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Title:
Calibration of the absorbing clamp in the frequency range 30 MHz to 1000 MHz (ref CISPR 16-1, Clause 5.3 and Annex H)

(Titre) :

Introductory note

This document takes into account the discussion of the subject at the CISPR A Working Group 1 meetings in Bristol and the Collation of Comments document referenced above. There remains areas which need further consideration by the working group and the project team, based on NC comments, as indicated in document CIS/A/313/CC. Therefore it was decided to issue a second CD to assure that the issues raised have been adequately addressed.

Introductory note:

This CD is the second CD on the calibration of the absorbing clamp.

The first CD was published in CISPR/A/292/CD in March 2001. Comments on this CD were collated in CISPR/A/313/CC. Both documents were discussed during the CISPR meeting in Bristol.

The comments of CISPR/A/313/CC and the results of the discussion held during the CISPR/A/WG1 meeting are incorporated in the present 2nd CD.

The major changes with respect to the first CD are:

a. Introduction of an additional clamp calibration method using a reference device.
b. Clarification of the relation between the absorbing clamp measurement method, the three possible absorbing clamp calibration methods and the validation method of the absorbing clamp test site.
c. Introduction of a reference device for both clamp calibration and for site validation
d. Introduction of verification methods for the decoupling properties of the absorbing clamp and of the secondary absorbing device
e. Introduction of quality assurance test methods for the absorbing clamp and for the whole absorbing clamp test set up

Note that the scope (title) of the Clause 5.3 is changed from 'absorbing clamp' to 'absorbing clamp instrumentation', because the clause now contains requirement specifications for

- The absorbing clamp
- The secondary absorbing device
- The absorbing clamp test site

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE (CISPR)

Subcommittee A: Radio Interference Measurements and Statistical Methods

Working Group 1: EMC Measurement Instrumentation

Subject: **CISPR 16-1 Amend. 1 f3 Ed. 2.0**
Calibration of the absorbing clamp in the frequency range 30 MHz to 1000 MHz (ref CISPR 16-1 Clause 5.3 and Annex H)

Notes:
1. The text given by this CD replaces the present Clause 5.3 and the Annexes H and J of CIISPR 16-1. Also a new Annex (identified as Annex HX) is added.

2. The following list of abbreviations is given here for convenience of the reader of this CD. Normally such a list is not incorporated in a sub clause. Therefore, this list is not part of the CD.

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
DM = the decoupling factor that specifies the decoupling of the current transformer from the common mode impedance of the measurement cable
EUT = Equipment Under Test
JTF = Jig Transfer Factor
LUT = Lead Under Test
NSA = Normalized Site Attenuation
NWA = Network Analyzer
OATS = Open Area Test Site
RTF = Reference Transfer Factor
SAD = Secondary Absorbing Device
SAR = Semi Anechoic Room
SRP = Slide Reference Point

Absorbing clamp instrumentation for use in the frequency range 30 MHz to 1000 MHz

Introduction

Measurement of the disturbance power using the absorbing clamp is a method for the determination of the radiated disturbance in the frequency range above 30 MHz. This measurement method is an alternative method for the measurement of the disturbance field strength on an OATS. The absorbing clamp measurement method (ACMM) is described in Clause 2.5 of CISPR 16-2.
The ACMM uses the following measurement instrumentation:

- The absorbing clamp assembly
- The secondary absorbing device
- The absorbing clamp test site

Figure Y.1 gives an overview of the absorbing clamp measurement method including the instrumentation required for this method and including the calibration and validation methods for the instrumentation. The requirements for the instrumentation necessary for the ACMM are laid down in this clause 5.3. Details on the absorbing clamp calibration method, and validation of other properties of the clamp and the secondary absorbing are described in Annex H. Details on the absorbing clamp test site validation are described in Annex HX.
Absorbing clamps can be used for the emission measurement if the radiation via the connected cables is dominant and the case of the EUT is smaller than $\lambda/4$ of the measured frequency. The disturbance capability of an appliance having a mains lead being the only external lead may be taken as the power it 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. Radiation direct from the appliance is not taken into account. Equipment having external leads other than a mains lead can radiate disturbing energy from such leads, shielded or unshielded, in the same manner as radiation from the mains lead. Absorbing clamp measurements can be done on these leads also.
The application of the ACMM is specified in more detail in Clause 2.5.2 of CISPR 16-2.

The absorbing clamp assembly

a. Description of the absorbing clamp assembly

Annex J describes the construction of the clamp and gives a typical example such a construction.
The absorbing clamp assembly consists of the following six parts:

a) A broadband RF current transformer;
b) A broadband RF power absorber and impedance stabilizer for the lead under test;
c) 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;
d) A 6 dB attenuator between the output of the absorbing clamp and the coaxial cable connecting to the measuring receiver;
e) A coaxial cable as measurement 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.

b. The clamp factor and the clamp site attenuation

An actual measurement of an EUT using the ACMM is depicted in a schematic way in Figure Y2. Details on the ACMM are given in Clause 2.5 of CISPR 16-2.
The disturbance power is measured at the connected lead of an EUT which is smaller than λ/4 of the measured frequency[1]. The disturbance power measurement is based on the measurement of the asymmetrical current generated by the EUT that 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 disturbance on the mains. The maximum current is determined by moving the absorbing clamp along the stretched lead. The stretched lead 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_{rec} 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:

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

where: Z_i = 50 Ω, input impedance of the measuring receiver, and
V_{rec} = measured voltage level in dBμV.

Using the Eqs. 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:

$$P_{eut} - P_{rec} = CF_{act} + 17 \tag{3}$$

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).

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

This actual clamp site attenuation depends on both the clamp response properties, the site properties and on the EUT properties.

c. Decoupling functions of the absorbing clamp

Where the current transformer of the absorbing clamp measures the disturbance power, the decoupling attenuation of the ferrites around the lead under test separates the current transformer from the far end of the lead under test. This separation reduces the disturbing

[1] Product committees may in justified cases allow the use of the absorbing clamp also for equipment with dimensions greater than λ/4.

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 common mode impedance of the measurement 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 (DM).

d. Requirements for the absorbing clamp assembly

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

a) Clamp factor (CF) of the absorbing clamp assembly, as defined in 5.3.2.a shall be determined in accordance with the normative methods described in Annex H. The uncertainty of the clamp factor shall be determined in accordance with the requirements given in Annex H.

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 H. The decoupling factor shall be at least 20 dB at 30 MHz.

c) The decoupling function from the lead under test to the measuring output (DM) of the absorbing clamp. The measurement procedure is under discussion. The decoupling factor to the measurement receiver shall be at least YY dB at 30 MHz.

d) The length of the clamp housing shall be 600 mm ± 30 mm.

e) An attenuator of at least 6 dB shall be used directly at the clamp output.

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 5.3.2.b we have seen that the clamp factor is a function of the EUT, the clamp properties and the site performance. For standardization (reproducibility) reasons, the calibration method has to apply:

a. A test site with a specified and reproducible performance
b. An EUT with a specified and reproducible performance

In this way, the variable left is the clamp under consideration.

Three clamp calibration methods are developed each with their own advantages, disadvantages and applications (see Table Z1). Figure Y3 gives a schematic overview of the three possible methods.

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

First, as a reference, the output power P_{gen} of the generator is measured directly through a 10 dB attenuator using a receiver (Figure Y3a). Secondly, the disturbance power of the same generator and 10 dB attenuator is measured through the clamp using the following three possible methods.

1. The original method

The original clamp calibration method uses a reference site including a large vertical reference plane (Figure Y3b). The lead under test is connected to the center 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_{org} is measured while the clamp is moved along the lead under test in accordance with a certain procedure such that for each frequency the maximum value is obtained. The minimum site attenuation A_{org} and the clamp factor CF_{org} can be determined using the following equations:

$$A_{org} = P_{gen} - P_{org}$$
and (5)
$$CF_{org} = A_{org} - 17$$

2. The jig calibration method

The jig calibration method uses a small jig that serves as a reference structure for the clamp (Figure Y3c). For this calibration configuration P_{jig} is measured as a function of the frequency while the clamp is in a fixed position within the jig. The site attenuation A_{jig} and the clamp factor CF_{jig} can be determined using the following equations:

$$A_{jig} = P_{gen} - P_{jig}$$
and (6)
$$CF_{jig} = A_{jig} - 17$$

3. 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 that is a coaxial structure for this reason (Figure Y2d).

