CISPR 16-1-4

Edition 4.0 2023-04

INTERNATIONAL STANDARD

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

AMENDMENT 2
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Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-4: Radio disturbance and immunity measuring apparatus – Antennas and test sites for radiated disturbance measurements

Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Partie 1-4: Appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Antennes et emplacements d'essai pour les mesures des perturbations rayonnées

CISPR 16-1-4:2019-01/AMD2:2023-04(en-fr)

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SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY MEASURING APPARATUS AND METHODS –

Part 1-4: Radio disturbance and immunity measuring apparatus – Antennas and test sites for radiated disturbance measurements

AMENDMENT 2

FOREWORD

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Amendment 2 to CISPR 16-1-4:2019 has been prepared by subcommittee CISPR A: Radio-interference measurements and statistical methods, of IEC technical committee CISPR: International special committee on radio interference.

The text of this Amendment is based on the following documents:

Draft	Report on voting
CIS/A/1389/FDIS	CIS/A/1393/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this Amendment is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at www.iec.ch/members_experts/refdocs. The main document types developed by IEC are described in greater detail at www.iec.ch/publications/.

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

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

IMPORTANT – The "colour inside" logo on the cover page of this document indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

2 Normative references

Replace the existing references to CISPR 16-1-1, CISPR 16-1-6, CISPR 16-2-3 by the following:

CISPR 16-1-1:2019, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus*

CISPR 16-1-6:2014, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-6: Radio disturbance and immunity measuring apparatus – EMC antenna calibration*
CISPR 16-1-6:2014/AMD1:2017
CISPR 16-1-6:2014/AMD2:2022

CISPR 16-2-3:2016, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-3: Methods of measurement of disturbances and immunity – Radiated disturbance measurements*
CISPR 16-2-3:2016/AMD1:2019
CISPR 16-2-3:2016/AMD2:20–

Add the following references:

IEC 61000-4-20, *Electromagnetic compatibility (EMC) – Part 4-20: Testing and measurement techniques – Emission and immunity testing in transverse electromagnetic (TEM) waveguides*

IEC 61000-4-21, *Electromagnetic compatibility (EMC) – Part 4-21: Testing and measurement techniques – Reverberation chamber test methods*

3.1.3
antenna pair reference site attenuation

Replace the existing term and definition by the following new term and definition:

3.1.3
antenna pair reference site attenuation
A_{APR}
30 MHz to 1 GHz site attenuation for both vertical and horizontal polarizations using a pair of antennas separated by a specified distance at an ideal open-area test site, with one antenna at a specified fixed height above the ground plane, and the other antenna scanned over a specified height range in which the minimum insertion loss is recorded

Note 1 to entry: While ideal A_{APR} is based on an ideal site, actual A_{APR} is also measured at a REFTS (see 6.6.3), or at a large OATS (see 6.6.4), and the measured values are used as a reference for comparing corresponding site attenuation measurement results at a COMTS as well as for determining the suitability of an OATS for use in the reference site method (RSM).

Note 2 to entry: Because A_{APR} is defined in terms of an ideal OATS, the difference between the actual OATS and an ideal OATS is treated as an uncertainty contribution.

3.1.13
ideal open-area test site

Replace the existing note to entry by the following new note to entry:

Note 1 to entry: An ideal OATS is a theoretical construct that is used in the definition of the measurands A_{APR}, A_{LPR}, and in the calculation of the normalized site attenuation A_N and normalized site insertion loss A_{Ni} for ground plane sites.

3.1.26
site insertion loss

Add, after the definition, the following new note to entry:

Note 1 to entry: With loop antennas, the locations of their feed points shall be as specified in this document.

Add, after the existing term and definition 3.1.29, the following two new terms and definitions:

3.1.30
antenna pair reference site insertion loss
A_{LPR}
9 kHz to 30 MHz site insertion loss for three orientations using a pair of antennas separated by a specified distance at an ideal open-area test site, with both antennas at a specified fixed height above the ground plane and with specified feed point locations

Note 1 to entry: While ideal A_{LPR} is based on an ideal site, actual A_{LPR} is measured at a REFTS (see 5.5.3) and the measured values are used as a reference for comparing corresponding site insertion loss measurement results at a REFTS to evaluate the performance of the COMTS.

