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INTERNATIONAL STANDARD

NORME INTERNATIONALE

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

Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-4: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Radiated disturbances

Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l’immunité aux perturbations radioélectriques – Partie 1-4: Appareils de mesure des perturbations radioélectriques et de l’immunité aux perturbations radioélectriques – Matériels auxiliaires – Perturbations rayonnées

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FOREWORD

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International Standard CISPR 16-1-4 has been prepared by CISPR subcommittee A: Radio interference measurements and statistical methods.

The document CISPR/A/710/FDIS, circulated to the National Committees as amendment 3, led to the publication of the new edition.

This consolidated version of CISPR 16-1-4 consists of the second edition (2007) [documents CISPR/A/710/FDIS and CISPR/A/722/RVD] and its amendment 1 (2007) [documents CISPR/A/750/FDIS and CISPR/A/760/RVD].

The technical content is therefore identical to the base edition and its amendment and has been prepared for user convenience.

It bears the edition number 2.1.

A vertical line in the margin shows where the base publication has been modified by amendment 1.

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

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

CISPR 16-1 consists of the following parts, under the general title *Specification for radio disturbance and immunity measuring apparatus and methods – Radio disturbance and immunity measuring apparatus:*

Part 1-1: Measuring apparatus

Part 1-2: Ancillary equipment – Conducted disturbances

Part 1-3: Ancillary equipment – Disturbance power

Part 1-4: Ancillary equipment – Radiated disturbances

Part 1-5: Antenna calibration test sites for 30 MHz to 1 000 MHz

The committee has decided that the contents of the base publication and its amendments 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.

INTRODUCTION
(to amendment 1)

In this amendment, the use of a balanced dipole antenna (the CISPR tuned dipole) as a physical reference for radiated emission measurements in the frequency range between 30 MHz and 300 MHz is deleted. It is replaced by the requirement that in this frequency range the quantity to be measured is the electric field strength that can be determined using different types of antennas, provided that the antenna factor and the associated uncertainty are known.

This fundamental change of measurand in the frequency range between 30 MHz and 300 MHz was subject to thorough investigations and discussion within CISPR A, and brings it into line with the measurand that already applies in the rest of the frequency range 9 kHz to 1 GHz, and indeed above 1 GHz. The decision for this change has been supported by the results of a questionnaire. More details on the rationale for the decision to introduce the 'electric field' measurand instead of the CISPR reference dipoles can be found in the CISPR Maintenance Cycle Report CISPR/A/541/MCR.

CISPR/A/541/MCR explains that the need for a CISPR reference dipole no longer exists, due to improvements in the calibration of antennas used for EMC compliance testing and the increased implementation of quality systems in test and calibration laboratories in accordance with ISO 17025. Moreover, Clause 4 of CISPR 16-1-4 covers the frequency range 9 kHz to 1 GHz, yet a reference antenna is only specified in the range 30 MHz to 300 MHz, which seems to make this frequency range an exception to the general rule.

In other words, most measurements of physical quantities are made with an instrument that is traceable to national standards. There is no need for measurement of electric field strength in the frequency range 30 MHz to 300 MHz to deviate from this, especially when application of such a physical reference antenna may give a greater uncertainty to the intended measurand than a regular calibrated broadband antenna. Moreover, these days, the CISPR reference dipole is rarely used in practice because it is impractical from a operational point of view (time consuming). The new measurand is the field strength as defined by the limit level in dBμV/m and as required by the method of measurement. If various operators follow the same measurement method, involving calibrated antennas, a high degree of reproducibility is ensured.

A consequence of using the tuned dipole antenna as a reference is that the antenna uncertainties in CISPR 16-4-2 require the field strength measured by a broadband antenna to be referred to the field strength that would have been measured had a tuned dipole been used. The ramifications would be dependent on the difference in radiation patterns and mutual coupling of a dipole compared to a broadband antenna (including height dependence of antenna factor). This practice can actually result in larger EMC measurement uncertainties than if the field strength were derived from the traceably calibrated broadband antenna. The relating of the behaviour of the commonly used broadband antenna to the extremely rarely used tuned dipole in the notes to the uncertainty budget in CISPR 16-4-2, requires specialist knowledge to understand.

SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY MEASURING APPARATUS AND METHODS –

Part 1-4: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Radiated disturbances

1 Scope

This part of CISPR 16 is designated a basic standard, which specifies the characteristics and performance of equipment for the measurement of radiated disturbances in the frequency range 9 kHz to 18 GHz.

Specifications for ancillary apparatus are included for: antennas and test sites, TEM cells, and reverberating chambers.

The requirements of this publication must be complied with at all frequencies and for all levels of radiated disturbances within the CISPR indicating range of the measuring equipment.

