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Title:
Amendment 1 to CISPR 16-2, clause 2.5: Measurements using the absorbing clamp, 30 MHz to 1000 MHz

(Titre) :

Introductory note

This work originated in CIS/A/WG1 while studying improvements of the calibration method of the Absorbing Clamp (ref CISPR/A/210/NP). It was found (and substantiated by the results of two CISPR/A Absorbing Clamp Round Robin Tests) that the uncertainties of this test method can be significantly reduced if the existing absorbing clamp measurement method is modified (clause 2.5 of CISPR 16-2). The major shortcoming of the absorbing clamp measurement method is that the specification is not sufficient tight.
The CD addresses these issues and introduces the necessary changes to the absorbing clamp measurement method.

Subject: CD for modification of CISPR 16-2 (clause 2.5 and annex C) concerning the measurement method of the disturbance power with the absorbing clamp

Reference: CISPR/A/WG2 project on the Absorbing Clamp

Foreword

This document is a CD that describes a proposal for modification of CISPR 16-2 (clause 2.5 and annex C) concerning the measurement method of the disturbance power using the absorbing clamp.

This work originated in CISPR/A WG1 with the subject of modification of the calibration method of the Absorbing Clamp (ref CISPR/A/210/NP). However from practice, from some publications and also from the results of two CISPR/A Absorbing Clamp Round Robin Tests it is clear that the uncertainties can be reduced further if also the existing absorbing clamp measurement method is amended (clause 2.5 of CISPR 16-2). The major shortcoming of the absorbing clamp measurement method is that the specification is not sufficient tight. Furthermore, the description of the measurement method deviates from the description given in CISPR 14-1.

The amendments in this CD are based on findings from

a. Two CISPR Round Robin Tests,
b. The Schaffner/NPL report, results published in [C.4.3], see annex C.
c. Various meetings of the absorbing clamp ad-hoc group.

In addition, the modified measurement method is harmonized with the description given in CISPR 14-1 for EUTs having one or more leads. The specification of the measurement method for EUTs with auxiliary units is not included.

This amendment of CISPR 16-2 is originally not within the scope of the clamp calibration project, that is part of WG1 work. During the Bristol meeting it is decided to perform this work on the revision of the clamp measurement method within WG2. This CD deals with the absorbing clamp measurement method. Finally it is noted that the description of the uncertainty aspects of the clamp measurement method and the clamp calibration method will be given in a separate report that will be included in the present CISPR 16-3 publication or in the possible future 16-4 publication.

2.5 Measurements using the absorbing clamp

2.5.1 Introduction

For small Equipments Under Test (EUTs) connected only by one mains lead, or another type of lead, the Absorbing Clamp Measurement Method (ACMM) offers an alternative for the radiated emission measurement method. The ACMM measures the disturbance power by using an absorbing clamp and some additional test devices. The advantages of the ACMM with respect to the radiated emission test are mainly the reduced measurement time and reduced cost of the test site.

The basis of the ACMM was the recognition that radiated emissions from electrically small equipment can primarily be attributed to common mode currents flowing on e.g. the mains lead attached to the equipment. The disturbance potential of an EUT having one external lead may be taken as the power it could supply to its lead acting as a radiating antenna. This power is assumed to be nearly equal to that supplied by the EUT to the absorbing clamp placed around the Lead Under Test (LUT) at the position where the measured common mode current is maximum. An exact model of the ACMM is not available. This makes the uncertainty considerations and the comparison between the radiated emission measurement method and the ACMM difficult. The historical background of the absorbing clamp is described in detail in annex C.

This clause lays down the general requirements for the measurement of disturbance power produced at the leads of an EUT. For specific products, more specific measurement procedures and operating conditions may be necessary. The calibration and validation methods related to the ACMM are given in clause 5.3 of CISPR 16-1. The uncertainty considerations on the measurement method and the clamp calibration method are described in CISPR 16-3.

