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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 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus**

**Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques –
Partie 1-1: Appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Appareils de mesure**





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INTERNATIONAL ELECTROTECHNICAL COMMISSION
INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

**SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY
MEASURING APPARATUS AND METHODS –**

**Part 1-1: Radio disturbance and immunity measuring apparatus –
Measuring apparatus**

FOREWORD

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

This fifth edition cancels and replaces the fourth edition published in 2015. This edition constitutes a technical revision.

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

- a) Reorganization of the document structure to remove common elements of receiver performance from Clauses 4, 5, 6, and 7 and create a new clause that applies across all of these clauses. Key common parameters include:

- 1) Input impedance
- 2) CW amplitude accuracy
- 3) Limitations of intermodulation effects
- 4) Limitation of receiver noise and internally generated spurious signals
- b) Rewording of Subclause B.1.1 for the purpose of correcting existing errors
- c) Amendments to Subclause 7.5.2 to modify the definition of the test signal to be used for calibrating and verifying the required RMS-average detector response to pulses of the receiver. This section will include a note requiring that the amplitude of the pulsed signal be verified prior to the calibration, and will include several verification methods.
- d) Amendments to Subclause 6.5.2 to modify the definition of the test signal to be used for calibrating and verifying the required average detector response to pulses. The purpose of this proposed change is the alignment of the test signal type with that of the newly proposed signal used to verify the RMS-average detector, allowing the use of a pulsed RF signal. This section will include a note requiring that the amplitude of the pulsed signal be verified prior to the calibration and will include several verification methods.
- e) Implementation and use of Gaussian filters
- f) Amendments to Clause 9 on discontinuous disturbance analyzers (DDAs) to allow the use of measuring receivers with built-in DDAs, to clarify which signal is used for click time parameter determination and to allow the use of FFT-based measuring instruments with internal DDAs.
- g) Amendments to Subclauses 4.2, 5.2, 6.2 and 7.2 to remove the mention of a symmetric input for measuring receivers.
- h) Deletion of Subclause 4.8.1 “Screening Effectiveness”.
- i) add a frequency accuracy specification to the proposed reorganized clause mentioned in a) above.
- j) Amend Subclause 6.5.3 to adjust the allowable tolerance for the variation with repetition frequency for the linear average detector.
- k) Add interpretation information to Clause K.4 based on CISPR-A-1188-INF.
- l) Indicate that the 31,6 Hz pulse repetition frequency for the RMS-Average test requirement for Bands C and D in Table 15 is optional. For the RMS-Average overload requirement in Table 13, change the minimum pulse repetition frequency to 100 Hz and the associated Peak to RMS-Average ratio to 30,6 dB.
- m) Improve the phrasing used for the tolerance statements in Subclauses 4.4.1, 5.5, 6.5.2, 6.5.3, 6.5.4 and 7.5.2.
- n) Remove a note from Clause E1.
- o) Add a reference for FFT-based discontinuous disturbance analyzers

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

The text of this International Standard is based on the following documents:

FDIS	Report on voting
CIS/A/1290/FDIS	CIS/A/1295/RVD

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

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

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

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
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INTRODUCTION

The CISPR 16 series, published under the general title *Specification for radio disturbance and immunity measuring apparatus and methods*, is comprised of the following sets of documents:

- CISPR 16-1 – six parts covering measurement instrumentation specifications;
- CISPR 16-2 – five parts covering methods of measurement;
- CISPR TR 16-3 – a single publication containing various technical reports (TRs) with further information and background on CISPR and radio disturbances in general;
- CISPR 16-4 – five parts covering uncertainties, statistics and limit modelling.

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: Coupling devices for conducted disturbance measurements
- Part 1-3: Ancillary equipment – Disturbance power
- Part 1-4: Antennas and test sites for radiated disturbance measurements
- Part 1-5: Antenna calibration sites and reference test sites for 5 MHz to 18 GHz
- Part 1-6: EMC antenna calibration

The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent concerning the measuring receiver with RMS-average detector (patent no DE 10126830) given in Clause 7.

IEC takes no position concerning the evidence, validity and scope of this patent right.

