

Specification for radio disturbance and immunity measuring apparatus and methods —

Part 1-4: Radio disturbance and immunity measuring apparatus — Ancillary equipment — Radiated disturbances

ICS 17.220.20; 33.100.01; 33.100.10; 33.100.20

National foreword

This British Standard is the UK implementation of EN 55016-1-4:2007+A2:2009. It is identical to CISPR 16-1-4:2007, incorporating amendment 2:2008. It supersedes BS EN 55016-1-4:2007+A1:2008 which will be withdrawn on 1 July 2012.

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to IEC text carry the number of the IEC amendment. For example, text altered by IEC amendment 1 is indicated by **A1** **A1**.

The UK participation in its preparation was entrusted by Technical Committee GEL/210, EMC — Policy committee, to Subcommittee GEL/210/12, EMC basic, generic and low frequency phenomena standardization.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

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Amendments/corrigenda issued since publication

Date	Comments
31 July 2008	Implementation of IEC amendment 1:2007, with CENELEC endorsement A1:2008
31 July 2009	Correct 2007 IEC text incorporated, and implementation of IEC amendment 1:2007 and its CENELEC endorsement A1:2008
28 February 2010	Implementation of IEC amendment 2:2008 with CENELEC endorsement A2:2009

English version

**Specification for radio disturbance
and immunity measuring apparatus and methods -
Part 1-4: Radio disturbance and immunity measuring apparatus -
Ancillary equipment -
Radiated disturbances
(CISPR 16-1-4:2007)**

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 -
Matériels auxiliaires -
Perturbations rayonnées
(CISPR 16-1-4:2007)

Anforderungen an Geräte
und Einrichtungen sowie Festlegung
der Verfahren zur Messung
der hochfrequenten Störaussendung
(Funkstörungen) und Störfestigkeit -
Teil 1-4: Geräte und Einrichtungen
zur Messung der hochfrequenten
Störaussendung (Funkstörungen)
und Störfestigkeit -
Zusatz-/Hilfseinrichtungen -
Gestrahlte Störaussendung
(CISPR 16-1-4:2007)

This European Standard was approved by CENELEC on 2007-06-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CENELEC member.

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CENELEC

European Committee for Electrotechnical Standardization
Comité Européen de Normalisation Electrotechnique
Europäisches Komitee für Elektrotechnische Normung

Central Secretariat: rue de Stassart 35, B - 1050 Brussels

Foreword

The text of document CISPR/A/710/FDIS, future edition 2 of CISPR 16-1-4, prepared by CISPR SC A, Radio-interference measurements and statistical methods, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 55016-1-4 on 2007-06-01.

This European Standard supersedes EN 55016-1-4:2004 + A1:2005 + A2:2005.

The following dates were fixed:

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Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard CISPR 16-1-4:2007 was approved by CENELEC as a European Standard without any modification.

Foreword to amendment A1

The text of document CISPR/A/750/FDIS, future amendment 1 to CISPR 16-1-4:2007, prepared by CISPR SC A, Radio-interference measurements and statistical methods, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A1 to EN 55016-1-4:2007 on 2008-02-01.

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Endorsement notice

The text of amendment 1:2007 to the International Standard CISPR 16-1-4:2007 was approved by CENELEC as an amendment to the European Standard without any modification.

Foreword to amendment A2

The text of document CISPR/A/786/FDIS, future amendment 2 to CISPR 16-1-4:2007, prepared by CISPR SC A, Radio-interference measurements and statistical methods, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A2 to EN 55016-1-4:2007 on 2009-07-01.

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- latest date by which the national standards conflicting with the amendment have to be withdrawn (dow) 2012-07-01

Endorsement notice

The text of amendment 2:2008 to the International Standard CISPR 16-1-4:2007 was approved by CENELEC as an amendment to the European Standard without any modification.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION
INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

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

**Part 1-4: Radio disturbance and immunity measuring apparatus –
Ancillary equipment – Radiated disturbances**

FOREWORD

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International Standard CISPR 16-1-4 has been prepared by CISPR subcommittee A: Radio interference measurements and statistical methods.

The document CISPR/A/710/FDIS, circulated to the National Committees as amendment 3, led to the publication of the new edition.