2.5.2 Application of the absorbing clamp measurement method

The applicability (scope) of this ACMM is given by the following limitations.

a) Frequency range
The ACMM as described in this clause may be applied to measure the disturbance power of an EUT between 30 MHz and 1000 MHz.

b) EUT unit limitations
The EUT unit is the housing of the EUT without its connecting leads. The ACMM is applicable for EUT units having dimensions typically smaller than a quarter of a wavelength of the largest measured frequency and with one ore more leads as the main source of disturbance radiation. If the EUT unit approaches a quarter of a wavelength of the highest measured frequency, then direct radiation of the EUT unit may occur. Then, the ACMM may not be suitable to assess the full radiation properties of the EUT.

c) LUT requirements
Initially, the ACMM is applied for EUTs with a single mains lead (see annex C). EUTs having external leads other than a mains lead can also radiate disturbances. The ACMM can also be used to measure these leads. This clause does not apply for EUTs the lead of which is connected through an auxiliary unit.

2.5.3 Requirements measurements instrumentation and test site

The schematic drawing of the ACMM is given in figure XXa. The following requirements apply for the various parts of the instrumentation and for the test site.

a) Measuring receiver
The measuring receiver shall comply with the requirements of CISPR 16-1. When using spectrum analysers or scanning receivers, the recommendation given in annex B shall be considered.

b) Absorbing clamp assembly

The absorbing clamp assembly consists of the following parts:

- An absorbing clamp (includes the current transformer and absorbers along the LUT and measurement cable)
- A 6 dB attenuator
- A measurement cable

The absorbing clamp assembly shall comply with the requirements given in clause 5.3 of CISPR 16-1. The Clamp Factor (CF) of this absorbing clamp assembly shall be determined in accordance with the CF-measurement procedure given in CISPR 16-1, clause 5.3.

The Clamp Reference Point (CRP) indicates the longitudinal position of the front edge 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.

c) Secondary absorbing device

In addition to the absorbing part of the clamp, a Secondary Absorbing Device (SAD) directly behind the absorbing clamp shall be applied to reduce the uncertainty of the test. The performance of the SAD is specified in clause 5.3 of CISPR 16-1. This SAD can be a ferrite clamp (a termination clamp) or a clip-on ferrite sleeve. In case, the SAD is not applied, the additional uncertainty associated with the absence of the SAD shall be incorporated in the uncertainty budget (see CISPR 16-3).

d) Absorbing Clamp Test Site requirements

The Absorbing Clamp Test Site (ACTS) is a site that is used for application of the ACMM. The ACTS is specified in detail in CISPR 16-1, clause 5.3 and its performance shall be validated in accordance with the procedure given in CISPR 16-1. The ACTS can be either an outdoor or indoor facility and includes the following elements (figure XXb):

- The EUT table which is a support for the EUT unit
- The clamp slide which is a support for the LUT and for the absorbing clamp and the SAD
- A gliding support for the measurement cable of the absorbing clamp
- Auxiliary means like a rope to move both the absorbing clamp and the absorbing device

All the abovementioned ACTS elements shall be subject of the ACTS validation procedure.

The near end of the clamp slide (at the side of the EUT) is denoted as the Slide Reference Point (SRP, see figure XXb). This SRP is used to define the horizontal distance to the CRP of the clamp. Some of the requirements for the above mentioned elements of the ACTS that are specified in detail in clause 5.3 of CISPR 16-1 are repeated below for convenience:

1. The length of the clamp slide shall ensure that the absorbing clamp and the secondary absorbing device can be moved over a distance of 5 m which corresponds to a half wavelength at 30 MHz. This means that the clamp slide shall have a length of at least 6.7 m.
   NOTE - The length of the clamp slide is determined by the sum of the scanning length (5 m at 30 MHz), the margin between the SRP and the CRP (0.1 m), the margin for interconnection of the absorbing clamp and the secondary absorbing device (0.1 m) and the length of the absorbing clamp and the secondary absorbing device (2 x 0.7 m) + a margin to accommodate lead fixtures at the end (0.1 m). This totals a length of 6.7 m for the clamp slide.
2. The height of the clamp slide shall be 0.8 m. such that it enables the height of the LUT to be 0.8 m above the reference plane of the site. This implies that within the absorbing clamp and within the SAD, the height of the LUT above the reference plane will be a few centimeters larger.
3. The material of the EUT table shall be non-reflecting, non-conducting and the dielectric properties shall be close to the dielectric properties of air. In this way, the EUT table is non-existent (neutral) from an electromagnetic point of view.
4. The material of the rope used to move the clamp along the clamp slide shall also be neutral from an electromagnetic point of view.

NOTE – The influence of the material of the EUT table and the clamp slide may be significant for frequencies above 300 MHz.

The ambient noise level present at the ACTS shall comply with the requirements given in clause 2.3.1.

2.5.4 Requirements EUT leads

The disturbance power shall be measured for each of the leads, one by one. The measurement procedure is given in 2.5.7. The requirements for the leads are as follows.

a) Lead under test

The length of the LUT shall be at least a half-wavelength at the lowest frequency of measurement, plus the length of the absorbing clamp and an optional secondary absorbing device, plus an additional length to connect the lead to a mains connection on the floor. This means that the lead length shall be at least 8 m.

NOTE 1 - The lead length is determined by the minimum length of the clamp slide (6.7 m) + 1 m (drop of cable to floor) + 0.1 m margin = 7.8 m. Additional cable may be required for the cable run between the EUT and the clamp reference point. Typically a lead length of 8 m is required.
NOTE 2 - In general, the original cable of the EUT used for the compliance measurement is much shorter than 8 m, and the cable must be extended or completely replaced by a lead of the required length and of the same type and construction as the original cable of the EUT. Extension of cables is generally not practical, because in general the extension plugs will not pass through the absorbing clamp.

b) Leads not under test

If the EUT has more than one lead, the leads that are not subject to test shall be removed if operationally possible, at the time when another lead is measured. A lead that cannot be removed shall be isolated by means of lossy ferrite rings or another absorbing device put around the lead immediately adjacent to the housing of the EUT. The isolated leads shall be positioned near the EUT on the EUT table. The performance requirements for the absorbing device or the lossy ferrite rings are given in CISPR 16-1, clause 5.3.4.

2.5.5 Requirements test set up

a) General

- The test set up of the EUT and the LUT on the ACTS are shown in figures XXa and XXb.
- The distance between the clamp test set up (EUT, LUT, clamp, SAD) and any objects (including persons, but floor excluded) shall be at least 1 m.
- The configuration of the ACTS shall be the same as during the ACTS performance verification.

b) EUT set up

- The EUT is placed on a support table. The height of the table shall be 0.8 m.
- The EUT shall be positioned on the EUT table at its normal operating position. The LUT shall run directly towards the SRP of the clamp slide. In case a normal position is not defined, then the EUT shall be positioned such that its LUT runs directly towards the clamp slide. The distance from EUT unit to the SRP shall be as small as possible.

c) LUT set up

- The LUT is stretched horizontally in a straight line above the clamp slide, to permit variation of the position of the absorbing clamp along the lead to find the maximum indication. Outside the absorbing clamp and the SAD, the height of the LUT above the floor shall be 0.8 m. For better fixing of the LUT during the clamp sliding procedure, it is convenient to fix the LUT at the near end and the far end of the clamp slide by using quick release locks.

d) Absorbing clamp

- The absorbing clamp is placed around the LUT as shown in figure XXb. The absorbing clamp shall be positioned on the clamp slide with the current transformer faced to the EUT.
- The LUT shall be kept central within the absorbing clamp at the location of the current transformer, i.e. at the CRP. Most clamps have centering features for this purpose.

e) SAD

- The distance between the SAD and the absorbing clamp shall be maximally 0.1 m.

f) Measurement cable

- In case the 6 dB attenuator is not an integrated into the absorbing clamp assembly, then it is important to connect the separate 6 dB attenuator close to the measurement junction of the clamp.
- The measurement cable is connected to the measuring receiver or spectrum analyser.
- The measurement cable shall run over a gliding pulley so that the cable runs at almost a right angle to the absorbing clamp and does not touch the ground.