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

$$A_{ref} = P_{gen} - P_{ref} \quad (7)$$
and
$$CF_{ref} = A_{ref} - 17$$

Annex H describes the three possible clamp calibration methods in more detail. A survey of the three clamp calibration methods is also given in Figure Y1. Figure Y1 also gives the relation of the clamp measurement method and the clamp calibration methods and the role of the reference site.

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

The JIG transfer factor *JTF* is calculated by

$$JTF = CF_{jig} - CF_{org} \quad (8)$$

The *JTF* in dB is to be determined for each type of absorbing clamp by the clamp manufacturer.

Similarly, the reference transfer factor *RTF* is determined by

$$RTF = CF_{ref} - CF_{org} \tag{9}$$

Again, the *RTF* in dB is to be determined for each type of absorbing clamp by the clamp manufacturer.

In summary, the original calibration method directly gives the value of CF_{org}. The jig and the reference device method give the CF_{jig} and the CF_{ref} respectively, from which the original clamp factor can be calculated using the Eqns. 8 and 9.

The 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 measurement. The function of this SAD is to provide attenuation in addition to the attenuation provided by the decoupling attenuation of the absorbing clamp. This attenuation of the secondary absorbing device is also called the Decoupling Factor (DF).

The decoupling factor of the SAD shall be verified in accordance with the measurement procedure as described in Annex H. The decoupling factor for the SAD shall be at least 20 dB at 30 MHz.

The absorbing clamp test site (ACTS)

a. Description of the ACTS

The Absorbing Clamp Test Site (ACTS) is a site that is used for application of the ACMM. The ACTS can be either an outdoor or indoor facility and includes the following elements (see Annex HX, Figure HX.1):

- The EUT table which is a support for the EUT unit
- The clamp slide which is a support for the connected lead of the EUT (or lead under test (LUT) and for the AC and the SAD
- A gliding support for the measurement cable of the AC
- 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 HX1.1). This SRP is used to define the horizontal distance to the CRP of the clamp.

b. The functions of the ACTS

The ACTS has the following functions:

b1. The geometrical function: to provide specific supporting means for the EUT and the LUT.

b2. The electrical function: to provide a horizontal and ideal (RF-wise) site for the EUT and the clamp assembly and to provide a well defined measurement environment for application of the absorbing clamp (no distortion of emissions by walls or by the supporting elements like the EUT table, the clamp slide, gliding support and rope)

c. Requirements for the ACTS

The following requirements apply for the ACTS:

c1. 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 (0.04 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.

c2. The height of the clamp slide shall be 0.8 m. 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.

c3. The material of the EUT table and of the clamp slide 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.

c4. The material of the rope used to move the clamp along the clamp slide shall also be neutral from an electromagnetic point of view.

c5. The adequateness of the site (see the electrical ACTS function) is verified by comparing the site attenuation of the ACTS (A_{ref}^{ACTS}) with the site attenuation of the ACRS (A_{ref}^{ACRS}) using the reference device calibration method (see Clause 5.3.3). The absolute difference between both site attenuations shall comply with the following requirement:

$$\Delta A_{ref} = \left| A_{ref}^{ACTS} - A_{ref}^{ACRS} \right|$$

shall be

< 3 dB between 30 and 150 MHz, (10)

< 2 dB between 150 and 300 MHz, and

< 1 dB between 150 and 1000 MHz

This site validation procedure is specified in more detail in the next sub clause.

Validation methods for the ACTS.

The requirements for the ACTS are validated as follows.

The geometrical requirements c1 and c2 can be validated by inspection.

The electrical function of the ACTS (requirement c5) shall be validated by comparing the site attenuation of the ACTS with the site attenuation of the ACRS both in accordance with the reference device method.

Investigations have shown that a 10 m OATS or SAR validated for radiated emission measurements can be considered as an ideal site for performing the ACMM. This means that the uncertainty contribution due to the site is less than t.b.d. dB. Therefore, a validated 10 m OATS or SAR is adopted as a reference site for electrical validation of the ACTS. Consequently, if a validated 10 m OATS or SAR is used as a clamp test site, then the electrical function of this site does not need to be validated anymore.

The validation procedure of the electrical function of a clamp test site is described in detail Annex HX.

Quality assurance procedures for the absorbing clamp instrumentation.

a. Introduction

The test houses need procedures for the verification of the quality of the absorbing clamp instrumentation, i.e. the absorbing clamp assembly, the SAD and the ACTS because these elements may be subject to changes.

For instance, the performance of the absorbing clamp and the performance of the secondary absorbing device may be change in time by use or by aging or by defects. Similarly, the ACTS performance may change due to changes in the construction or by aging.

The jig calibration method and the reference device calibration method are methods that can be used conveniently for quality assurance procedures provided that the jig clamp factor and the reference device clamp factor are initially known.

b. Quality assurance check for the ACTS

The data of the site attenuation A_{ref} of the ACTS determined at the time the site has been validated can be used as a reference.

After a certain time interval and after modification of the site, this site attenuation measurement can be repeated, and the results can be compared with the reference data.

The advantage of this method is that all elements of the ACMM are evaluated at once.

c. Quality assurance check for the absorbing clamp

The decoupling functions and the clamp factor performance determined at the time the clamp has been validated, can be used as reference performance data.

After certain time intervals, these performance parameters can be verified again by measuring the decoupling factors and by measuring the clamp factor using the jig method (Annex H).

d. Quality assurance check for the SAD

The decoupling factor of the SAD determined at the time the SAD has been validated, can be used as reference performance data.

After certain time intervals, the decoupling factor can be verified again by measuring the decoupling factors (Annex H).

e. Quality assurance pass/fail criteria

The pass/fail criteria for the quality assurance tests are related to the measurement uncertainty of the measurement parameter in question. This means that a change of the parameter in question is acceptable if this change is less than one times the measurement uncertainty.

Relation of the disturbance power limit to the field strength limits

If a product committee is setting a limit for the disturbance power for its product or product family, it shall consider the ratio of the radiated field strength to the measured disturbance power.

In general it can be assumed that the ratio of the measured disturbance power to the radiated field strength decreases by 10 dB per decade in the frequency range 30 MHz to 300 MHz and by 20 dB per decade in the frequency range 300 MHz to 1000 MHz.

Figure Y1: Overview of the absorbing clamp measurement method and the associated calibration and validation procedures