Note 2 to entry: Because A_{LPR} is defined in terms of an ideal OATS, the difference between the actual OATS and an ideal OATS is treated as an uncertainty contribution.

3.1.31
feed point (of a shielded loop antenna)
location of the slit in the shielding of the loop antenna

Note 1 to entry: The feed point of a shielded loop antenna is important for a correct set-up. The location of the feed point has an influence on the site insertion loss between two magnetic field antennas [33].

Note 2 to entry: For simulation using NEC [27], the source of the transmit antenna and the load of the receive antenna is placed at this location.

3.2 Abbreviated terms

Add, to the existing list, the following new abbreviated terms:

DANL displayed average noise level

NSIL normalized site insertion loss

4.3.2 Magnetic field antenna

Replace the existing subclause by the following new subclauses and new figure:

4.3.2 Magnetic field antenna

4.3.2.1 General

A shielded loop antenna of dimensions such that the loop antenna can be completely enclosed by a square having sides of 60 cm in length shall be used. The shielding, but not the electronic unit including mechanical mounting features and connected cables, shall be taken into account when applying the size criterion; see Figure 34.

For site validation as per 5.5, the loop antenna shall have a single turn.

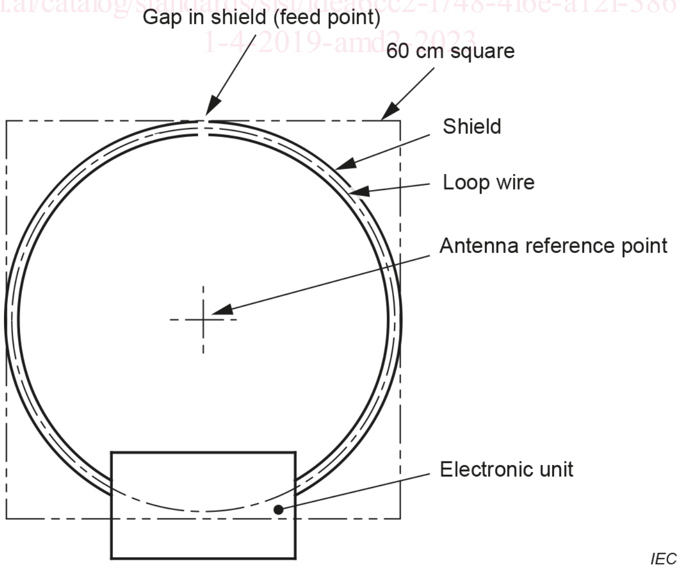
NOTE 1 Derivation of NSIL values as described in Annex J, is less complicated and more accurate for single-turn loops.

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

NOTE 2 Direct measurements can be made of the strength of the magnetic field component, in dB(µA/m) or µA/m, of a radiated field under all conditions; that is, both in the near field and in the far field [32].

The reference point of the shielded loop antenna is specified as the centre point of the circle or rectangle formed by the loop, ignoring any attached balun or mechanical mounting feature.

The magnetic field antenna shall be calibrated according to CISPR 16-1-6 for determination of the magnetic field antenna factor. The magnetic field antenna factor is required for site validation as per 5.5, and also for radiated disturbance measurements as per CISPR 16-2-3.



NOTE This example illustrates the maximum diameter circular-shaped loop antenna that still complies with the size criterion.

Figure 34 – Example of size-compliant loop antenna

4.3.2.2 Considerations on active antennas

In principle, an active antenna can be seen as a passive antenna with a preamplifier. CISPR 16-1-1:2019, Annex J describes the problems that can arise when preamplifiers are used. Especially when pulsed signals are measured, a larger dynamic range is required.

When using active antennas, it is recommended to use those types that are equipped with an overload indicator. In this case, the indicator shall be observed such that any overload condition is detected, and actions are taken to correct it.

Alternatively, the output voltage of the antenna shall be checked simultaneously with an oscilloscope by using a tee connector to split the receive cable. This tee connector shall be connected directly to the input of an oscilloscope and the second output to the receiver via a cable. The oscilloscope shall be set to high input impedance to minimise any influence on the measurement result. The trigger point of the oscilloscope shall be set to a voltage that corresponds to the 1 dB compression point of the active antenna. The measurement is assumed to be valid if no trigger event occurs during the entire measurement.