This consolidated version of CISPR 16-1-4 consists of the second edition (2007) [documents CISPR/A/710/FDIS and CISPR/A/722/RVD] and its amendment 1 (2007) [documents CISPR/A/750/FDIS and CISPR/A/760/RVD].

The technical content is therefore identical to the base edition and its amendment and has been prepared for user convenience.

It bears the edition number 2.1.

A vertical line in the margin shows where the base publication has been modified by amendment 1.

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

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

CISPR 16-1 consists of the following parts, under the general title *Specification for radio disturbance and immunity measuring apparatus and methods – Radio disturbance and immunity measuring apparatus*:

Part 1-1: Measuring apparatus

Part 1-2: Ancillary equipment – Conducted disturbances

Part 1-3: Ancillary equipment – Disturbance power

Part 1-4: Ancillary equipment – Radiated disturbances

Part 1-5: Antenna calibration test sites for 30 MHz to 1 000 MHz

The committee has decided that the contents of the base publication and its amendments will remain unchanged until the maintenance result date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

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

INTRODUCTION (to amendment 1)

In this amendment, the use of a balanced dipole antenna (the CISPR tuned dipole) as a physical reference for radiated emission measurements in the frequency range between 30 MHz and 300 MHz is deleted. It is replaced by the requirement that in this frequency range the quantity to be measured is the electric field strength that can be determined using different types of antennas, provided that the antenna factor and the associated uncertainty are known.

This fundamental change of measurand in the frequency range between 30 MHz and 300 MHz was subject to thorough investigations and discussion within CISPR A, and brings it into line with the measurand that already applies in the rest of the frequency range 9 kHz to 1 GHz, and indeed above 1 GHz. The decision for this change has been supported by the results of a questionnaire. More details on the rationale for the decision to introduce the 'electric field' measurand instead of the CISPR reference dipoles can be found in the CISPR Maintenance Cycle Report CISPR/A/541/MCR.

CISPR/A/541/MCR explains that the need for a CISPR reference dipole no longer exists, due to improvements in the calibration of antennas used for EMC compliance testing and the increased implementation of quality systems in test and calibration laboratories in accordance with ISO 17025. Moreover, Clause 4 of CISPR 16-1-4 covers the frequency range 9 kHz to 1 GHz, yet a reference antenna is only specified in the range 30 MHz to 300 MHz, which seems to make this frequency range an exception to the general rule.

In other words, most measurements of physical quantities are made with an instrument that is traceable to national standards. There is no need for measurement of electric field strength in the frequency range 30 MHz to 300 MHz to deviate from this, especially when application of such a physical reference antenna may give a greater uncertainty to the intended measurand than a regular calibrated broadband antenna. Moreover, these days, the CISPR reference dipole is rarely used in practice because it is impractical from a operational point of view (time consuming). The new measurand is the field strength as defined by the limit level in dB μ V/m and as required by the method of measurement. If various operators follow the same measurement method, involving calibrated antennas, a high degree of reproducibility is ensured.

A consequence of using the tuned dipole antenna as a reference is that the antenna uncertainties in CISPR 16-4-2 require the field strength measured by a broadband antenna to be referred to the field strength that would have been measured had a tuned dipole been used. The ramifications would be dependent on the difference in radiation patterns and mutual coupling of a dipole compared to a broadband antenna (including height dependence of antenna factor). This practice can actually result in larger EMC measurement uncertainties than if the field strength were derived from the traceably calibrated broadband antenna. The relating of the behaviour of the commonly used broadband antenna to the extremely rarely used tuned dipole in the notes to the uncertainty budget in CISPR 16-4-2, requires specialist knowledge to understand.

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SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY MEASURING APPARATUS AND METHODS –

Part 1-4: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Radiated disturbances

1 Scope

This part of CISPR 16 is designated a basic standard, which specifies the characteristics and performance of equipment for the measurement of radiated disturbances in the frequency range 9 kHz to 18 GHz.

Specifications for ancillary apparatus are included for: antennas and test sites, TEM cells, and reverberating chambers.

The requirements of this publication must be complied with at all frequencies and for all levels of radiated disturbances within the CISPR indicating range of the measuring equipment.