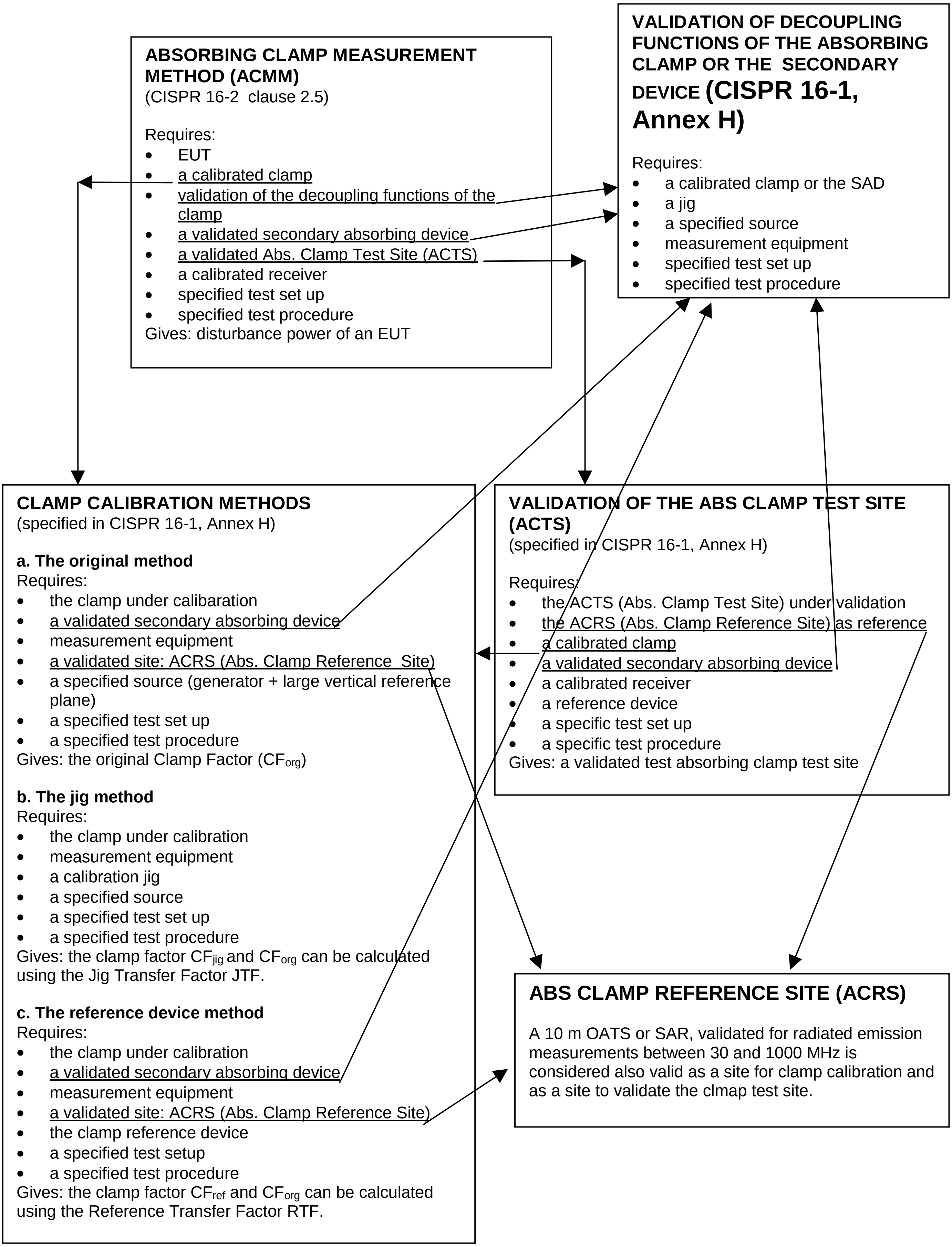


Table Z1:Overview of the characteristics of the three clamp calibration methods and their relation

Name of the calibration Method	'Test Site' used	'EUT' used	Advantages (+), disadvantages (-) and remarks (•)	Applications
The original method	An Abs. Clamp Reference Site	Large vertical reference plane and fed behind this reference plane by a generator	• Calibration set up resembles an actual measurement with a large EUT - Handling of the large vertical reference plane is laborious - A reference site (ACRS) required + By definition this method gives directly the CF because this method is the original calibration method and therefore considered as the reference	• Direct calibration of the absorbing clamp
The jig method	An Abs. Clamp Calibration Jig	One of the vertical flanges of the jig and fed behind this jig flange by a generator	- Calibration set up does not resemble an actual test + Convenient handling + No reference site (ACRS) required + Good reproducibility - Does not give directly the CF; CF is calculated using the JTF	• Indirect calibration of the absorbing clamp • Quality assurance check of the clamp
The reference device method	An Abs. Clamp Reference Site	Small reference device fed from the far end by a generator	• Calibration set up resembles an actual measurement with a large EUT + Reference device easy to handle - A reference site (ACRS) required - Does not give directly the CF; CF is calculated using the RTF	• Indirect calibration of the absorbing clamp • Validation of the ACTS • Quality assurance check of the overall clamp measurement set up

Note: an ACRS is a validated 10 m OATS or SAR facility

Figure Y2: Schematic overview of the absorbing clamp test method

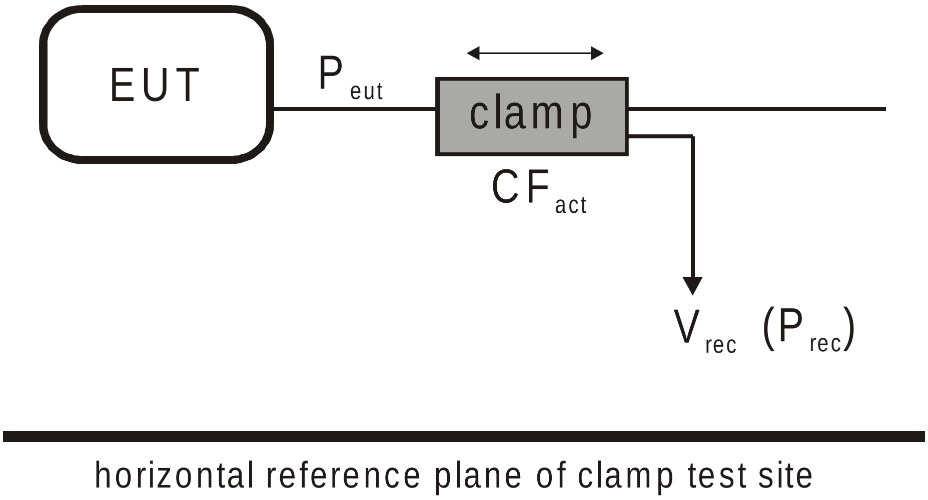
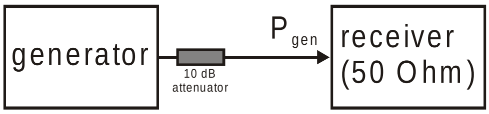
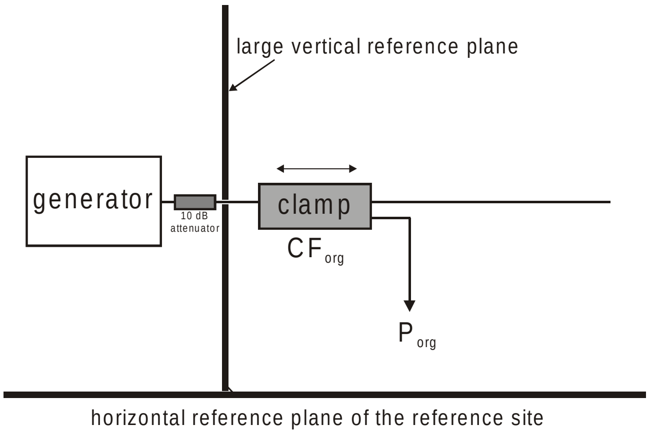


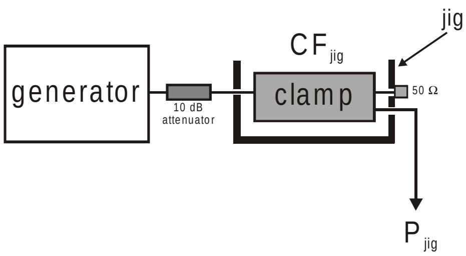
Figure Y3: Schematic overview of the clamp calibration methods



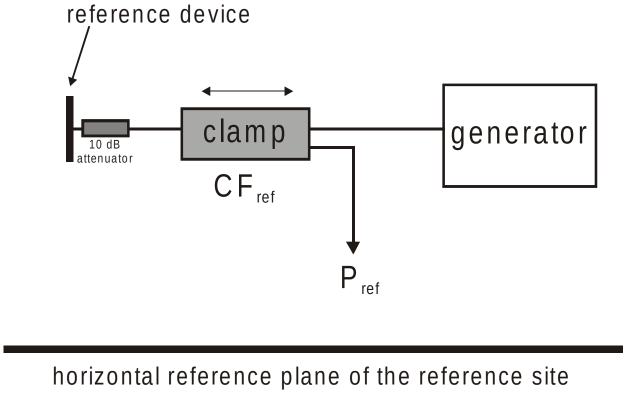
a.



b.