NOTE The influence of the input impedance of the oscilloscope to the measurement result is negligible. For 1 MΩ in parallel with 20 pF, the error is less than 0,04 dB.

A resistive power divider may be used instead of a tee connector. In this case the input impedance of the oscilloscope shall be set to 50 Ω. The noise floor of the system might be increased by the insertion of 6 dB loss between antenna and receiver. The loss through the power divider shall be accounted for when determining the measured magnetic field strength level (i.e. added to the level measured by the receiver).

The highest measurable field strength is usually given in the datasheet of the antenna, which shall be checked to ensure that it is valid for the entire measurement frequency range.

The ratio between the peak value of the field strength and power of the fundamental frequency depends on the type of disturbance. For pulse-width modulated signals especially, this value can reach 30 dB or more; see [26]. When considering overload, the peak value of a disturbance signal shall be taken into consideration.

Use of an active antenna might not be necessary at measurement distances of 3 m or 5 m. Passive antennas can be suitable to provide a sufficient signal-to-noise ratio.

5 Test sites for measurement of radio disturbance field strength for the frequency range of 9 kHz to 30 MHz

Replace the existing text of this clause "(Void)" with the following new text:

5.1 General

An environment shall ensure valid, repeatable measurement results of the disturbance field strength from an EUT. The provisions in this clause are not intended for measurements on EUTs at their place of use (in that case, see, e.g., the in situ measurement procedures in CISPR 16-2-3).

In the frequency range below 30 MHz, a semi-free space environment is required. Such a semi-free-space environment shall be an OATS, an OATS with a weather-protection enclosure, or a SAC.

5.2 Radio-frequency ambient environment of a test site

The test site shall allow disturbances from an EUT to be distinguished from ambient noise. Its suitability in this respect can be determined by measuring the ambient noise levels with the EUT inoperative and ensuring that the ambient noise levels are at least 6 dB below the limits that apply for the measurement being carried out.

It is not necessary to reduce the ambient noise level to 6 dB below the specified limit where the combination of the ambient noise plus the disturbance from the EUT does not exceed the specified limit. Under those conditions, the EUT is considered to comply with the specified limit.

5.3 Measurement distance and test volume

The test site shall be validated at the measurement distances that are used for disturbance measurements as per the methods of CISPR 16-2-3:2016/AMD2:20─. The measurement distance shall be 3 m, 5 m, or 10 m.

NOTE According to CISPR 16-2-3, measurements at 30 m distance are considered as in-situ measurements.

The test volume is determined by the locations of the transmit antenna used during test site validation, where the site meets the criteria in 5.5.4. The maximum size of the EUT shall not exceed the validated test volume (the maximum volume is also limited by Table 10 of CISPR 16-2-3:2016/AMD1:2019).

5.4 Set-up table and antenna positioner

The shape and construction of the set-up table and the antenna positioner for the receive antenna are not critical in the frequency range below 30 MHz provided that non-conductive material is used. In this case, the influence of the set-up table and antenna positioner shall not be evaluated.

5.5 Validation procedure of test site

5.5.1 General

For an OATS, an OATS with a weather-protection enclosure or a SAC, a single site insertion loss measurement is insufficient to determine possible reflections from ground plane edges, the construction material and/or the RF-absorbing material comprising the walls and ceiling of the facility. Evaluating H_x, H_y, and H_z antenna orientations (as illustrated in Figure 35) requires 15 separate SIL measurements, i.e. five positions for each of the three orientations of the loop antennas [25].

Loop antennas conforming to the requirements of 4.3.2 shall be used for these measurements. Distances are measured with respect to the reference points of the antennas. The measurement heights for the transmit antenna and the receive antenna are fixed at 1,3 m from the ground plane to reference points of the loop antennas. Height scanning is not required for either antenna. The reference point of the transmit antenna shall be placed at the required locations in turn: centre and four locations (left, right, front, rear) on the perimeter of the test volume to be validated, in accordance with Figure 36 and Figure 37.