Methods of measurement are covered in Part 2-3, and further information on radio disturbance is given in Part 3 of CISPR 16. Uncertainties, statistics and limit modelling are covered in Part 4 of CISPR 16.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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

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

CISPR 16-3, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 3: CISPR technical reports*

CISPR 16-4 (all parts), *Specification for radio disturbance and immunity measuring apparatus and methods – Uncertainties, statistics and limit modelling*

CISPR 16-4-2:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-2: Uncertainties, statistics and limit modelling – Uncertainty in EMC measurements*

IEC 60050-161, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply. Also see IEC 60050(161).

3.1

bandwidth

B_n

width of the overall selectivity curve of the receiver between two points at a stated attenuation, below the midband response

NOTE The bandwidth is represented by the symbol B_n , where n is the stated attenuation in decibels.

3.2

CISPR indicating range

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

3.3

calibration test site

CALTS

open area test site with metallic ground plane and tightly specified site attenuation performance in horizontal and vertical electric field polarization

NOTE 1 A CALTS is used for determining the free-space antenna factor of an antenna.

NOTE 2 Site attenuation measurements of a CALTS are used for comparison to corresponding site attenuation measurements of a compliance test site, in order to evaluate the performance of the compliance test site.

3.4

compliance test site

COMTS

environment which assures valid, repeatable measurement results of disturbance field strength from equipment under test for comparison to a compliance limit

3.5

antenna

that part of a transmitting or receiving system that is designed to radiate or to receive electromagnetic waves in a specified way

NOTE 1 In the context of this standard, the balun is a part of the antenna.

 NOTE 2 This term covers various devices such as the wire antenna, free-space-resonant dipole and hybrid antenna. 

3.6

balun

passive electrical network for the transformation from a balanced to an unbalanced transmission line or device or vice versa

3.7

free-space-resonant dipole

wire antenna consisting of two straight colinear conductors of equal length, placed end to end, separated by a small gap, with each conductor approximately a quarter-wavelength long such that at the specified frequency the input impedance of the wire antenna measured across the gap is pure real when the dipole is located in the free space

NOTE 1 In the context of this standard, this wire antenna connected to the balun is also called the "test antenna".

NOTE 2 This wire antenna is also referred to as "tuned dipole".

3.8

A1 site attenuation

site attenuation is defined as the minimum site insertion loss measured between two polarization-matched antennas located on a test site when one antenna is moved vertically over a specified height range and the other is set at a fixed height

3.9

site insertion loss

the loss between a pair of antennas placed at specified positions on a test site, when a direct electrical connection between the generator output and receiver input is replaced by transmitting and receiving antennas placed at the specified positions A1

3.10

wire antenna

a specified structure consisting of one or more metallic wires or rods for radiating or receiving electromagnetic waves

NOTE A wire antenna does not contain a balun.

3.11

fully anechoic room

FAR

shielded enclosure, the internal surfaces of which are lined with radio-frequency absorbing material (i.e. RF absorber), which absorbs electromagnetic energy in the frequency range of interest

3.12

A1 quasi-free space test-site

facility for radiated emission measurements, or antenna calibration, that is intended to achieve free-space conditions. Unwanted reflections from the surroundings are kept to a minimum in order to satisfy the site acceptance criterion applicable to the radiated emission measurement or antenna calibration procedure being considered A1

3.13

test volume

volume in the FAR in which the EUT is positioned

NOTE In this volume the quasi-free space condition is met and this volume is typically 0,5 m or more from the absorbing material of the FAR.

A1 3.14

cross-polar response

measure of the rejection by the antenna of the cross-polarised field, when the antenna is rotated in a uniform electromagnetic field

3.15

hybrid antenna

conventional wire-element log-periodic dipole array (LPDA) antenna with boom lengthened at the open-circuit end to add one broadband dipole (e.g., biconical or bow-tie), such that the infinite balun (boom) of the LPDA serves as a voltage source for the broadband dipole. Typically a common-mode choke is used at this end of the boom to minimize parasitic (unintended) RF currents on the outer conductor of the coaxial cable flowing into the receiver

3.16

low uncertainty antenna

good quality robust biconical or LPDA antenna, whose antenna factor is reproducible to better than $\pm 0,5$ dB, used for the measurement of E-field strength at a defined point in space

