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

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

Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Partie 1-3: Appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Matériels auxiliaires – Puissance perturbatrice

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FOREWORD

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This consolidated version of the official IEC Standard and its amendments has been prepared for user convenience.

CISPR 16-1-3 edition 2.2 contains the second edition (2004-06) [documents CISPR/A/517/FDIS and CISPR/A/532/RVD] and its corrigendum 1 (2006-02), its amendment 1 (2016-03) [documents CIS/A/1111/CDV and CIS/A/1138/RVC] and its amendment 2 (2020-01) [documents CIS/A/1305/FDIS and CIS/A/1314/RVD].

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendments 1 and 2. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

International Standard CISPR 16-1-3 has been prepared by CISPR subcommittee A: Radio interference measurements and statistical methods.

This edition constitutes a technical revision. In this edition a more detailed calibration method for the absorbing clamp is specified. Furthermore, new alternative calibration methods are introduced which are more practicable than the one which was specified previously. Additional parameters to describe the absorbing clamp are defined, like the decoupling factor for the broadband absorber (DF) and the decoupling factor for the current transformer (DR), along with their validation methods. A procedure for the validation of the absorbing clamp test site (ACTS) is also included in the document.

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

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

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SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY MEASURING APPARATUS AND METHODS –

Part 1-3: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Disturbance power

1 Scope

This part of CISPR 16 is designated a basic standard, which specifies the characteristics and calibration of the absorbing clamp for the measurement of radio disturbance power in the frequency range 30 MHz to 1 GHz.

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 16-1-2:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-2: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Conducted disturbances*

CISPR 16-2-2:2003, *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 TR 16-4-1:2009, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-1: Uncertainties, statistics and limit modelling – Uncertainties in standardized EMC tests*

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

IEC 60050-161:1990, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*
Amendment 1 (1997)
Amendment 2 (1998)

3 Terms, definitions and abbreviations

3.1 Terms and definitions

See IEC 60050-161, where applicable.

3.2 Abbreviations

ACA Absorbing clamp assembly

ACMM Absorbing clamp measurement method

ACRS Absorbing clamp reference site

ACTS	Absorbing clamp test site
CF	Clamp factor
CRP	Clamp reference point
DF	Decoupling factor
DR	Decoupling factor that specifies the decoupling of the current transformer from the common mode impedance of the measurement receiver
JTF	Jig transfer factor
LUT	Lead under test
~~RTF~~	~~Reference transfer factor~~
SAD	Secondary absorbing device
SAR	Semi-anechoic room
SRP	Slide reference point

4 Absorbing clamp instrumentation

4.1 Introduction

The measurement of disturbance power using an absorbing clamp is a method for the determination of the radiated disturbance in the frequency range above 30 MHz. This measurement method represents an alternative approach to the measurement of the disturbance field strength on an OATS. The absorbing clamp measurement method (ACMM) is described in Clause 7 of CISPR 16-2-2.

The ACMM uses the following measurement instrumentation:

– the absorbing clamp assembly;
– the secondary absorbing device;
– the absorbing clamp test site.

Figure 1 gives an overview of the absorbing clamp measurement method including the instrumentation required for this method and the calibration and validation methods for the instrumentation. The requirements for the instrumentation necessary for the ACMM are specified in this clause. Details of the absorbing clamp calibration method, and validation of other properties of the clamp and the secondary absorbing device, are described in Annex B. Details of the absorbing clamp test site validation are described in Annex C. Absorbing clamps are suitable for the measurement of disturbances from some types of equipment, depending on construction and size. The precise measuring procedure and its applicability is to be specified for each category of equipment. If the EUT itself (without connecting leads) has a dimension that approaches 1/4 of the wavelength, direct cabinet radiation may occur. The disturbance capability of an appliance having a mains lead as the only external lead may be taken as the power the appliance could supply to its mains lead, which acts as a transmitting antenna. This power is nearly equal to that supplied by the appliance to a suitable absorbing device placed around the lead at the position where the absorbed power is at a maximum. Direct radiation from the appliance is not taken into account. Equipment having external leads other than a mains lead can radiate disturbance energy from such leads, whether shielded or unshielded, in the same manner as radiation from the mains lead. Measurements using the absorbing clamp can be made on these types of lead as well.

The application of the ACMM is specified in more detail in 7.9 of CISPR 16-2-2.

4.2 The absorbing clamp assembly

4.2.1 Description of the absorbing clamp assembly

Annex A describes the construction of the clamp and gives a typical example of such a construction.

The absorbing clamp assembly consists of the following five parts:

- a broadband RF current transformer;
- a broadband RF power absorber and impedance stabilizer for the lead under test;
- an absorbing sleeve and assembly of ferrite rings to reduce RF current on the surface of the coaxial cable from the current transformer to the measuring receiver;
- a 6 dB attenuator between the output of the absorbing clamp and the coaxial cable connecting to the measuring receiver;
- a coaxial cable as receiver cable.