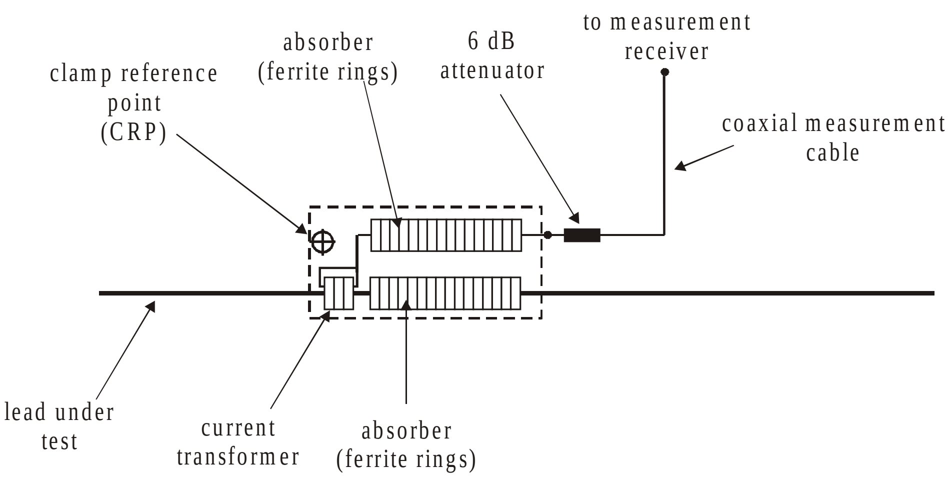
c.



d.

Annex J
(informative)
Construction of the absorbing clamp
(clause 5.3)

Old Annex J text can be used, but may need some minor revision.



the absorbing clamp assembly
(Note: the 6 dB attenuator and measurement cable are integral part of the clamp assembly)

Figure J.1 – The absorbing clamp assembly and its parts (Annex J)

B is the lead under test
C is the current transformer
D is the absorbing section
E is the absorbing section on cable from transformer
1 is the metal cylinder - two halves
2 is the centralizing tube for lead B
3 is the coaxial connector (for the 6 dB attenuator)

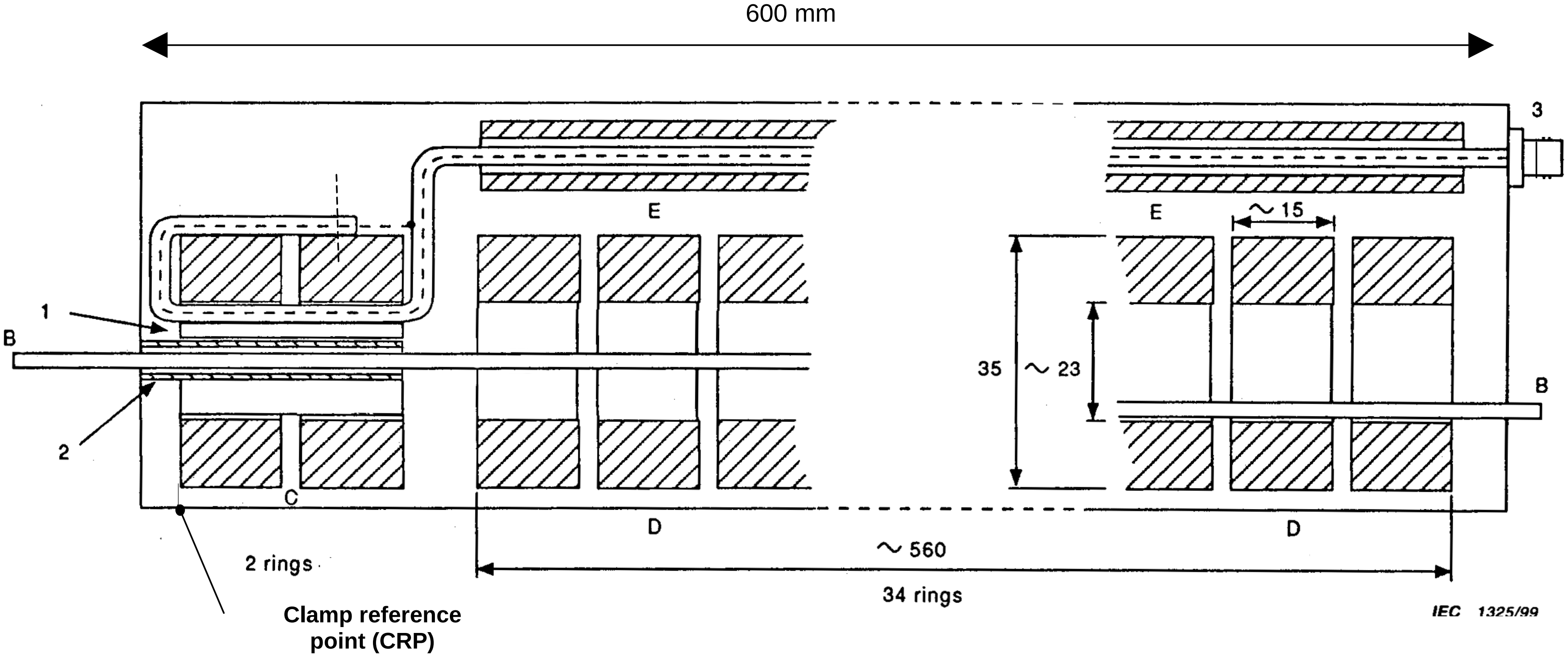


Figure J.2 - Example of the construction of an absorbing clamp (Annex J)

Annex H

(normative)

Calibration and validation methods for the absorbing clamp and the secondary absorbing device

(clause 5.3)

H.1 Introduction

This Annex gives the details on the various calibration and validation methods for the absorbing clamp assembly and for the secondary absorbing device.
The methods for the calibration of the clamp factor of the absorbing clamp (see also Clause 5.3.3) are given in H.2.
The methods for validation of the decoupling functions DF and DM are given in H.3.

H.2 Calibration methods of the absorbing clamp assembly

For all the three methods, the Clamp Factor (CF) of the absorbing clamp assembly including the required 6 dB attenuator and the measurement cable is determined.

H.2.1 The original calibration method

a. Calibration set up and equipment

Figure H.1 shows the calibration set up. The calibration set up must be located on an ACRS to avoid influence of its immediate surroundings. If the ACRS does not have a metallic ground plane, a horizontal ground plane of typically 6 m x 2 m is required.

An ACRS that is valid for this calibration procedure is an OATS or a SAR for a 10 m measurement distance that complies with the CISPR NSA requirements.

The calibration set up comprises the following components:

- a clamp slide from non-reflective material about 6 m long, to ensure that the lead under test is at a height of about 0.8 m above the ground;
- a vertical ground plane larger than 2.0 m x 2.0 m, connected to the metallic ground plane and with a type N jack mounted in its vertical symmetrical axis at a height of 0.87 m. This vertical ground plane is positioned close to the front of the clamp slide, which is called the absorbing clamp test site reference point (SRP);
- an insulated lead for test purposes, with a length of approx 7.5 m and a cross-section of 4 mm^2, made of stranded wire, with one end connected (e.g. soldered) to the mounting jack. The other end of the lead is connected to the line and neutral of a type M CDN (see CISPR 16-1 Figure 45), which is connected to the metallic (horizontal) ground plane; the measurement output of the CDN is terminated with 50 Ω (**for safety reasons the CDN is not connected to the mains!**);

- an appropriate non-metallic clamping device at the other end of the clamp slide, to slightly stretch the lead under test;
- a secondary absorbing device (SAD) positioned on the clamp slide 100 mm from the clamp under calibration. The secondary absorbing device may be a (gliding) ferrite clamp with a decoupling function *DF* larger than or equal to that defined in 5.3;
- a buffer of non-reflective material near the vertical ground plane to ensure that the front edge of the current transformer is always exactly 150 mm from the vertical ground plane.