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SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY MEASURING APPARATUS AND METHODS –

Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus

1 Scope

This part of CISPR 16 specifies the characteristics and performance of equipment for the measurement of radio disturbance in the frequency range 9 kHz to 18 GHz. In addition, requirements are provided for specialized equipment for discontinuous disturbance measurements.

NOTE In accordance with IEC Guide 107, CISPR 16-1-1 is a basic electromagnetic compatibility (EMC) standard for use by product committees of the IEC. As stated in Guide 107, product committees are responsible for determining the applicability of a basic EMC standard. CISPR and its subcommittee are prepared to co-operate with product committees in the evaluation of the value of particular EMC tests for specific products.

The specifications in this document apply to electromagnetic interference (EMI) receivers and spectrum analyzers. The term “measuring receiver” used in this document refers to both EMI receivers and spectrum analyzers (see also 3.7). The calibration requirements for measuring receivers are detailed in Annex J.

Further guidance on the use of spectrum analyzers can be found in Annex B of any one of the following documents: CISPR 16-2-1:2014, CISPR 16-2-2:2010, or CISPR 16-2-3:-2016.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 11:2015, *Industrial, scientific and medical equipment - Radio-frequency disturbance characteristics - Limits and methods of measurement*

CISPR 11:2015/AMD1:2016

CISPR 11:2015/AMD2:2019

CISPR 14-1:2016, *Electromagnetic compatibility - Requirements for household appliances, electric tools and similar apparatus - Part 1: Emission*

CISPR 16-2-1:2014, *Specification for radio disturbance and immunity measuring apparatus and methods - Part 2-1: Methods of measurement of disturbances and immunity - Conducted disturbance measurements*

CISPR 16-2-1:2014/AMD1:2017

CISPR 16-2-2:2010, *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 16-2-3:2016, *Specification for radio disturbance and immunity measuring apparatus and methods - Part 2-3: Methods of measurement of disturbances and immunity - Radiated disturbance measurements*

CISPR TR 16-3:2010, *Specification for radio disturbance and immunity measuring apparatus and methods - Part 3: CISPR technical reports*
 CISPR TR 16-3:2010/AMD1:2012
 CISPR TR 16-3:2010/AMD2:2015

IEC 60050-161:1990, *International Electrotechnical Vocabulary (IEV) – Part 161: Electromagnetic compatibility* (available at www.electropedia.org)

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

3.1 bandwidth

B_x
width of the overall selectivity curve of the receiver between two points at a stated attenuation, below the mid-band response

Note 1 to entry: x is the stated attenuation in dB.

3.2 CISPR indication range

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

3.3 electrical charge time constant

T_C
time needed after the instantaneous application of a constant sine-wave voltage to the stage immediately preceding the input of the detector for the output voltage of the detector to reach 63 % of its final value

Note 1 to entry: This time constant is determined as follows: a sine-wave signal of constant amplitude and having a frequency equal to the mid-band frequency of the IF amplifier is applied to the input of the stage immediately preceding the detector. The indication, K_D , of an instrument having no inertia (e.g. an oscilloscope) connected to a terminal in the DC amplifier circuit so as not to affect the behavior of the detector, is noted. The level of the signal is chosen so that the response of the stages concerned remains within the linear operating range. A sine-wave signal of this level, applied for a limited time only and having a wave train of rectangular envelope is gated so that the deflection registered is $0,63 K_D$. The duration of this signal is equal to the charge time of the detector.

3.4 electrical discharge time constant

T_D
time needed after the instantaneous removal of a constant sine-wave voltage applied to the stage immediately preceding the input of the detector for the output of the detector to fall to 37 % of its initial value

Note 1 to entry: The method of measurement is analogous to that for the charge time constant, but instead of a signal being applied for a limited time, the signal is interrupted for a definite time. The time taken for the deflection to fall to $0,37 K_D$ is the discharge time constant of the detector (K_D is the indication of an instrument having no inertia (e.g. an oscilloscope) connected to a terminal in the DC amplifier circuit so as not to affect the behavior of the detector).