The clamp reference point (CRP) indicates the longitudinal position of the front of the current transformer within the clamp. This reference point is used to define the position of the clamp during the measurement procedure. The CRP shall be indicated on the outside housing of the absorbing clamp.

4.2.2 The clamp factor and the clamp site attenuation

An actual measurement of an EUT using the ACMM is depicted schematically in Figure 2. Details on the ACMM are given in Clause 7 of CISPR 16-2-2.

The disturbance power measurement is based on measurement of the asymmetrical current generated by the EUT, which is measured at the input of the absorbing clamp using a current probe. The absorbing ferrites of the clamp around the lead under test isolate the current transformer from disturbances on the mains. The maximum current is determined by moving the absorbing clamp along the stretched lead, which acts as a transmission line. The transmission line transforms the input impedance of the absorbing clamp to the output of the EUT. At the point of optimal adjustment, the maximum disturbance current at the current probe or the maximum disturbance voltage at the receiver input can be measured.

For this situation the actual clamp factor CF_{act} of an absorbing clamp relates the output signal of the clamp V_{rec} to the measurand of interest, i.e. the disturbance power P_{eut} of an EUT as follows:

$$P_{eut} = CF_{act} + V_{rec} \tag{1}$$

where

P_{eut} = the disturbance power of the EUT in dBpW;

V_{rec} = the measured voltage in dBμV;

CF_{act} = the actual clamp factor in dBpW/μV.

Ideally, the received power level P_{rec} in dBpW at the receiver input can be calculated using the following formula:

$$P_{rec} = V_{rec} - 10 \cdot \log(Z_i) = V_{rec} - 17 \tag{2}$$

where

Z_i = 50 Ω, input impedance of the measuring receiver, and

V_{rec} = measured voltage level in dBμV.

Using Equations (1) and (2) one can derive a relation between the disturbance power P_{eut} emitted by the EUT and the power P_{rec} received by the receiver as follows:

$$P_{eut} - P_{rec} = CF_{act} + 17 \quad (3)$$

This ideal relation between the disturbance power of the EUT and the power received by the measuring receiver is defined as the actual clamp site attenuation A_{act} (in dB).

$$A_{act} \equiv P_{eut} - P_{rec} = CF_{act} + 17 \quad (4)$$

This actual clamp site attenuation depends on three properties:

– the clamp response properties,
– the site properties and
– the EUT properties.

4.2.3 Decoupling functions of the absorbing clamp

Whereas the current transformer of the absorbing clamp measures the disturbance power, the decoupling attenuation of the ferrites around the lead under test establishes an asymmetrical impedance and separates the current transformer from the far end of the lead under test. This separation reduces the disturbing influence of the connected mains and of the impedance of the far end and its influence on the measured current. This decoupling attenuation is called the decoupling factor (*DF*).

A second decoupling function is needed for the absorbing clamp. The second decoupling function is the decoupling of the current transformer from the asymmetrical (or common mode) impedance of the receiver cable. This decoupling is achieved by the absorbing section of ferrite rings on the cable from the current transformer to the measurement receiver. This decoupling attenuation is called the decoupling factor to the measurement receiver (*DR*).

4.2.4 Requirements for the absorbing clamp assembly (ACA)

Absorbing clamps used for disturbance power measurements shall meet the following requirements:

a) The actual clamp factor (CF_{act}) of the absorbing clamp assembly, as defined in 4.2.1 shall be determined in accordance with the normative methods described in Annex B. The uncertainty of the clamp factor shall be determined in accordance with the requirements given in Annex B.

b) The decoupling factor (*DF*) of the broadband RF absorber and the impedance stabilizer for the lead under test shall be verified in accordance with the measurement procedure as described in Annex B. The decoupling factor shall be at least 21 dB for the whole frequency range.

c) The decoupling function from the current transformer to the measuring output (*DR*) of the absorbing clamp shall be determined in accordance with the measurement procedure as described in Annex B. The decoupling factor to the measurement receiver shall be at least 30 dB for the whole frequency range. The 30 dB contains 20,5 dB attenuation from the absorbing clamp and 9,5 dB from the coupling/decoupling network (CDN).

d) The length of the clamp housing shall be 600 mm ± 40 mm.

e) A 50 Ω RF attenuator of at least 6 dB shall be used directly at the clamp output.

4.3 The absorbing clamp assembly calibration methods and their relations

The purpose of the clamp calibration is to determine the clamp factor *CF* in a situation that resembles an actual measurement with an EUT as much as possible. However, in 4.2.2 it is stated that the clamp factor is a function of the EUT, the clamp properties and the site performance. For standardization (reproducibility) reasons, the calibration method shall use a test site with a specified and reproducible performance, and a signal generator and receiver with reproducible performance. Under these conditions, the only variable left is the absorbing clamp under consideration.