A receiver or a network analyzer is used to measure the generator output and clamp output. The measured signal levels shall be 40 dB higher than the ambient signals measured at the output of the absorbing clamp when the generator is switched off. The non-linearity of the measurement system shall be less than 0.1 dB.

As reference measurement, the tracking generator output of the receiver or NWA is connected via the coaxial cable through a 10 dB attenuator to the input of the NWA.

b. Calibration procedure

A non-metallic guide for the lead under test is mounted on the outside of the absorbing clamp under test so that the lead passes through the center of the current transformer (Figure H.2).

Both clamps – the clamp under test and the second absorbing clamp (SAD) – are positioned on the clamp slide as shown in Figure H.1. The current transformer of the clamp under test is placed with its side towards the vertical ground plane. The front edge of the current transformer is the clamp reference point (CRP) and shall be marked by the manufacturer. The clamp is positioned with a distance of 150 mm between the CRP and the vertical ground plane. The lead under test is passed through both clamps and should be stretched slightly using an appropriate non-metallic clamping device at the end of the clamp slide. The lead under test must not touch the metallic ground before it is connected to the CDN.

The output of the NWA is connected to the mounting jack via a coaxial cable and a 10 dB attenuator. The measurement cable of the absorbing clamp is connected to the input of the NWA.

The site attenuation is measured at least up to 60 MHz in 1 MHz steps, up to 120 MHz in 2 MHz steps, up to 300 MHz in 5 MHz steps, and above 300 MHz in 10 MHz steps.

The minimum site attenuation is measured while the two clamps are moved at a suitable speed from 150 mm to approx 3 m from the vertical ground plane. The clamps may be pulled by means of a non-metallic rope. The speed at which the clamps are moved must allow the insertion loss to be measured at each frequency at intervals less than 10 mm.

The clamp factor CF_{org} of the absorbing clamp assembly is calculated from the clamp site attenuation using Eqn. 5.

H.2.2 The jig calibration method

a. Specification of the absorbing clamp calibration jig

As described in Clause 5.3 the absorbing clamp calibration jig can be used for the calibration of the absorbing clamp. The jig is used for the measurement of the insertion loss of the absorbing clamp in a 50 Ω system. The measurement in a jig allows this insertion loss to be measured very well isolated from environment. The dimensional specifications of the jig are shown in Figures H.3 to H.5.

b. Calibration procedure

A non-metallic guide for the lead under test is mounted on the front side of the absorbing clamp under test so that the lead passes through the center of the current probe

(Figure H.4). The absorbing clamp is then positioned in the jig with the clamp reference point (CRP) of the absorbing clamp 20 mm from the metal.

The site attenuation is measured using a network analyzer (NWA). The measured signal level shall be 40 dB higher than the ambient signals measured at the output of the absorbing clamp. The non-linearity of the insertion loss measurement shall be less than 0.1 dB.

The output of the NWA is connected via a coaxial cable and a 10 dB attenuator to the input of the NWA to calibrate the measurement set up.

After the measurement set up has been calibrated, the output of the NWA is connected via the coaxial cable and a 10 dB attenuator to the mounting jack on the side of the jig where the CRP of the clamp is positioned. The mounting jack opposite the CRP is terminated with 50 Ω. The output of the absorbing clamp is connected via a 6 dB attenuator and the measurement cable to the input of the NWA.

The site attenuation is then measured at least up to 60 MHz in 1 MHz steps, up to 120 MHz in 2 MHz steps, up to 300 MHz in 5 MHz steps, and above 300 MHz in 10 MHz steps.

The clamp factor CF_{jig} is calculated from the site attenuation using Eqn. 6. At least the manufacturer is to determine the jig transfer factor *JTF* defined in Eqn. 8, which allows the CF_{org} for this type of absorbing clamp to be calculated.

H.2.3 The reference device calibration method

a. Specification and use of the reference device and test site

The reference device shall be able to generate a defined current on the lead under test, independent of any environment, supply voltage and measurement equipment. This is ensured where the reference device is fed with an RF voltage over a coaxial cable via a 10 dB attenuator. The reference device is a printed board with one metallic side that is connected to a 10 dB attenuator (see Figure H.7). A double shielded cable shall be used to connect this reference device to ensure that the currents induced on the lead under test stem from the reference device and not from direct leakage within the cable.

The reference device replaces the large vertical ground plane in the original calibration procedure on an ACRS. The calibration set up is shown in Figure H.6. The site suitable for this calibration method is the ACRS. An ACRS that is valid for this calibration procedure is an OATS or a SAR for a 10 m measurement distance that complies with the CISPR NSA requirements.

b. Calibration procedure

A non-metallic guide for the lead under test is mounted on the outside of the absorbing clamp under test so that the lead passes through the center of the current transformer (Figure H.2).

Both clamps – the clamp under test and the second (ferrite) clamp (SAD) – are positioned on the clamp slide as shown in Figure H.7. The current transformer of the clamp under test is placed with its side towards the reference device, which is positioned at the SRP of the clamp slide. The front edge of the current transformer is the clamp reference point (CRP) and shall be marked on the clamp case by the manufacturer. The clamp is positioned with a distance of 150 mm between the CRP and the reference device. The lead under test (the coaxial cable from the network analyzer) is passed through both clamps and should be stretched slightly using an appropriate non-metallic clamping device at both ends of the clamp slide.

The coaxial cable (lead under test) with the 10 dB attenuator is connected to the output of the NWA. The measurement cable of the absorbing clamp is connected to the input of the NWA.

The site attenuation is measured at least up to 60 MHz in 1 MHz steps, up to 120 MHz in 2 MHz steps, up to 300 MHz in 5 MHz steps, and above 300 MHz in 10 MHz steps.

The minimum site attenuation is measured while the two clamps are moved at a suitable speed from 150 mm to approx 5 m from the vertical ground plane. The clamps may be pulled by means of a non-metallic rope. The speed at which the clamps are moved must allow the insertion loss to be measured at each frequency at intervals less than 10 mm.

The clamp factor *CF* of the absorbing clamp assembly is calculated from the lowest measured site attenuation using Eqn. 7. At least the manufacturer is to determine the reference device transfer factor *RTF* using Eqn. 9 which allows the CF_{org} for this type of absorbing clamp to be calculated.

H.2.4 Measurement uncertainty of the absorbing clamp calibration

The calibration uncertainty is to be mentioned in every calibration report. The calibration report shall contain the following influencing factors:

- The original calibration method:
  - o the uncertainty of the measurement equipment,
  - o the mismatch between the output of the absorbing clamp (with a 6 dB attenuator) and the measurement equipment, and
  - o the repeatability of the calibrations, which includes factors such as centering the lead under test in the current transformer and guidance of the measurement cable to the network analyzer.

  The absorbing clamp is to fulfill the minimum requirement of the decoupling factors *DF* and *DM*.
- The jig calibration method:
  - o the uncertainty of the clamp factor *CF*,
  - o the uncertainty of the measurement equipment,
  - o the mismatch between the output of the absorbing clamp (with a 6 dB attenuator) and the measurement equipment, and
  - o repeatability of the calibrations, which includes factors such as centering the lead under test in the current transformer.

  The absorbing clamp is to fulfill the minimum requirement of the decoupling factors *DF* and *DM*.
- The reference device calibration method:
  - o the uncertainty of the clamp factor *CF*,
  - o the uncertainty of the measurement equipment,
  - o the mismatch between the output of the absorbing clamp (with a 6 dB attenuator) and the measurement equipment, and
  - o the repeatability of the calibrations, which includes factors such as centering the lead under test in the current transformer and guidance of the measurement cable to the network analyzer.

  The absorbing clamp is to fulfill the minimum requirement of the decoupling factors *DF* and *DM*.

H.3 Validation methods of the decoupling functions

H.3.1 The decoupling factor DF of the absorbing clamp and of the secondary absorbing device.