3.5 impulse area

A_{imp}
voltage-time area of a pulse defined by the integral:

$$A_{\text{imp}} = \int_{-\infty}^{+\infty} V(t) dt \quad (1)$$

Note 1 to entry: The impulse area, sometimes referred to as impulse strength, is typically expressed in μVs or $\text{dB}(\mu\text{Vs})$.

Note 2 to entry: Spectral density (D) is related to the impulse area and expressed in $\mu\text{V}/\text{MHz}$ or $\text{dB}(\mu\text{V}/\text{MHz})$. For rectangular impulses of pulse duration T at frequencies $f \ll 1/T$, the relationship $D (\mu\text{V}/\text{MHz}) = \sqrt{2} \times 10^6 A_{\text{imp}}$ (μVs) applies.

3.6 impulse bandwidth

B_{imp}

$$B_{\text{imp}} = \frac{A(t)_{\text{max}}}{2G_0 \times A_{\text{imp}}} \quad (2)$$

where

$A(t)_{\text{max}}$ is the peak of the envelope at the IF output of the receiver with an impulse area A_{imp} applied at the receiver input;

G_0 is the gain of the circuit at the centre frequency;

A_{imp} is the impulse area.

Note 1 to entry: Specifically, for two critically-coupled tuned transformers,

$$B_{\text{imp}} = 1,05 \times B_6 = 1,31 \times B_3 \quad (3)$$

where B_6 and B_3 are the bandwidths at the -6 dB and -3 dB points, respectively.

For the Gaussian filter type, the relationship is [12],¹

$$B_{\text{imp}} = 1,065 \times B_6 = 1,506 \times B_3 \quad (4)$$

Note 2 to entry: See Clause A.2 for further information.

3.7 measuring receiver

instrument such as a tunable voltmeter, an EMI receiver, a spectrum analyzer or a Fast Fourier Transform (FFT)-based measuring instrument, with or without preselection, which meets the relevant parts of this standard

¹ Numbers in square brackets refer to the Bibliography.

Note 1 to entry: See Annex I for further information.

3.8 mechanical time constant

T_M
<critically damped indicating instrument>

$$T_M = \frac{T_L}{2\pi} \quad (5)$$

where T_L is the period of free oscillation of the instrument with all damping removed.

Note 1 to entry: For a critically damped instrument, the formula of motion of the system can be written as:

$$T_M^2 \left(\frac{d^2\alpha}{dt^2} \right) + 2T_M \frac{d\alpha}{dt} + \alpha = ki \quad (6)$$

where

- α is the deflection;
- i is the current through the instrument; and
- k is a constant.

It can be deduced from this relation that this time constant is also equal to the duration of a rectangular pulse (of constant amplitude) that produces a deflection equal to 35 % of the steady deflection produced by a continuous current having the same amplitude as that of the rectangular pulse.

Note 2 to entry: The methods of measurement and adjustment are deduced from one of the following:

- a) the period of free oscillation having been adjusted to $2\pi T_M$, damping is added so that $\alpha T = 0,35\alpha_{\max}$;
- b) when the period of oscillation cannot be measured, the damping is adjusted to be just below critical such that the overshoot is not greater than 5 % and the moment of inertia of the movement is such that $\alpha T = 0,35\alpha_{\max}$.

3.9 overload factor

ratio of the level that corresponds to the range of practical linear function of a circuit (or a group of circuits) to the level that corresponds to full-scale deflection of the indicating instrument

Note 1 to entry: The maximum level at which the steady-state response of a circuit (or group of circuits) does not depart by more than 1 dB from ideal linearity defines the range of practical linear function of the circuit (or group of circuits).

3.10 weighting

<impulsive disturbance> pulse-repetition-frequency (PRF) dependent conversion (mostly reduction) of a peak-detected impulse voltage level to an indication that corresponds to the interference effect on radio reception

Note 1 to entry For an analogue receiver, the psychophysical annoyance of the interference is a subjective quantity (audible or visual, usually not a certain number of misunderstandings of a spoken text).