~~Three~~ Two absorbing clamp calibration methods are developed below, each with their own advantages, disadvantages and applications (see Table 1). Figure 3 gives a schematic overview of the ~~three~~ two possible methods.

In general, each of the calibration methods comprises the following two steps.

First, as a reference, the output power P_{gen} of the RF generator (with 50 Ω output impedance) is measured directly through a 10 dB attenuator using a receiver (Figure 3a). Secondly, the disturbance power of the same generator and 10 dB attenuator is measured through the clamp using one of the following ~~three~~ two possible methods.

a) The original method

The original absorbing clamp set-up calibration method uses a reference site including a large vertical reference plane (Figure 3b). By definition this method gives the *CF* directly, because this is the original calibration method, which is used for the determination of the limits and therefore considered as the reference. The lead under test is connected to the centre conductor of the feed-through connector in the vertical reference plane. At the back of this vertical plane, the feed-through connector is connected to the generator. For this calibration configuration, P_{orig} is measured while the clamp is moved along the lead under test, in accordance with the procedure described in Annex B such that for each frequency the maximum value is obtained. The minimum site attenuation A_{orig} and the absorbing clamp factor CF_{orig} can be determined using the following equations:

$$A_{orig} = P_{gen} - P_{orig} \quad (5)$$

and

$$CF_{orig} = A_{orig} - 17 \quad (6)$$

The minimum site attenuation A_{orig} is in the range of about 13 dB to 22 dB.

b) The jig calibration method

The jig calibration method uses a jig that can be adapted to the length of the absorbing clamp under calibration and the secondary absorbing device (SAD). This jig serves as a reference structure for the absorbing clamp (see Figure 3c). For this calibration configuration P_{jig} is measured as a function of frequency while the clamp is in a fixed position within the jig. The site attenuation A_{jig} and the absorbing clamp factor CF_{jig} can be determined using the following equations:

$$A_{jig} = P_{gen} - P_{jig} \quad (7)$$

and

$$CF = A_{jig} - 17 \quad (8)$$

~~c) The reference device method~~

~~The reference device method uses a reference site (without vertical reference plane) and a reference device that is fed through the lead under test, which is a coaxial structure for this purpose (see Figure 3d).~~

~~For this calibration configuration, P_{ref} is measured while the absorbing clamp is moved along the lead under test in accordance with the procedure described in Annex A such that for each frequency the maximum value is obtained. The minimum site attenuation A_{ref} and the absorbing clamp factor CF_{ref} can be determined using the following equations:~~

~~$$A_{ref} = P_{gen} - P_{ref} \qquad (9)$$~~

~~and~~

~~$$CF_{ref} = A_{ref} - 17 \qquad (10)$$~~

Annex B describes the ~~three~~ two possible absorbing clamp calibration methods in more detail. A survey of the ~~three~~ two clamp calibration methods is also given in Figure 1. Figure 1 also gives the relation of the clamp measurement method and the clamp calibration methods and the role of the reference site.

NOTE Calibration takes place on clamp, attenuator and cable. They have to be held together.

The absorbing clamp factors obtained through the jig method and the reference device method (CF_{jig}, CF_{ref}) differ systematically from the original absorbing clamp factor CF_{orig}. It is necessary to establish this systematic relation between these different clamp factors as follows.

The jig transfer factor *JTF* is calculated by

$$JTF = CF_{jig} - CF_{orig} \qquad (11)$$

The *JTF* in dB is to be determined for each type of absorbing clamp by the clamp manufacturer. The manufacturer or an accredited calibration laboratory in charge shall determine the *JTF* by averaging the results of at least five reproduced calibrations for five devices of a production series. ~~Similarly, the reference transfer factor *RTF* is determined by~~

~~$$RTF = CF_{ref} - CF_{orig} \qquad (12)$$~~

~~Again, the *RTF* in dB is to be determined for each type of absorbing clamp by the clamp manufacturer. The manufacturer or an accredited calibration laboratory in charge shall determine the *RTF* by averaging the results of at least five reproduced calibrations for five devices of a production series.~~

In summary, the original calibration method directly gives the value of CF_{orig}. The jig ~~and the reference device~~ method gives the CF_{jig} ~~and the CF_{ref} respectively~~, from which the original absorbing clamp factor can be calculated using Equation~~s~~ (11) ~~and (12)~~.

Absorbing clamps with different geometries, different arrangement and material of ferrites, different current probes as well as different housing material do require a separate determination of the JTF. A new determination is also required if a different type of jig is used, e.g. larger geometry.