2.5.6 Operating conditions of the EUT

When measurements of the disturbance power are performed, the EUT shall be operated in its normal modes of operation, including standby mode. A pre-scan procedure (ref 2.5.7 *B1*) aims to find the mode of operation that causes the highest emission. The detailed operating conditions of the EUT as given in clause 2.3 shall be met.

2.5.7 Measurement procedure

a) Ambient measurement procedure and requirement

The emission contribution from the ambient shall be measured prior to the actual test of the EUT by using the LUT (the main lead, or if not applicable another lead). The ambient disturbance power is measured while the EUT is switched off. The ambient shall be measured, while the absorbing clamp is moving in accordance with the final scan procedure described in B2. The ambient disturbance power calculated using equation 1, shall be at least 6 dB below the applicable limit. Detailed requirements on the ambient noise level are given in clause 2.3.1.

NOTE - Application of a secondary absorbing device (as described in *B3* below) may reduce the ambient contribution coupled into the lead through from the mains supply.

b) EUT measurement procedure

For each lead connected to the EUT (see 2.5.4) the following measurement procedure shall be applied.

B1. Pre-scan at a fixed position

The clamp shall be positioned at the SRP + 0.1 m. The EUT shall be switched on and the operating conditions shall be as specified in clause 2.5.6. For this fixed position and for each of the relevant operating modes of the EUT a frequency scan shall be performed to find the operating modes at which the highest emissions occur. For the mode of operation at which the maximum emission occurs, the final-scan procedure shall be performed. A peak detector may be used in this pre-scan procedure.

NOTE - The results obtained from the pre-scan at a fixed location are somehow related to the results that will be obtained by using the final scan procedure. So this pre-scan procedure is only adequate if for the different modes of operation, the spectral components of the emission spectrum appear at the same frequencies.

The pre-scan procedure is also used to gain information on the type of disturbances (narrowband, broadband). The procedure for the final scan will depend on the type of disturbance found. Guidance on the procedures for narrowband, broadband, continuous and discontinuous disturbances can be found in the clauses 2.3.2 and 2.3.4 and in CISPR 14.

B2. Final scan

Depending on the type of disturbance found during the pre-scan procedure, for the final scan, the following two alternative procedures can be applied:

<u>1. Measurement at fixed frequencies and clamp scanning continuously:</u>

The position of the CRP of the absorbing clamp along the lead shall be varied continuously over a length of one free space half-wavelength between SRP + 0.1 m and SRP + 5.1 m distance from the EUT at each test frequency. At each frequency, the maximum indication obtained on the measurement receiver connected to the absorbing clamp shall be determined.

<u>2. Measurement at fixed clamp positions and receiver scanning over the frequency band:</u>

It may be more convenient to position the absorbing clamp along the clamp slide at a sufficient number of discrete positions depending on the upper frequency applied. For instance a step size of 0.02 m is sufficient if the maximum frequency is 1000 MHz (step size is 1/15 wavelength). The measurement receiver shall perform full frequency scan at each clamp position. The measurement receiver shall maintain the maximum reading for all positions. A constant step size along the whole lead under test would increase the measurement time significantly. As the distance between the EUT and the absorbing clamp increases, a progressive step size may be used. This reduces the number of steps considerably. Tables S1 and S2 show the sample schemes that can be applied depending on the upper frequency used.

B3. Application of the secondary absorbing device.