Methods of measurement are covered in Part 2-3, and further information on radio disturbance is given in Part 3 of CISPR 16. Uncertainties, statistics and limit modelling are covered in Part 4 of CISPR 16.

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 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 16-2-3, *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 (all parts), *Specification for radio disturbance and immunity measuring apparatus and methods – Uncertainties, statistics and limit modelling*

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*

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

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply. Also see IEC 60050(161).

3.1
bandwidth
B_n
width of the overall selectivity curve of the receiver between two points at a stated attenuation, below the midband response

NOTE The bandwidth is represented by the symbol B_n, where n is the stated attenuation in decibels.

3.2
CISPR indicating range
range specified by the manufacturer which gives the maximum and the minimum meter indications within which the receiver meets the requirements of this part of CISPR 16

3.3
calibration test site
CALTS
open area test site with metallic ground plane and tightly specified site attenuation performance in horizontal and vertical electric field polarization

NOTE 1 A CALTS is used for determining the free-space antenna factor of an antenna.

NOTE 2 Site attenuation measurements of a CALTS are used for comparison to corresponding site attenuation measurements of a compliance test site, in order to evaluate the performance of the compliance test site.

3.4
compliance test site
COMTS
environment which assures valid, repeatable measurement results of disturbance field strength from equipment under test for comparison to a compliance limit

3.5
antenna
that part of a transmitting or receiving system that is designed to radiate or to receive electromagnetic waves in a specified way

NOTE 1 In the context of this standard, the balun is a part of the antenna.

NOTE 2 This term covers various devices such as the wire antenna, free-space-resonant dipole and hybrid antenna.

3.6
balun
passive electrical network for the transformation from a balanced to an unbalanced transmission line or device or vice versa

3.7
free-space-resonant dipole
wire antenna consisting of two straight colinear conductors of equal length, placed end to end, separated by a small gap, with each conductor approximately a quarter-wavelength long such that at the specified frequency the input impedance of the wire antenna measured across the gap is pure real when the dipole is located in the free space

NOTE 1 In the context of this standard, this wire antenna connected to the balun is also called the "test antenna".

NOTE 2 This wire antenna is also referred to as "tuned dipole".

3.8
site attenuation
site attenuation is defined as the minimum site insertion loss measured between two polarization-matched antennas located on a test site when one antenna is moved vertically over a specified height range and the other is set at a fixed height

3.9
site insertion loss
the loss between a pair of antennas placed at specified positions on a test site, when a direct electrical connection between the generator output and receiver input is replaced by transmitting and receiving antennas placed at the specified positions

3.10
wire antenna
a specified structure consisting of one or more metallic wires or rods for radiating or receiving electromagnetic waves

NOTE A wire antenna does not contain a balun.

3.11
fully anechoic room
FAR
shielded enclosure, the internal surfaces of which are lined with radio-frequency absorbing material (i.e. RF absorber), which absorbs electromagnetic energy in the frequency range of interest

3.12
quasi-free space test-site
facility for radiated emission measurements, or antenna calibration, that is intended to achieve free-space conditions. Unwanted reflections from the surroundings are kept to a minimum in order to satisfy the site acceptance criterion applicable to the radiated emission measurement or antenna calibration procedure being considered

3.13
test volume
volume in the FAR in which the EUT is positioned

NOTE In this volume the quasi-free space condition is met and this volume is typically 0,5 m or more from the absorbing material of the FAR.

3.14
cross-polar response
measure of the rejection by the antenna of the cross-polarised field, when the antenna is rotated in a uniform electromagnetic field

3.15
hybrid antenna
conventional wire-element log-periodic dipole array (LPDA) antenna with boom lengthened at the open-circuit end to add one broadband dipole (e.g., biconical or bow-tie), such that the infinite balun (boom) of the LPDA serves as a voltage source for the broadband dipole. Typically a common-mode choke is used at this end of the boom to minimize parasitic (unintended) RF currents on the outer conductor of the coaxial cable flowing into the receiver

3.16
low uncertainty antenna
good quality robust biconical or LPDA antenna, whose antenna factor is reproducible to better than ±0,5 dB, used for the measurement of E-field strength at a defined point in space

NOTE It is further described in A.2.2.