For each measurement made with a spectrum analyzer or a network analyzer, the procedure requires two different measurements of the received voltage V_R. The first reading of V_R is with the two coaxial cables disconnected from the two loop antennas and connected to each other via an adaptor. The second reading of V_R is taken with the coaxial cables reconnected to their respective loop antennas. For both of these measurements, the signal source voltage, V_I, remains unchanged. The first reading of V_R is called V_{DIRECT} and the second is called V_{SITE}.

An acceptable signal to noise ratio shall be maintained; however, a requirement is not specified because the receive level depends on the antennas used, the available transmit power, the noise level of the receiver, and the ambient level. A value of 20 dB is recommended. The achieved values shall be used in the uncertainty budget given in Annex I.

Special care shall be taken to avoid coupling between the receive system and the transmit system. Typically a ground loop is formed if the transmit antenna and receive antenna cables are routed through the chamber shielding using standard bulkhead connectors; see [31]. There are several possible methods to avoid this ground loop. One of them is to operate the signal generator inside and the measuring receiver outside the shielded room. It is also possible to use an isolating transformer in the transmit path. It is recommended to check the dynamic range of the system before use. This check is done by connecting a termination instead of the transmit antenna and recording the receive level. If an active receive antenna is used it should be turned on during a dynamic range test to take the noise of the preamplifier into account.

If the cables have an influence on the measurement result, they shall be equipped with ferrite cores. It is highly recommended that ferrites with a minimum impedance of 50 Ω at 25 MHz are placed on the transmit antenna and receive antenna cables every 20 cm along their entire length within the test volume being validated.

Three different loop antennas orientations shall be measured according to Figure 35. The measurements shall be performed in the frequency range from 9 kHz to 30 MHz, with frequency steps less than or equal to those specified in Table 9.

Figure 36 and Figure 37 illustrate the measurement positions in the test volume. Five positions in the test volume shall be measured. The measurement distance d shall be kept constant.

Table 9 – Maximum frequency step size

Frequency range	Maximum step size
9 kHz to 20 kHz	1 kHz
20 kHz to 150 kHz	5 kHz
150 kHz to 1 MHz	50 kHz
1 MHz to 30 MHz	100 kHz

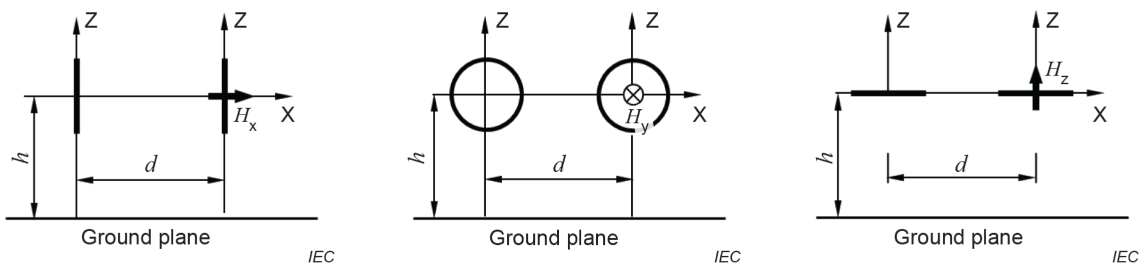
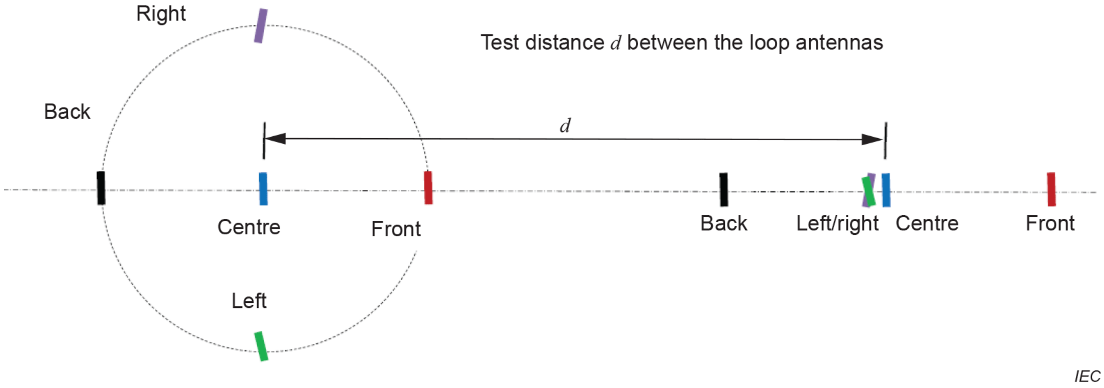
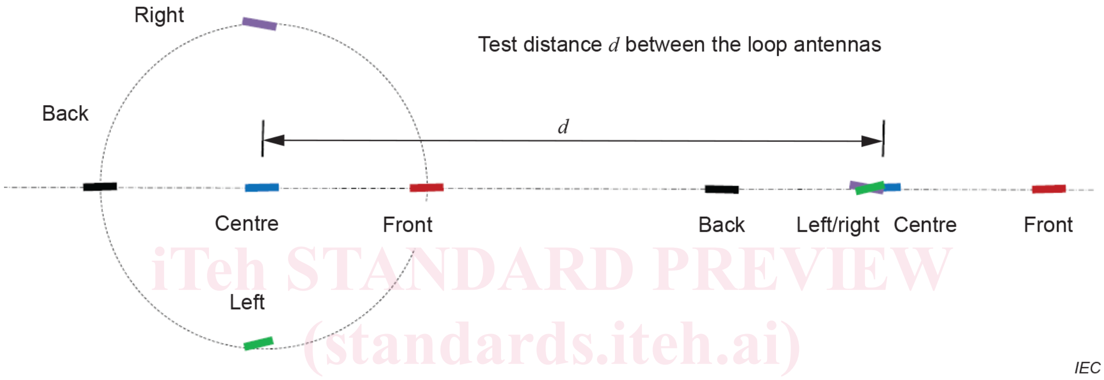