Note 2 to entry For a digital receiver, the interference effect is an objective quantity that may be defined by the critical bit error ratio (BER) or bit error probability (BEP) for which perfect error correction can still occur, or by another, objective and reproducible parameter.

Note 3 to entry: This note applies to the French language only.

3.10.1**weighted disturbance measurement**

measurement of disturbance using a weighting detector

3.10.2**weighting characteristic**

peak voltage level as a function of PRF for a constant effect on a specific radio communication system, i.e. the disturbance is weighted by the radio communication system itself

3.10.3**weighting detector**

detector which provides an agreed weighting function

3.10.4**weighting factor**

value of the weighting function relative to a reference PRF or relative to the peak value

Note 1 to entry: The weighting factor is expressed in dB.

3.10.5**weighting function****weighting curve**

relationship between the input peak voltage level and the PRF for constant level indication of a measuring receiver with a weighting detector, i.e. the curve of response of a measuring receiver to repeated pulses

3.11**measurement time**

T_m

effective, coherent time for a measurement result at a single frequency (in some areas also called dwell time)

- for the peak detector, the effective time to detect the maximum of the signal envelope
- for the quasi-peak detector, the effective time to measure the maximum of the weighted envelope
- for the average detector, the effective time to average the signal envelope
- for the RMS-average detector, the effective time to determine the maximum of the weighted signal envelope

3.12**calibration**

operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication

Note 1 to entry: A calibration may be expressed by a statement, calibration function, calibration diagram, calibration curve, or calibration table. In some cases, it may consist of an additive or multiplicative correction of the indication with associated measurement uncertainty.

Note 2 to entry: Calibration should not be confused with adjustment of a measuring system, often mistakenly called "self-calibration," nor with verification of calibration.

Note 3 to entry Often, the first step alone in the preceding definition is perceived as being calibration.

[SOURCE: ISO/IEC Guide 99:2007, 2.39] [5]

3.13**verification**

provision of objective evidence that a given item fulfils specified requirements

EXAMPLE Checking whether the functions of a measuring instrument or auxiliary equipment, such as a common mode absorption device (CMAD; see CISPR 16-1-4), meet stated specifications, such as those given in a data sheet.

Note 1 to entry: This note applies to the French language only.

[SOURCE: ISO/IEC Guide 99:2007, 2.44, modified – addition of an example and of Note 1] [5]

3.14**adjustment of a measuring system**

set of operations carried out on a measuring system so that it provides prescribed indications corresponding to given values of a quantity to be measured

Note 1 to entry: Types of adjustment of a measuring system include zero adjustment of a measuring system, offset adjustment, and span adjustment (sometimes called gain adjustment).

Note 2 to entry: Adjustment of a measuring system should not be confused with calibration, which is a prerequisite for adjustment.

Note 3 to entry: After an adjustment of a measuring system, the measuring system shall usually be recalibrated.

[SOURCE: ISO/IEC Guide 99:2007, 3.11] [5]

3.15**correction**

compensation for an estimated systematic effect

Note 1 to entry: See ISO/IEC Guide 98-3:2008, 3.2.3 [4] for an explanation of 'systematic effect'.

Note 2 to entry: The compensation can take different forms, such as an addend or a factor, or can be deduced from a table.

[SOURCE: ISO/IEC Guide 99:2007, 2.53] [5]

3.16**metrological traceability**

property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty

[SOURCE: ISO/IEC Guide 99:2007, 2.41] [5]

4 Fundamental characteristics of a measuring receiver**4.1 General**

Spectrum analyzers and FFT-based measuring instruments that meet the requirements of Clause 4 and Clauses 5, 6, 7, 8 and 10 for the relevant detector or discontinuous disturbance analyzer (DDA) may be used for compliance measurements. For emission measurements, FFT-based measuring instruments shall sample and evaluate the signal continuously during the measurement time.

This standard utilizes a “black-box” approach to determining equipment compliance to the standard. Equipment shall be determined to be compliant with CISPR 16-1-1 based only on meeting the stated performance requirements of this document. Equipment compliance to CISPR 16-1-1 shall not be based on circuit topology or design (e.g. analog or digital), unless specifically stated in this document.