For the EUT measurement procedure described above, a SAD shall be applied to reduce the measurement uncertainty. The SAD shall be moved together with the first clamp, as shown in figure XXb. The measurement uncertainty depends on the application of such a SAD. The lowest measurement uncertainty is achieved when this SAD is applied as specified. Typical uncertainty budgets for both measurement configurations are given in CISPR 16-3.

2.5.8 Derivation of disturbance power

From the measurement data for each of the LUTs, the disturbance power shall be calculated.

The disturbance power P corresponding to the measured voltage V at each test frequency is calculated by using the Clamp Factor (CF) obtained from the absorbing clamp calibration procedure described in clause 5.3 of CISPR 16-1.

$$P = V + CF \tag{1}$$

where

P = the disturbance power in dBpW

V = the measured voltage in dBì V

CF = the Clamp Factor in dBpW/ì V

2.5.9 Derivation of the measurement uncertainty

For each absorbing clamp test facility, the actual standards induced uncertainty value U_{lab} shall be determined using the guidance given in CISPR 16-3.
Uncertainties due to various measurement uncertainty factors must be taken into account in the compliance criterion (clause 2.5.10) to a certain level. This means that uncertainties in excess of an agreed value U_{cispr} shall be incorporated in the compliance criterion. The U_{cispr} values for the absorbing clamp test method are given in CISPR 16-4.
Guidance for determination of the actual uncertainty budgets, including typical examples, is given in CISPR 16-3. Note that the uncertainty budgets depend on whether a secondary absorbing device is applied or not.

2.5.10 Compliance criteria

The disturbance power P obtained for each of the LUTs shall be checked for compliance against the applicable limit P_L as a function of the frequency. The compliance criterion shall also incorporate the measurement uncertainty to a certain extent. Guidance on the application of the compliance criterion is given in CISPR 16-4.

In case of market control, a different compliance criterion shall be applied. In the latter situation, also the uncertainty of the market controllers test house U_{contr} shall be taken into account. The guidance for application of compliance criteria for market control is presently under development within CISPR. Most probably this guidance will be published in a future edition of CISPR 16-3.

Table S1- Sample scheme for an absorbing clamp measurement with an upper frequency bound of 300 MHz

Range of positions of the absorbing clamp (CRP with respect to the SRP)		**Sample distance** (m)	**Number of samples**
SRP + 0.1 m	SRP + 0.40 m	0.06	5
SRP + 0.40 m	SRP + 0.80 m	0.10	4
SRP + 0.80 m	SRP + 1.7 m	0.15	6
SRP + 1.7 m	SRP + 2.9 m	0.20	6
SRP + 2.9 m	SRP + 5.1 m	0.30	8
Total number of samples along lead under test			29

Table S2 - Sample scheme for an absorbing clamp measurement with an upper frequency bound of 1000 MHz

Range of positions of the absorbing clamp (CRP with respect to the SRP)		**Sample distance** (m)	**Number of samples**
SRP + 0.1 m	SRP + 0.2 m	0.02	5
SRP + 0.2 m	SRP + 0.4 m	0.04	5
SRP + 0.4 m	SRP + 0.8 m	0.05	8
SRP + 0.8 m	SRP + 1.4 m	0.10	6
SRP + 1.4 m	SRP + 3.0 m	0.20	8
SRP + 3.0 m	SRP + 5.1 m	0.30	8
Total number of samples along lead under test			40