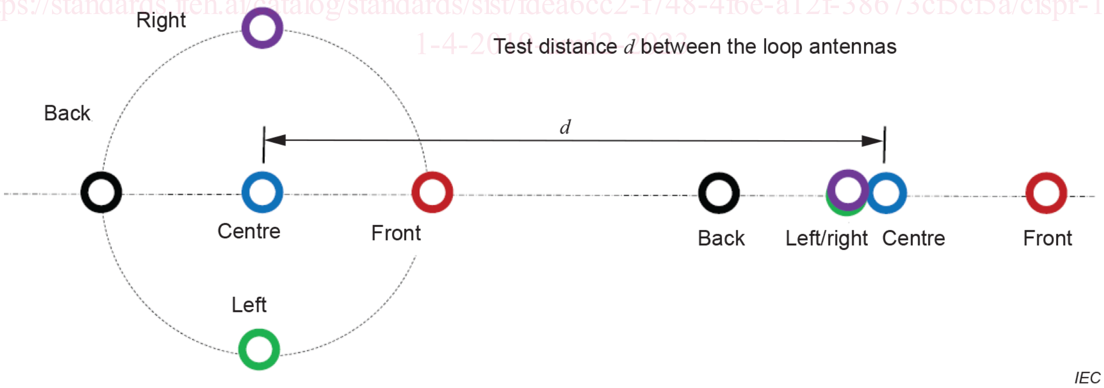
Figure 35 – General arrangement of the three measurement orientations H_x, H_y and H_z, where d is the measurement distance and h is the height of the reference point



a) H_x validation measurement with loop antennas



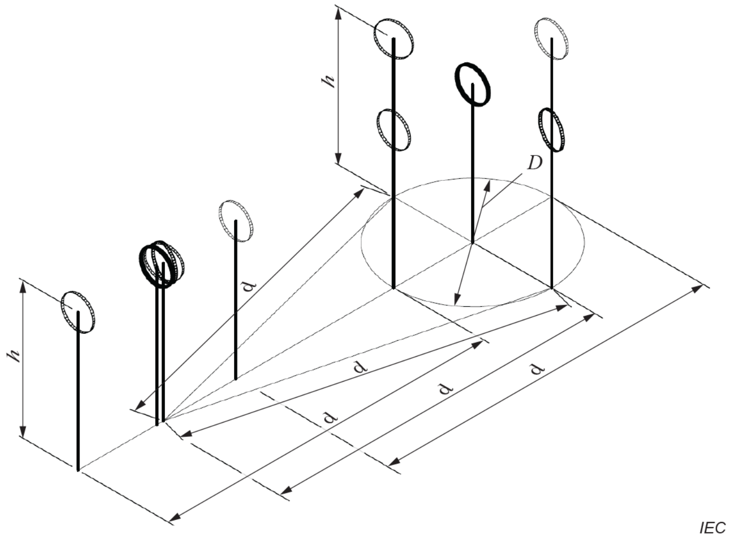
b) H_y validation measurement with loop antennas