NOTE It is further described in A.2.2. A1

3.17

**semi-anechoic chamber
SAC**

shielded enclosure, in which five of the six internal surfaces are lined with radio-frequency-energy absorbing material (i.e., RF absorber), which absorbs electromagnetic energy in the frequency range of interest, and the bottom horizontal surface is a conducting ground plane for use with OATS test set-ups

3.18

**common mode absorption device
CMAD**

a device that may be applied on cables leaving the test volume in radiated emission measurements to reduce the compliance uncertainty

3.19

insertion loss

the loss arising from the insertion of a device into a transmission line, expressed as the ratio of voltages immediately before and after the point of insertion of a device under test, before and after the insertion. It is equal to the inverse of the transmission S-parameter, $|1/S_{21}|$

3.20

reflection coefficient

the ratio of a common quantity to both the reflected and incident travelling waves. Hence, the voltage reflection coefficient is defined as the ratio of the complex voltage of the reflected wave to the complex voltage of the incident wave. The voltage reflection coefficient is equal to the scattering parameter S_{11}

3.21

**short-open-load-through (SOLT) or through-open-short-match (TOSM)
calibration method**

calibration method for a vector network analyser using three known impedance standards – short, open, and match/load, and a single transmission standard – through. The SOLT method is widely used, and the necessary calibration kits with 50 Ω characteristic impedance components are commonly available. A full two-port error model includes six error terms for each of the forward and reverse directions, for a total of twelve separate error terms, which requires twelve reference measurements to perform the calibration

3.22

scattering parameters (S-parameters)

a set of four parameters used to describe the properties of a two-port network inserted into a transmission line

3.23

through-reflect-line (TRL) calibration

calibration method for a vector network analyser using three known impedance standards “Through”, “Reflect” and “Line” for the internal or external calibration of the VNA. Four reference measurements are needed for this calibration

3.24

**vector network analyser
VNA**

a network analyser capable of measuring complex values of the four S-parameters S_{11} , S_{12} , S_{21} , S_{22} 

4 Antennas for measurement of radiated radio disturbance

A1 Antennas of the type that are used for radiated emissions measurements, having been calibrated, shall be used to measure the field strength, taking into account their radiation patterns and mutual coupling with their surroundings. **A1** The antenna and the circuits inserted between it and the measuring receiver shall not appreciably affect the overall characteristics of the measuring receiver. When the antenna is connected to the measuring receiver, the measuring system shall comply with the bandwidth requirements of CISPR 16-1-1 appropriate to the frequency band concerned.

A1 The antenna shall be linearly polarised. It shall be orientable so that all polarizations of incident radiation can be measured. The height of the centre of the antenna above ground or above the absorber in a FAR may have to be adjustable according to a specific test procedure. **A1**

For additional information about the parameters of broadband antennas see Annex A.

A1 4.1 Physical parameter for radiated emissions measurements

The physical parameter for radiated emission measurements made against an emission limit expressed in volts per metre is E-field strength measured at a defined point in space relative to the position of the equipment under test (EUT). More specifically, for measurements in the frequency range 30 MHz to 1 000 MHz on an OATS or in a SAC, the measurand is the maximum field strength as a function of horizontal and vertical polarization and at heights between 1 m and 4 m, and at a horizontal distance of 10 m from the EUT, while the EUT is rotated over all angles in the azimuth plane. **A1**

The accuracy of field-strength measurement of a uniform field of a sine-wave shall be better than ± 3 dB when an antenna meeting the requirements of this subclause is used with a measuring receiver meeting the requirements of CISPR 16-1-1.

NOTE This requirement does not include the effect due to a test site.

4.2 Frequency range 9 kHz to 150 kHz

Experience has shown that, in this frequency range, it is the magnetic field component that is primarily responsible for observed instances of interference.

4.2.1 Magnetic antenna

For measurement of the magnetic component of the radiation, either an electrically-screened loop antenna of dimension such that the antenna can be completely enclosed by a square having sides of 60 cm in length, or an appropriate ferrite-rod antenna, may be used.