The measurement method of the decoupling factor applies for both the absorbing clamp and for the secondary absorbing device.
The decoupling factor DF is measured using the clamp calibration jig (see Figures H.3, H.4 and H.5).
The procedure for the measurement of the decoupling factor DF is as follows (see Figure H.8). Figure H.8 shows the two measurements steps that are necessary when using a spectrum analyzer. First a reference measurement performed. The output of the generator is measured through two 10 dB attenuators. Then, the output P_{ref} is measured. After this the clamp or the SAD is positioned as described in H.2.2.b. At both connections of the jig, a 10 dB attenuator is applied. The distance between the vertical flange of the jig and the reference point of the device under test (CRP in case of the clamp) shall be 20 mm. Then the output P_{fil} is the measured. The decoupling factor DF is determined as follows:

$$DF = P_{ref} - P_{fil} \qquad \text{(H.1)}$$

The decoupling factor for both the absorbing clamp and the SAD shall be at least 20 dB over the frequency band in question.

This measurement may be performed also with a NWA. In this case the application of the attenuators may be omitted if the NWA calibration is performed at the interfaces that are connected to the jig.

H.3.2 The decoupling factor DM of the absorbing clamp.

The measurement method of the decoupling factor DM is under discussion.

Figures related to Annex H

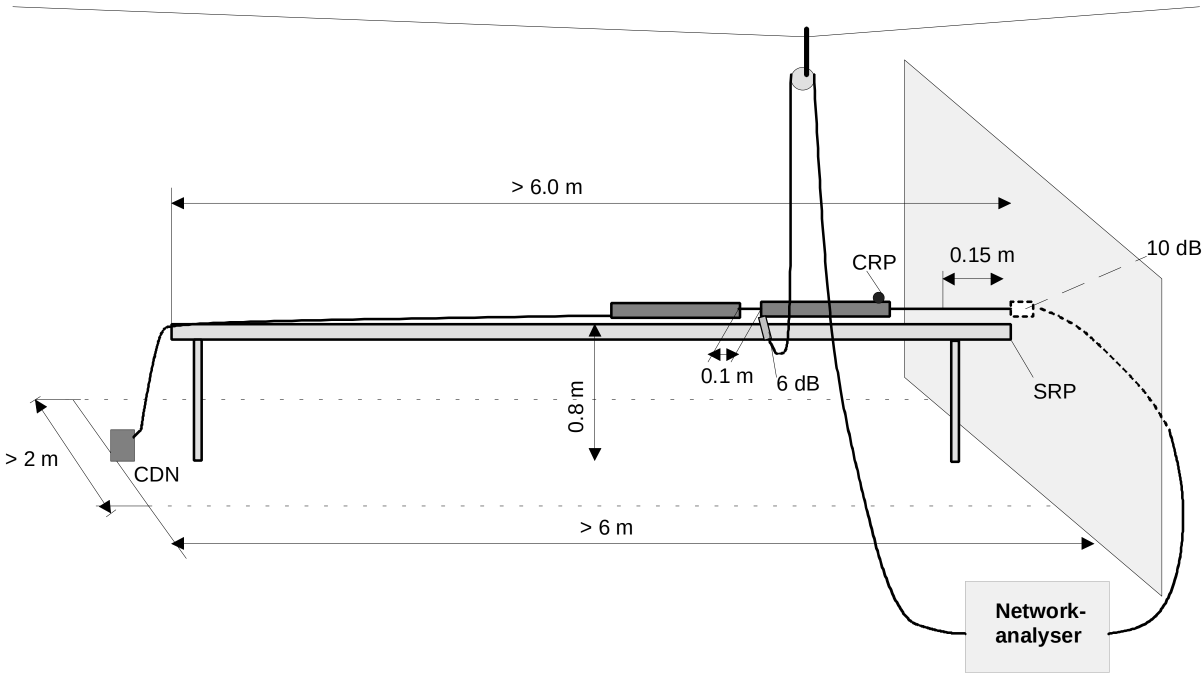


Figure H.1: The original calibration site

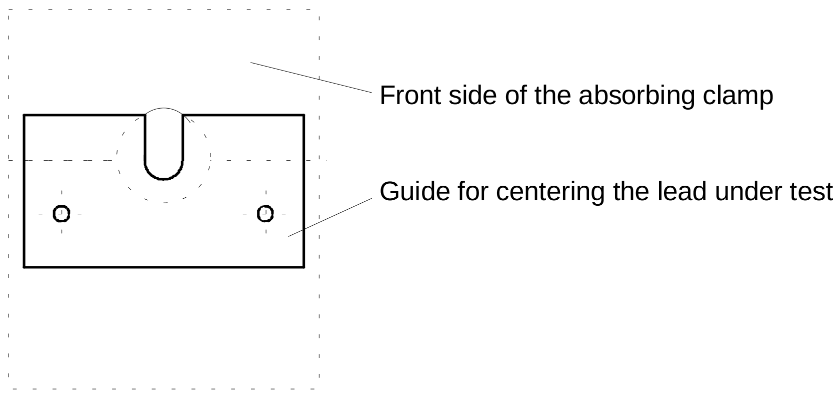


Figure H.2: Position of guide for centering the lead under test

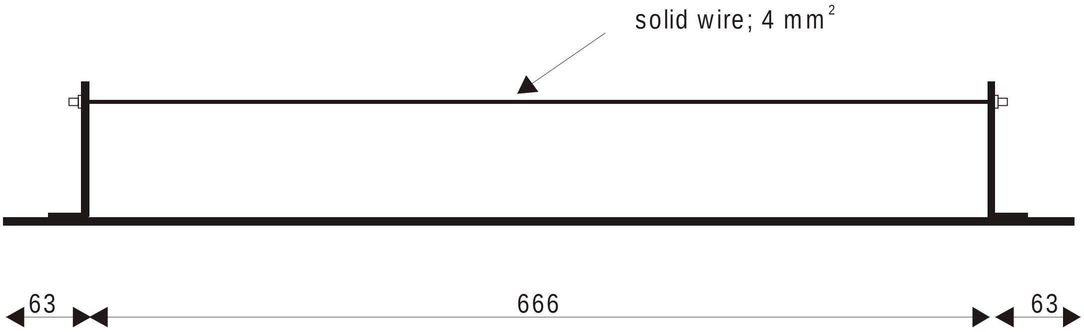


Figure H.3 Side view of the calibration jig (all dimensions in mm)

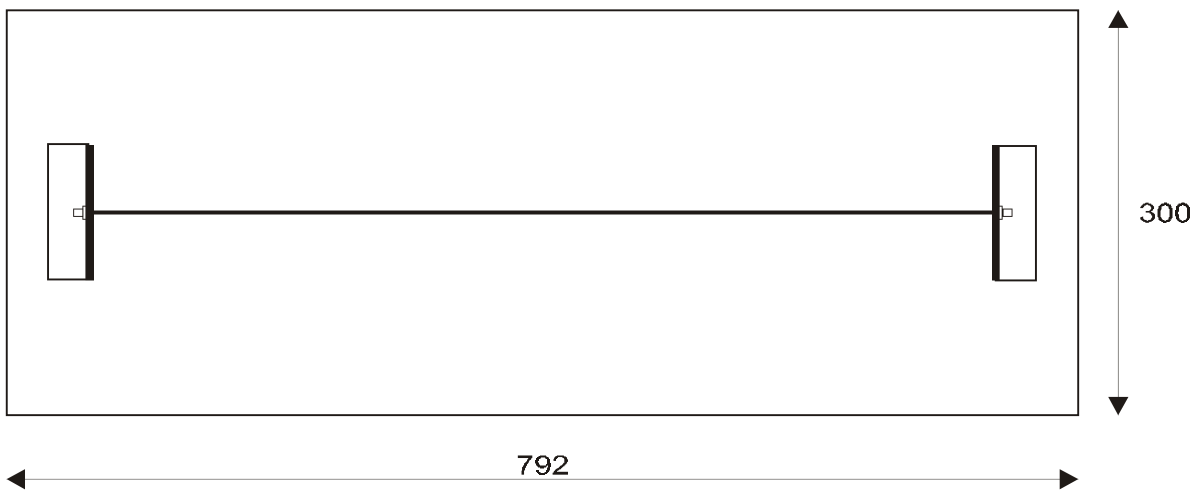


Figure H.4: Top view of the jig (all dimensions in mm)