~~2.5.4~~

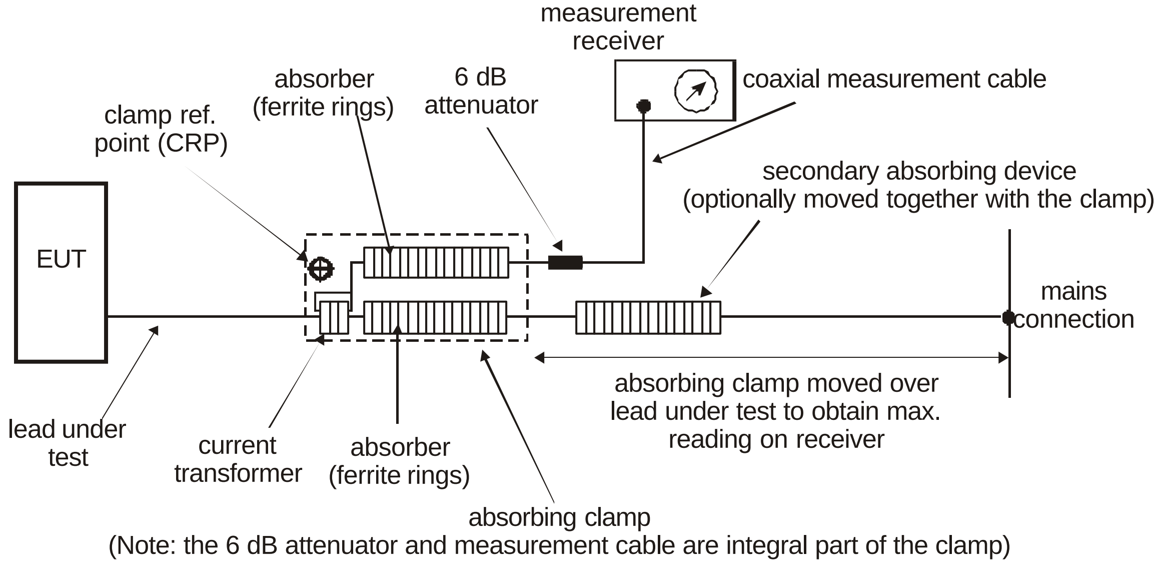

Figure XXa - Schematic drawing of the absorbing clamp measurement method
(see clause 2.5)

