequency interpolation error, in dB

$\delta D_{\mathrm{mains}}$ Correction for the error caused by mains disturbances, in dB

δV_{env} Correction for the effect of the environment, in dB

δZ_{VP} Correction for imperfect voltage probe impedance, in dB

$\delta Z_{\mathrm{mains}}$ Correction for the error caused by the mains impedance when compared with AMN, in dB

5.2.3 Input quantities to be considered for conducted disturbance measurements at a mains port using a VP

– Receiver reading
– Attenuation of the connection between VP and receiver
– VP VDF
– VP VDF frequency interpolation
– Receiver related input quantities:
  • Receiver sine-wave voltage accuracy
  • Receiver pulse amplitude response
  • Receiver pulse response variation with repetition frequency
  • Receiver noise floor
– Mismatch effects between VP receiver port and receiver
– VP impedance
– Effect of mains disturbances
– Effect of mains impedance when compared with AMN
– Effect of environment

5.3 Conducted disturbance measurements at a telecommunication port using an AAN (Y-network) (see also B.3)

NOTE The term "asymmetric artificial network (AAN)" is defined in CISPR 16-1-2. It is referred to as an impedance stabilization network (ISN) in CISPR 22. The term Y-network differentiates it from V- and Δ-networks.

5.3.1 Measurand for measurements using an AAN

V Asymmetric (common mode) voltage, in dB(μV), measured at the EUT port of the AAN referred to the reference ground plane

5.3.2 Symbols of input quantities specific for measurements using an AAN

F_{AAN} Voltage division factor (VDF) of the AAN, in dB

$\delta F_{\mathrm{AAN}f}$ Correction for the VDF frequency interpolation error, in dB

δD_{AE} Correction for the error caused by disturbances from the AE, in dB

δV_{env} Correction for the effect of the environment, in dB

δa_{LCL} Correction for imperfect longitudinal conversion loss of the AAN, in dB

δZ_{AAN} Correction for imperfect asymmetric (common mode) impedance of the AAN, in dB

5.3.3 Input quantities to be considered for conducted disturbance measurements at a telecommunication port using an AAN

– Receiver reading