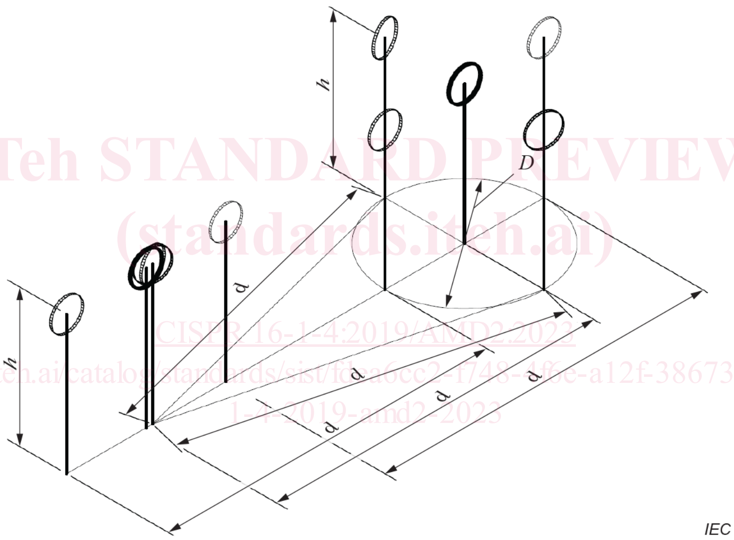
c) H_z validation measurement with loop antennas

NOTE The receive loop antenna positions corresponding to the left and right transmit antenna positions, shown with green and magenta colors respectively, are one and the same. However, these are shown with a slight offset in the diagram so that both are visible.

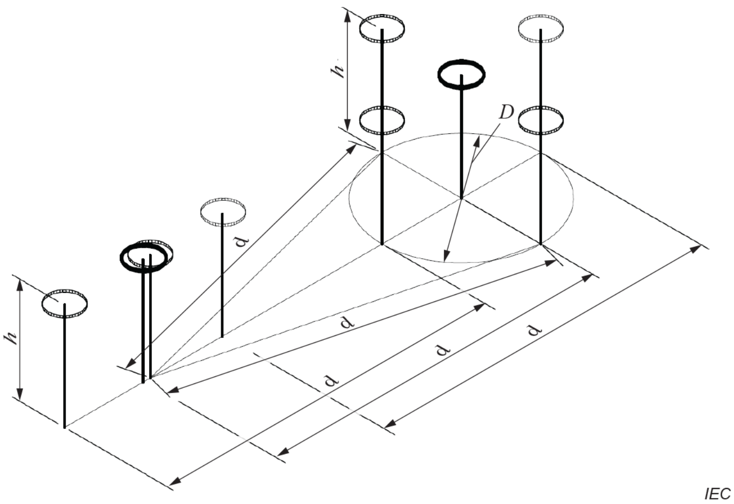
Figure 36 – Antenna positions



a) H_x validation measurement with loop antennas



b) H_y validation measurement with loop antennas



c) H_z validation measurement with loop antennas

Figure 37 – Antenna positions

5.5.2 Normalized site insertion loss (NSIL)

The site insertion loss deviation is calculated by Equation (27):

$$\Delta A_{\mathrm{i}} = V_{\mathrm{DIRECT}} - V_{\mathrm{SITE}} - F_{\mathrm{aH,T}} - F_{\mathrm{aH,R}} - A_{\mathrm{Ni}} \tag{27}$$

where

V_{DIRECT} is the level recorded by the receiver when transmit antenna and receive antenna cables are connected via an adaptor, in dBm or dB(μV);

V_{SITE} is the level recorded by the receiver when transmit antenna and receive antenna cables are connected to the antennas, in dBm or dB(μV); the same unit shall be used as for V_{DIRECT};

$F_{\mathrm{aH,T}}$ is the magnetic field antenna factor of the transmit antenna, in dB(S/m);

$F_{\mathrm{aH,R}}$ is the magnetic field antenna factor of the receive antenna, in dB(S/m);

A_{Ni} is the normalized site insertion loss, in dB(m^2/S^2), calculated in accordance with Annex J;

ΔA_{i} is the site insertion loss deviation, in dB.