The unit of the magnetic field strength is $\mu\text{A/m}$ or, in logarithmic units, $20 \log(\mu\text{A/m}) = \text{dB}(\mu\text{A/m})$. The associated emission limit shall be expressed in the same units.

NOTE Direct measurements can be made of the strength of the magnetic component, in $\text{dB}(\mu\text{A/m})$ or $\mu\text{A/m}$ of a radiated field under all conditions, that is, both in the near field and in the far field. However, many field strength measuring receivers are calibrated in terms of the equivalent plane wave electric field strength in $\text{dB}(\mu\text{V/m})$, i.e. assuming that the ratio of the E and H components is 120π or 377Ω . **A1** Text deleted **A1**

To obtain the reading of H ($\mu\text{A/m}$), the reading E ($\mu\text{V/m}$) is divided by 377Ω :

$$H (\mu\text{A/m}) = E (\mu\text{V/m}) / 377 \Omega \quad (1)$$

To obtain the reading of H $\text{dB}(\mu\text{A/m})$, 51,5 $\text{dB}(\Omega)$ is subtracted from the reading E $\text{dB}(\mu\text{V/m})$:

$$H \text{ dB}(\mu\text{A/m}) = E \text{ dB}(\mu\text{V/m}) - 51,5 \text{ dB}(\Omega) \quad (2)$$

The impedance $Z = 377 \Omega$, with $20 \log Z = 51,5 \text{ dB}(\Omega)$, used in the above conversions is a constant originating from the calibration of field strength measuring equipment indicating the magnetic field in $\mu\text{V/m}$ (or $\text{dB}(\mu\text{V/m})$).

4.2.2 Shielding of loop antenna

Inadequate shielding of a loop antenna can result in E-field response. The E-field discrimination of the antenna shall be evaluated by rotating the antenna in a uniform field, such that the plane of the loop remains parallel to the E-field vector. When the plane of the loop antenna is perpendicular to the magnetic flux and then the antenna is rotated so that its plane is parallel to the magnetic flux the measured response shall decrease by at least 20 dB. ^[A1]

4.3 Frequency range 150 kHz to 30 MHz

4.3.1 Electric antenna

For the measurement of the electric component of the radiation, either a balanced or an unbalanced antenna may be used. If an unbalanced antenna is used, the measurement will refer only to the effect of the electric field on a vertical rod antenna. The type of antenna used shall be stated with the results of the measurements.

^[A1] Information pertaining to calculating the performance characteristics of a monopole (rod) antenna and the characterization of its matching network is specified in Annex B. Annex B states that the antenna factor derived by the Equivalent Capacitor Substitution Method (ECSM) has greater uncertainties for monopole lengths greater than one-eighth of a wavelength. ^[A1]

The unit of electric field strength shall be $\mu\text{V/m}$ or, in logarithmic units, $20 \log(\mu\text{V/m}) = \text{dB}(\mu\text{V/m})$. The associated emission limit shall be expressed in the same units.

4.3.2 Magnetic antenna

For the measurement of the magnetic component of the radiation, an electrically-screened loop antenna, as described in 4.2.1 shall be used.

Tuned electrically balanced loop antennas may be used to make measurements at lower field strengths than untuned electrically-screened loop antennas.

4.3.3 Cross-polar response of antenna

If a balanced electric field antenna is used, it shall comply with the requirement of 4.4.3. If a balanced magnetic field antenna is used, it shall comply with the requirement of 4.2.2.”

4.4 Frequency range 30 MHz to 1 000 MHz

In this frequency range the measurements are of the electric field, so magnetic field antennas are not included. The antenna shall be a dipole-like antenna designed to measure the electric field. This includes tuned dipole antennas, whose element pairs are either straight rods or conical in shape, and dipole arrays such as the log-periodic dipole array (LPDA) antenna, comprising a series of staggered sets of straight rod elements, and hybrid antennas.

4.4.1 Low-uncertainty antenna for use if there is an alleged non-compliance to the E-field limit

For lower measurement uncertainty, the value of E-field strength measured by a typical biconical antenna or LPDA antenna is preferred, in particular over hybrid antennas. Typical biconical and LPDA antennas are defined in Annex A and only calibrated antennas shall be used.