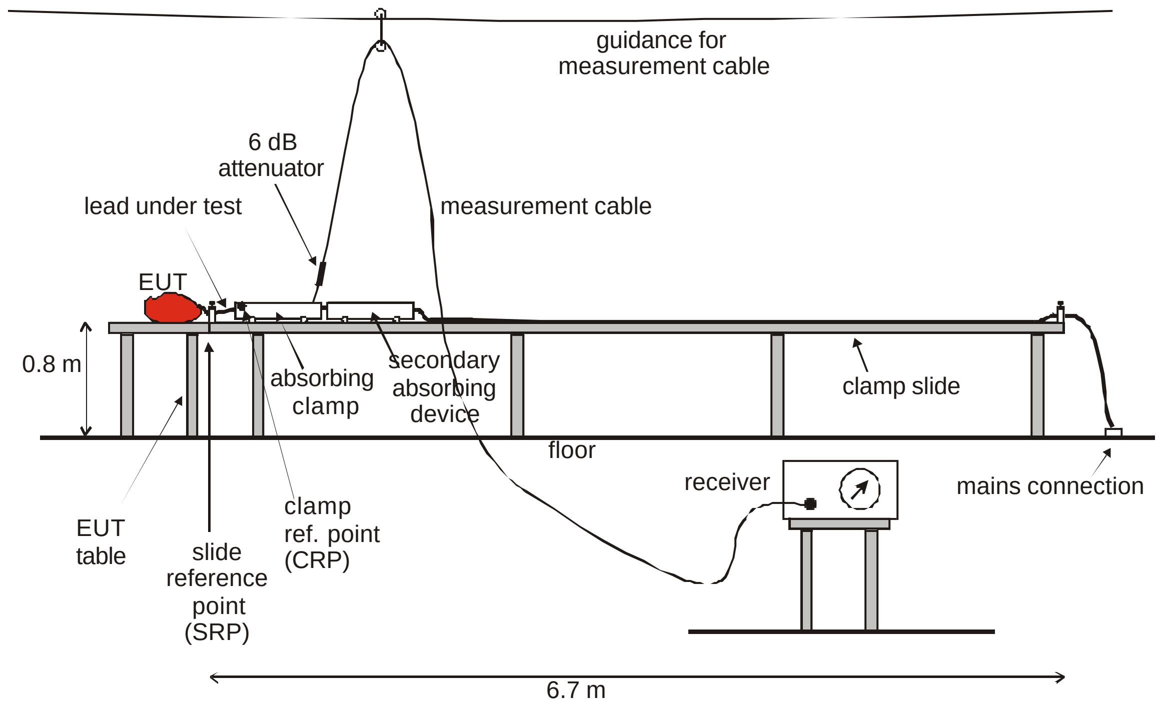

Figure XXb – Side view of the test set up of the absorbing clamp measurement method (see clause 2.5)

Annex C
(informative)

Historical background to the method of measurement of the disturbance power by using an absorbing clamp
(see clause 2.5)

C.1 Historical detail

Although measurement of field strength is, in theory, the most suitable for determining the interference capability of all types of appliances at frequencies higher than 30 MHz, the methods involved together with the precautions to be taken prove troublesome in application.
Consequently, engineers have for a long time used the terminal voltage method, while waiting for something more satisfactory. Several methods have been envisaged to replace those involving field measurements in open air by radiation measurements in the laboratory. Among the most interesting are the stop filter method and the ground current method. These are substitution methods, in which a slotted coaxial filter having negligible losses is used to adjust the radiating length of the supply lead of the source of interference in such a way as to obtain maximum radiation. In these methods, the interference capability of an appliance is defined as the power which a standard generator must inject into a simple aerial of known characteristics in order to obtain the same effect on an aerial connected to the measuring apparatus as that produced by the source of interference. Several more convenient methods have been developed from those just mentioned.

The measurement of terminal voltages has been considerably improved by replacing the artificial mains V-network by a Y-network, so as to obtain the true common mode voltage produced by the source of interference. A similar method using a reactive slotted coaxial filter was developed. A method for measuring the power that the source of interference may inject into the supply lead has also been proposed. This method is based on the measurement of the current at the input of an *absorbent* coaxial device.

The advantage of the latter over the terminal voltage method is that it is not necessary to disconnect the supply lead. It indicates values of the interference power corresponding closely with those obtained by the methods in which the radiation of the supply lead is measured in the resonant condition.

Although, through their ease of operation, the terminal voltage and the absorbing coaxial device methods were preferable to the stop filter and the ground current methods, it remained to be shown that the results which they gave conformed with those obtained in practice.
Statistical measurements on the disturbance sources have shown that the interference measured by the stop filter method agrees more closely than that measured by the terminal voltage method, with the effect of the same sources measured at the input of receivers located in the same building. Measurements made by the absorbent device method gave results intermediate between the two previous ones. Other methods have been compared.

C.2 Development of the method

In the stop filter method, a value directly related to the current at the center of a resonant half-wave aerial is measured. The most important thing is not the radiating system but the power that the source of interference is capable of transmitting to the radiating system. The same principle applies to the ground current method. If it were possible to measure this power without measuring a field, all the disadvantages arising from the influence of surrounding objects on the propagation between the radiating elements and the receiving aerial would be removed.
The attempt to replace the coaxial stop filter by a ferrite tube showed that a large part of the energy produced by the source of interference was dissipated in this tube. It was then thought that the measurement of the current at the input of the ferrite tube might replace, at least in part, the measurement of the field by the stop filter method. This gave rise to the devices described in annex K of CISPR 16-1.

The following question was then studied: how do the different methods of measurement compare in the particular case of a *shielded source* of interference of given available power, with a purely resistive internal impedance when transmitting all its interference energy to the supply lead in the common mode when the size of this source is varied? Experimental investigations showed the remarkable fact that the new device gave results which were practically independent of the dimensions of the source of interference (3,5 dm^3 to 1700 dm^3) and which were also more consistent than those obtained by other methods.