$F_{\mathrm{aH,T}}$ and $F_{\mathrm{aH,R}}$ shall be calibrated according to CISPR 16-1-6 with frequency steps less than or equal to those specified in Table 9.

Due to the required sensitivity at 10 m measurement distance, the use of a transmit power amplifier can be required. To avoid overloading the receiver in the V_{DIRECT} measurement mode, an additional attenuator can be necessary; see Figure 38. If such an attenuator is used in the V_{DIRECT} measurement, but not in the V_{SITE} measurement, a calibrated attenuator shall be used, and its attenuation a_{ATT} shall be taken into account, in accordance with Equation (28).

$$\Delta A_{\mathrm{i}} = V_{\mathrm{DIRECT}} + a_{\mathrm{ATT}} - V_{\mathrm{SITE}} - F_{\mathrm{aH,T}} - F_{\mathrm{aH,R}} - A_{\mathrm{Ni}} \tag{28}$$

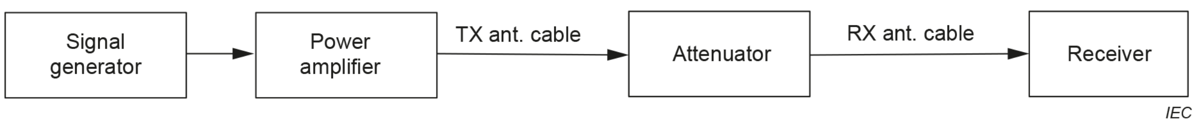


Figure 38 – Test set-up for V_{DIRECT} with power amplifier and attenuator

5.5.3 Reference site method

The site insertion loss deviation is calculated as given by Equation (29).

$$\Delta A_{\mathrm{i}} = V_{\mathrm{DIRECT}} - V_{\mathrm{SITE}} - A_{\mathrm{LPR}} \tag{29}$$

The antenna pair reference A_{LPR} is calibrated at a REFTS by using Equation (30).

$$A_{\mathrm{LPR}} = V_{\mathrm{DIRECT,R}} - V_{\mathrm{SITE,R}} \tag{30}$$

A REFTS suitable for this purpose shall have a site insertion loss deviation less than 1 dB for a measurement distance of 3 m, and less than 2 dB for the other measurement distances. Compliance to this requirement shall be shown using the NSIL method given in 5.5.2.

5.5.4 Acceptance criterion

The site insertion loss deviation ΔA_{i}, calculated in accordance with 5.5.2 or 5.5.3 depending on which site validation method was used, shall comply with the applicable criterion specified in Table 10 at all frequencies, for all three antenna orientations, and at all five test positions.

Table 10 – Acceptance criterion

Measurement distance m	**Maximum deviation** dB
3	±4 dB
5	±4 dB
10	±4 dB [a]

[a] Measurements of 10 m SACs show that it might not be possible to fulfill the criterion of ±4 dB over the complete frequency range. Therefore use of such a SAC is accepted, even if it is not compliant with the ±4 dB criterion. In this case, the increased uncertainty shall be taken into account for compliance with the applicable limit. For each frequency, the maximum of $|\Delta A_{\mathrm{i}}|$ of all points where the criterion is exceeded shall be taken as δA_{i} to calculate U_{lab}. U_{lab} is calculated separately for each orientation. See CISPR 16-4-2 and Annex M for further information. More information about measurement at various distances can be found in [25].

6.1 General

Add the following new second paragraph as follows:

In the frequency range 30 MHz to 1 GHz, a semi-free space environment is required. Such a semi-free space environment shall be an OATS, an OATS with a weather-protection enclosure, or a SAC. However, measurements in this frequency range can also be performed in a free-space environment (i.e. in a FAR).

9 Reverberation chamber for total radiated power measurement

Replace the existing subclauses, text and figures by the following:

Radiated disturbance measurements may be performed in reverberation chambers using the methods specified in IEC 61000-4-21.