NOTE 1 Improved uncertainties are achieved by using the biconical antenna over the frequency range 30 MHz to 250 MHz and the LPDA antenna over the range 250 MHz to 1 GHz. Alternatively, a change-over frequency of 200 MHz can be used, but uncertainties due to phase centre variations of the LPDA will be higher and must be included in the reported radiated emissions measurement uncertainty budget. ^[A1]

[A1] NOTE 2 The measurement uncertainty of radiated emissions from an EUT depends on many different influence factors such as the quality of the site, antenna factor uncertainty, antenna type, and the measurement receiver characteristics. The reason for defining low-uncertainty antennas is to limit other antenna influences on the measurement uncertainty, such as the effect of mutual coupling with a ground plane, the radiation pattern with respect to height scanning, and the variable phase centre position. Verification of effects of these influences is a comparison of the readings of the two antennas at the selected change-over frequency, which should give the same value of E-field strength within a margin of ± 1 dB.

4.4.2 Antenna characteristics

Since, at the frequencies in the range 300 MHz to 1 000 MHz, the sensitivity of the simple dipole antenna is low, a more complex antenna may be used. Such antenna shall be as follows.

- a) The antenna shall be linearly polarized, which shall be evaluated by applying the cross-polarization test procedure of 4.4.4.
- b) Balanced dipole antennas, such as tuned-dipole and biconical antennas, shall have validated balun performance, which shall be evaluated by applying the balance test procedure of 4.4.3. This also applies to hybrid antennas below 200 MHz.
- c) A test site with a conducting ground plane is assumed. The amplitude of the received signal will be reduced if either or both the direct and ground reflected signals from the EUT to the antenna are not entering the mainlobe of the radiation pattern of the antenna at its peak. The peak is usually in the boresight direction of the antenna. This reduction in amplitude is taken to be an error in the radiated emission: the ensuing uncertainty tolerance is based on the beamwidth, 2φ , see Figure 20.

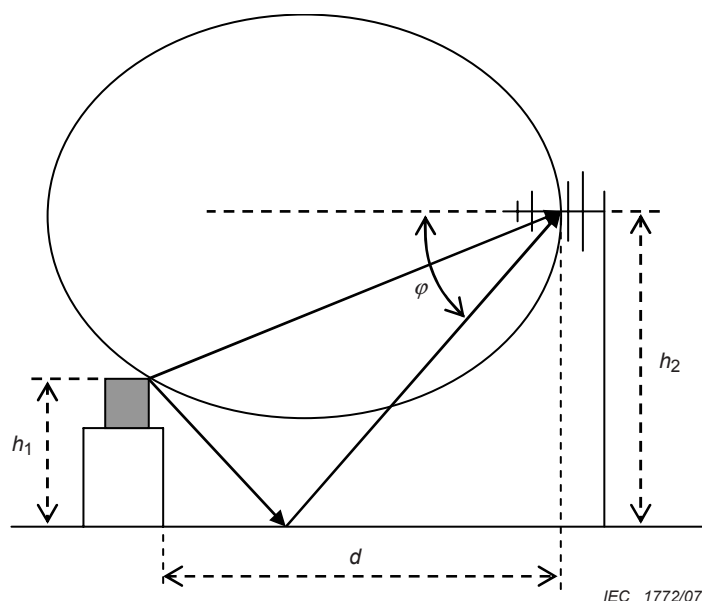


Figure 20 – Schematic of radiation from EUT reaching an LPDA antenna directly and via ground reflections on a 3 m site, showing the half beamwidth, φ , at the reflected ray

Conditions for ensuring that this error is no larger than +1dB are given below in 1) for a 10 m site and 2) for a 3 m site. Alternatively a condition based on antenna gain is given in 3) in order to bypass the laborious radiation pattern conditions.