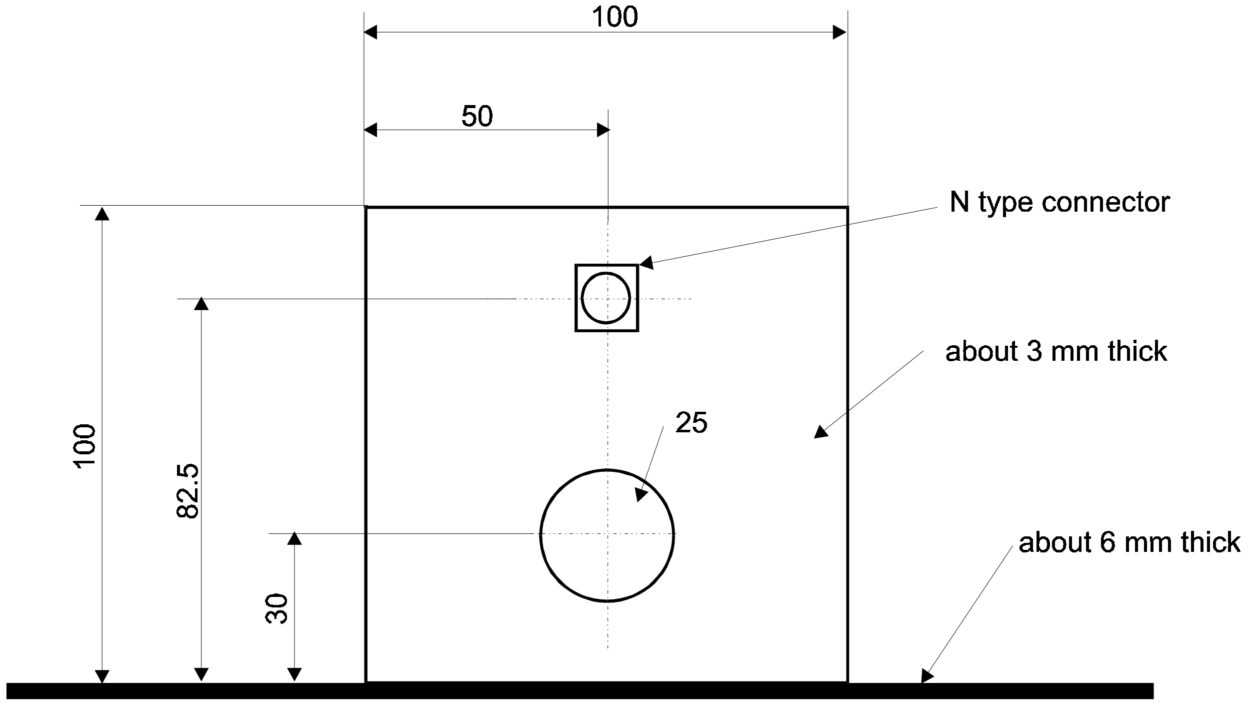


Figure H.5: Side view of the jig (all dimensions in mm)