3.17
semi-anechoic chamber
SAC

shielded enclosure, in which five of the six internal surfaces are lined with radio-frequency-energy absorbing material (i.e., RF absorber), which absorbs electromagnetic energy in the frequency range of interest, and the bottom horizontal surface is a conducting ground plane for use with OATS test set-ups

3.18
common mode absorption device
CMAD
a device that may be applied on cables leaving the test volume in radiated emission measurements to reduce the compliance uncertainty

3.19
insertion loss
the loss arising from the insertion of a device into a transmission line, expressed as the ratio of voltages immediately before and after the point of insertion of a device under test, before and after the insertion. It is equal to the inverse of the transmission *S*-parameter, $|1/S_{21}|$

3.20
reflection coefficient
the ratio of a common quantity to both the reflected and incident travelling waves. Hence, the voltage reflection coefficient is defined as the ratio of the complex voltage of the reflected wave to the complex voltage of the incident wave. The voltage reflection coefficient is equal to the scattering parameter S_{11}

3.21
short-open-load-through (SOLT) or through-open-short-match (TOSM) calibration method
calibration method for a vector network analyser using three known impedance standards – short, open, and match/load, and a single transmission standard – through. The SOLT method is widely used, and the necessary calibration kits with 50 Ω characteristic impedance components are commonly available. A full two-port error model includes six error terms for each of the forward and reverse directions, for a total of twelve separate error terms, which requires twelve reference measurements to perform the calibration

3.22
scattering parameters (S-parameters)
a set of four parameters used to describe the properties of a two-port network inserted into a transmission line

3.23
through-reflect-line (TRL) calibration
calibration method for a vector network analyser using three known impedance standards "Through", "Reflect" and "Line" for the internal or external calibration of the VNA. Four reference measurements are needed for this calibration

3.24
vector network analyser
VNA
a network analyser capable of measuring complex values of the four *S*-parameters S_{11}, S_{12}, S_{21}, S_{22}

4 Antennas for measurement of radiated radio disturbance

Antennas of the type that are used for radiated emissions measurements, having been calibrated, shall be used to measure the field strength, taking into account their radiation patterns and mutual coupling with their surroundings. The antenna and the circuits inserted between it and the measuring receiver shall not appreciably affect the overall characteristics of the measuring receiver. When the antenna is connected to the measuring receiver, the measuring system shall comply with the bandwidth requirements of CISPR 16-1-1 appropriate to the frequency band concerned.

The antenna shall be linearly polarised. It shall be orientable so that all polarizations of incident radiation can be measured. The height of the centre of the antenna above ground or above the absorber in a FAR may have to be adjustable according to a specific test procedure.

For additional information about the parameters of broadband antennas see Annex A.

4.1 Physical parameter for radiated emissions measurements

The physical parameter for radiated emission measurements made against an emission limit expressed in volts per metre is E-field strength measured at a defined point in space relative to the position of the equipment under test (EUT). More specifically, for measurements in the frequency range 30 MHz to 1 000 MHz on an OATS or in a SAC, the measurand is the maximum field strength as a function of horizontal and vertical polarization and at heights between 1 m and 4 m, and at a horizontal distance of 10 m from the EUT, while the EUT is rotated over all angles in the azimuth plane.

The accuracy of field-strength measurement of a uniform field of a sine-wave shall be better than ±3 dB when an antenna meeting the requirements of this subclause is used with a measuring receiver meeting the requirements of CISPR 16-1-1.

NOTE This requirement does not include the effect due to a test site.

4.2 Frequency range 9 kHz to 150 kHz

Experience has shown that, in this frequency range, it is the magnetic field component that is primarily responsible for observed instances of interference.

4.2.1 Magnetic antenna

For measurement of the magnetic component of the radiation, either an electrically-screened loop antenna of dimension such that the antenna can be completely enclosed by a square having sides of 60 cm in length, or an appropriate ferrite-rod antenna, may be used.

The unit of the magnetic field strength is µA/m or, in logarithmic units, 20 log(µA/m) = dB(µA/m). The associated emission limit shall be expressed in the same units.

NOTE Direct measurements can be made of the strength of the magnetic component, in dB(µA/m) or µA/m of a radiated field under all conditions, that is, both in the near field and in the far field. However, many field strength measuring receivers are calibrated in terms of the equivalent plane wave electric field strength in dB(µV/m), i.e. assuming that the ratio of the *E* and *H* components is 120 π or 377 Ω.

To obtain the reading of *H* (µA/m), the reading *E* (µV/m) is divided by 377 Ω:

$$H\ (\mu\text{A/m}) = E\ (\mu\text{V/m})\ /\ 377\ \Omega \qquad (1)$$

To obtain the reading of *H* dB(µA/m), 51,5 dB(Ω) is subtracted from the reading *E* dB(µV/m):

$$H\ \text{dB}(\mu\text{A/m}) = E\ \text{dB}(\mu\text{V/m}) - 51{,}5\ \text{dB}(\Omega) \qquad (2)$$

The impedance *Z* = 377 Ω, with 20 log *Z* = 51,5 dB(Ω), used in the above conversions is a constant originating from the calibration of field strength measuring equipment indicating the magnetic field in µV/m (or dB(µV/m)).