In fact, one can reduce the absorbing device measuring system to the following circuit: a source of interference of internal impedance Z_S supplying a load Z_C through a low-loss line of characteristic impedance Z_L. If the length of the line is varied from zero, the power absorbed by the load Z_C passes (when Z_C is different from Z_L) through maxima and minima corresponding to resonance and anti-resonance of the system.

Neglecting the radiation and other losses of the line and discussing the case in which the load is located at a distance corresponding to the first maximum, we consider the point in the line at which the source and the load appear as pure resistance R_S and R_C. It can thus be shown that if P_d is the available power of the source, P_C the power absorbed by the load and

$$m = \frac{R_s}{R_c}$$

then

$$\frac{P_c}{R_d} = \frac{4m}{(m+1)^2}$$

This gives for

$$m = 0{,}1 \quad 0{,}2 \quad 0{,}5 \quad 1 \quad 2 \quad 5 \quad 10 \quad 20 \quad 30$$

$$M = 10 . \log \frac{P_c}{P_d} = -4{,}8 \quad -2{,}5 \quad -0{,}5 \quad 0 \quad -0{,}5 \quad -2{,}5 \quad -4{,}8 \quad -7{,}4 \quad -9 \text{ dB}$$

It will be seen that the matching of the source to the lead is not very critical and that, if an absorbent clamp is used to constitute a load, for example of the order of 200 Ù, the results obtained will not be very different from those obtained if a load is applied to the output of the source of interference in the form of a line brought to resonance by means of a coaxial stop filter.

More details on the development and theory of operation of the absorbing clamp are described in [C.4.1].

C.3 Reasons for improvement of the clamp measurement method

The absorbing clamp measurement method has proven to be a convenient method for compliance testing and is widely used for several types of commercial electronic equipment (ref CISPR 13 and 14). However, the method is not without critics. For instance in [C.4.2] several drawbacks of the method and suggestions for improvement have been described. Also the validity of the ‘transmission line model’ of the clamp measurement method at higher frequencies is criticized in this paper.
The clamp measurement method is also useful for pre-compliance testing purposes. However, then the relation of the absorbing clamp measurement results with radiated emission measurement results is not always clear, due to relatively large uncertainties and different types of uncertainty sources associated with both methods.
In the past decade, the uncertainties and repeatability of EMC measurement methods in general, became a very important issue. This was driven by the fact that the EMC measurements suffer a relatively large intrinsic uncertainty and by the fact that accreditation bodies require inclusion of uncertainties in the compliance criteria. Also for the clamp calibration and clamp measurement method, this was the impetus for improvements i.e. to reduce the uncertainties associated with the clamp measurement method and clamp calibration method.
In [C.4.3], the results of an extensive study on the uncertainties of the calibration and use of absorbing clamps are reported. Various influence quantities were investigated experimentally and suggestions for improvement were given, such as

- The application of a secondary absorbing device,
- Keeping the cable under test central within the clamp,
- Remove objects and personnel 1 m away from the set up
- Application of a 6 dB attenuator directly at the output of the clamp

The latter suggestions are incorporated in the clamp measurement method and in the clamp calibration method.
Finally, it should be noted that the absence of a valid model of the clamp measurement method and the lack of knowledge of the true sensitivity coefficients associated with each influence quantity, makes the uncertainty assessment very difficult.

C.4 References

[C.4.1] J. Meyer de Stadelhofen, ’A new device for radio interference measurements at VHF: the absorbing clamp’, Proceedings, IEEE Int. EMC Symposium, 1969, pp. 189 – 193.

[C.4.2] H.K. Kwan, ‘A theory of operation of the CISPR absorbing clamp’, Proceedings of the IEE Symposium on EMC, 1988, pp. 141 -143.

[C.4.3] T. Williams, ‘Calibration and use of the CISPR absorbing clamp’, EMC Europe Symposium, Brugge, 2000, pp. 527 - 532.