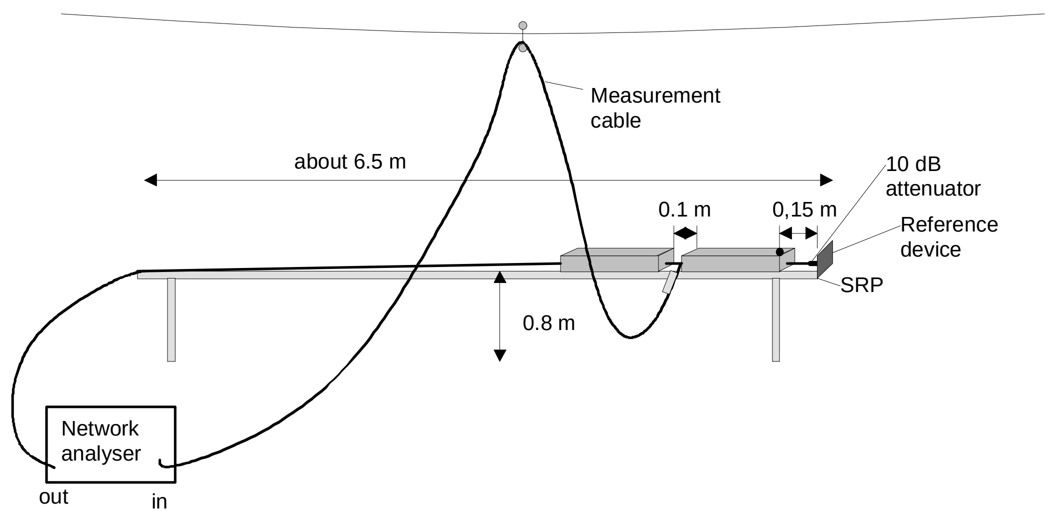


Figure H.6: Test set up for the reference device calibration method

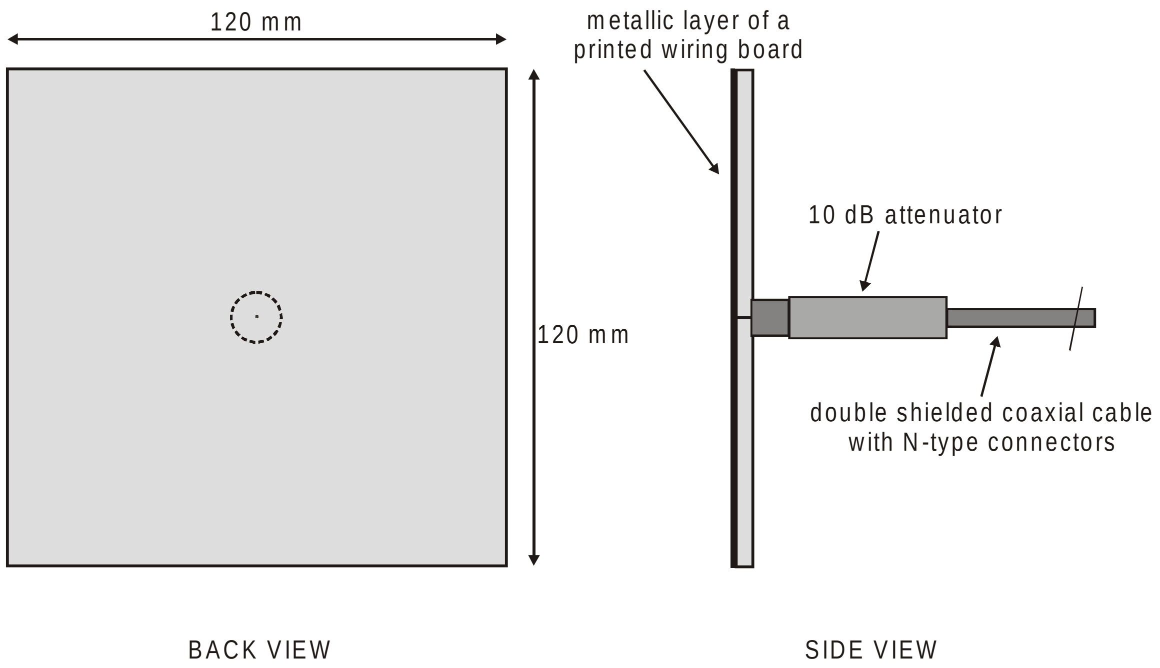


Figure H.7: Specification of the reference device

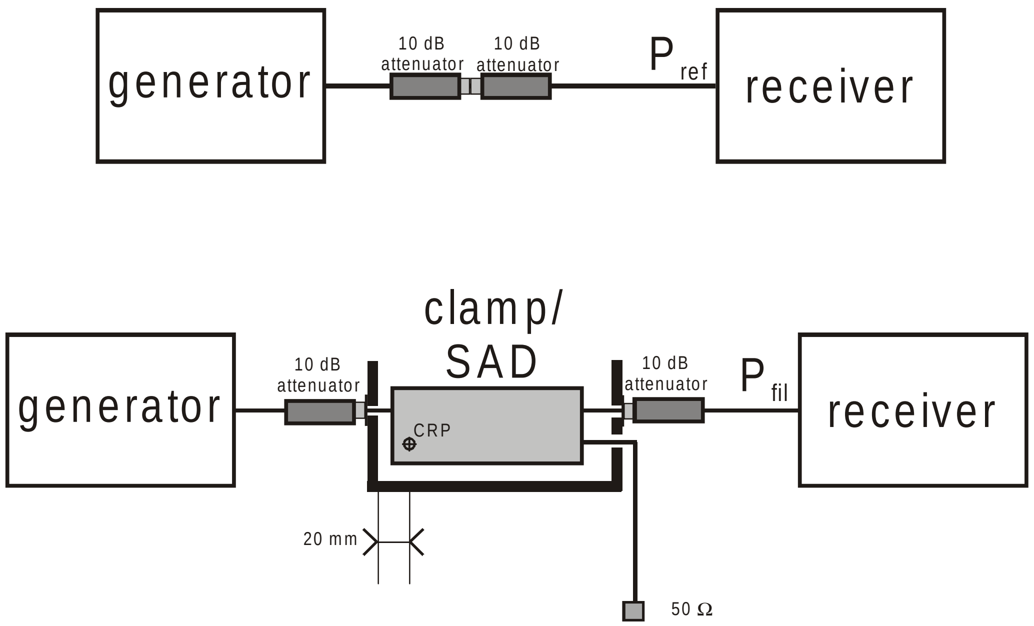


Figure H.8: Measurement setup of the decoupling factor DF
Step 1: reference measurement
Step 2: measurement with the device (clamp or SAD) placed in the jig

Annex HX

(normative)

Validation of the absorbing clamp test site

(clause 5.3)

H.1 Introduction

This Annex gives the details on the method for the validation of the absorbing clamp test site. An absorbing clamp test site (ACTS) shall be verified by comparing the site attenuation of the ACTS with the site attenuation of the absorbing clamp reference site ACRS using the reference device that is also used for one of the clamp calibration methods (see Clause 5.3.3 and Annex H). An ACRS that is valid for this validation procedure is an OATS or a SAR for a 10 m measurement distance that complies with the CISPR NSA requirements.

H.2 Equipment requirements for validation

The reference device is used to generate a common mode current on the connected coaxial cable. Figure H.7 of Annex H shows the specifications of the reference device.

The lead under test is a coaxial cable with a length of about 10 m and fitted with two N type connectors. The coaxial cable is connected via a 10 dB attenuator to the reference device. The other end of the coaxial cable is connected to the network analyzer generator output. A double shielded cable shall be used to connect this reference device to ensure that the currents induced on the lead under test stem from the reference device and not from direct leakage within the cable.

H.3 Validation measurement procedure

The following site attenuation measurement procedure is carried out on both the reference site (ACRS) and on ACTS to be validated.

<u>The site attenuation measurement procedure.</u>

<u>Note</u>: If a NWA is available then the next steps1 and 2 can be performed simultaneously.

Step 1. Reference measurement of generator power.
First, as a reference, the output power P_{gen} of the generator is measured directly through a 10 dB attenuator using a receiver (Figure HX.1a).

Step 2. Measurement of disturbance power on the ACTS /ACRS
Secondly, the maximum disturbance power P_{ref} of the reference device is measured using the same generator setting and 10 dB attenuator and using the set up given in Figure HX.1b.

The two clamps – the absorbing clamp and the secondary absorbing device (SAD) – are positioned on the clamp slide as shown in Figure HX.1b. The clamp reference point of the clamp under test is placed in the direction of the reference device> The reference device is positioned at the SRP of the clamp slide. The clamp is positioned with a distance of 150 mm between the CRP and the reference device. The lead under test (the coaxial cable) is passed through both clamps and should be stretched slightly using an appropriate non-metallic clamping device at both ends of the clamp slide. The lead under test is connected to the reference device via a 10 dB attenuator.
The coaxial cable (lead under test) is connected to the output of the NWA. The measurement cable of the absorbing clamp is connected to the input of the NWA.
The signal is measured at least up to 60 MHz in 1 MHz steps, up to 120 MHz in 2 MHz steps, up to 300 MHz in 5 MHz steps, and above 300 MHz in 10 MHz steps.
The maximum disturbance power is measured while the two clamps are moved at a suitable speed from 150 mm to approx 5 m from the vertical ground plane. The clamps may be pulled by means of a non-metallic rope. The speed at which the clamps are moved must allow the insertion loss to be measured at each frequency at intervals less than 10 mm.

Step 3. Calculation of the site attenuation
The site attenuation (in dB) of the site under consideration (ACTS or ACRS) can be determined using the following equation:

$$A_{ref}^{SITE} = P_{gen} - P_{ref} \tag{HX1}$$

H.4 Validation of the ACTS

The site attenuation of the ACTS (A_{ref}^{ACTS}) shall be compared with the site attenuation of the absorbing clamp reference site ACRS (A_{ref}^{ACRS}). The acceptance criterion for the validation of the ACTS is given by Eqn. 10 (Clause 5.3.6) provided that the uncertainty requirements given in Para. H. 5 are met.

H.5 Uncertainties of the ACTS validation method

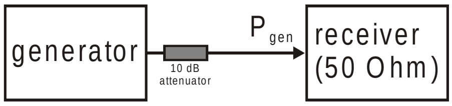
The measurement uncertainty of the ACTS validation depends on:

- The measurement uncertainty of the measurement equipment (0.1 dB),
- The mismatch between the output of the absorbing clamp (with a 6 dB attenuator) and the measurement equipment (+1.1/-1.4 dB), and
- The repeatability of the measurement, which includes the uncertainty of the attenuation of the coaxial cable used, the uncertainty of the 10 dB attenuator used, centering the lead under test in the current transformer, and guidance of the measurement cable to the network analyzer (< x.y dB).

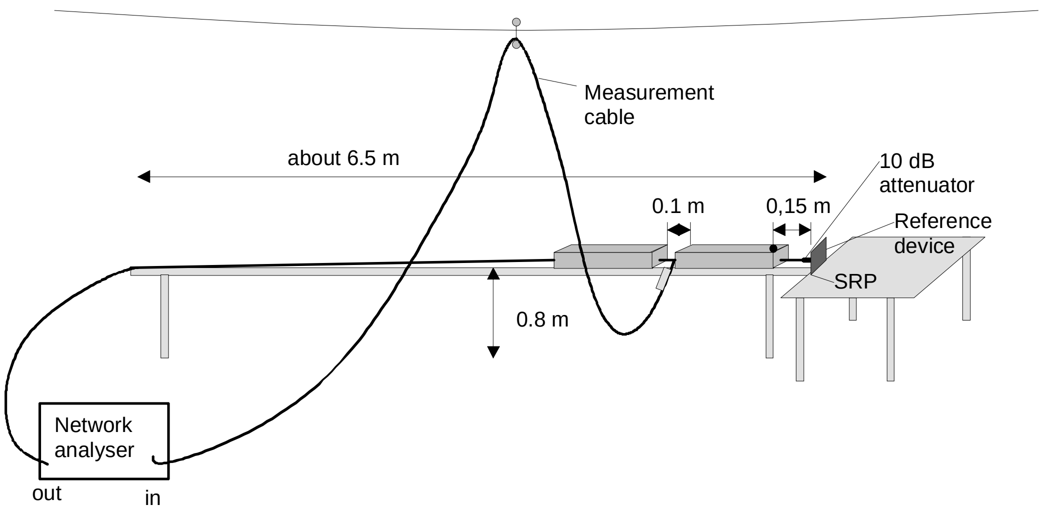
For the clamp site validation procedure, the following uncertainty requirements apply:

To be expanded

Figures related to Annex HX



a.



b.

Figure HX.1: Test set ups for the site attenuation measurement for clamp site validation using the reference device

a. Reference measurement of generator power

b. Set up for power measurements on the ACTS or on the ACRS