Emission measurements are performed with the antenna horizontally and vertically polarised. If it is chosen to measure the radiation patterns in only one plane, the narrower patterns shall be used, as follows: the pattern of the antenna shall be verified in the horizontal plane while orienting it for horizontal polarisation. **[A1]**

- A1** 1) For a 10 m OATS or SAC the antenna response in the direction of the direct ray differs negligibly from the boresight amplitude when the antenna is aligned such that its boresight direction is parallel to the ground plane. The directivity component of the uncertainty in the emission measurement can be kept to less than + 1 dB if the antenna response in the direction of the reflected ray is no more than 2 dB lower than the antenna boresight response. To ensure this condition, the total vertical beamwidth 2φ of the measurement antenna, within which the antenna gain is within 2 dB of its maximum, shall be such that:

$$\varphi > \tan^{-1} [(h_1 + h_2)/d]$$

- 2) For sites with less than 10 m separation, typically 3 m, the total vertical beamwidth 2φ of the measurement antenna, within which the antenna gain is within 1 dB of its maximum, shall be such that:

$$2\varphi > \tan^{-1} [(h_1 + h_2)/d] - \tan^{-1} [(h_1 - h_2)/d]$$

where:

h_1 is the height of the equipment under test;

h_2 is the measurement antenna height;

d is the horizontal distance between the phase centre of the measurement antenna and the device under test.

If antenna down tilting that would reduce the associated uncertainties is not employed, the reduction in received signal shall be calculated, see Note, from the radiation patterns and applied as corrections or as directivity uncertainties. Example uncertainties budgets are given in CISPR 16-4-2.

NOTE 1 Assuming an E-field radiation pattern normalised to unity on boresight (= peak of mainlobe) read the E-field at the angles of declination from the antenna for the direct, E_D , and reflected rays, E_R . The error, compared to an E-field of unity magnitude for each of the direct and reflected rays, is given in decibels by: $20\log (2/(E_D + E_R))$.

NOTE 2 The reduction in signal strength caused by reduced directivity at angles off antenna boresight is a systematic error and therefore can be corrected. If a correction is applied, from knowledge of the radiation patterns at each frequency and polarisation, the uncertainty in emitted signal strength can be reduced accordingly.

- 3) For broad beamwidth antenna types used for radiated emission testing, such as biconical, LPDA and hybrid antennas, the beamwidth is inversely related to antenna directivity. An alternative to the criterion based on beamwidths in 1) and 2) above, is to specify the maximum gain of an antenna and to refer to generic uncertainty tolerances for the directivity component in the uncertainty budget for an emission test. The generic uncertainties, based on the narrowest beamwidths in the frequency range used for a given antenna, are given in CISPR 16-4-2. The maximum isotropic antenna gain for biconical antennas shall be 2 dB, and shall be 8 dB for log-periodic dipole array (LPDA) and hybrid antennas. For V-type LPDA antennas, whose H-plane beamwidth is equalised to the E-plane beamwidth, the maximum permissible isotropic gain shall be 9 dB.
- NOTE 3 The directivity uncertainties given in CISPR 16-4-2 (2004) can be used for a 10 m separation, but revised uncertainties are needed for a 3 m separation.
- d) The return loss of the antenna with the antenna feeder connected shall not be less than 10 dB. A matching attenuator may be part of the feeder cable for antennas if needed to meet this requirement.
- e) A calibration factor shall be given making it possible to fulfil the requirements of 4.1. **A1**

4.4.3 Balance of antenna

4.4.3.1 Introduction

In radiated emission measurements, common-mode (CM) currents may be present on the cable attached to the receiving antenna (the antenna cable). In turn, these CM currents create EM fields which may be picked up by the receiving antenna. Consequently, the radiated emission measuring results may be influenced.

The major contributions to the antenna cable CM currents stem from

- a) the electric field generated by the EUT, if that field has a component parallel to the antenna cable, and
- b) the conversion of the differential mode (DM) antenna signal (the desired signal) into a CM signal by the imperfection of the balun of the receiving antenna.

 Text deleted 

In general, log-periodic dipole array antennas do not exhibit significant DM/CM conversion and the following check applies to dipoles, biconical antennas and bicone/log hybrid antennas.

4.4.3.2 Balun DM/CM conversion check

The following method describes the measurement of two voltages, U_1 and U_2 , in the frequency range for which the receiving antenna is to be used. The ratio of these voltages, both expressed in identical units (e.g., dB μ V), is a measure for the DM/CM conversion.

- 1) Set the receiving antenna under test vertically polarized with its centre at a height of 1,5 m above the ground plane. Lay the cable horizontally for $1,5 \text{ m} \pm 0,1 \text{ m}$ behind the rear active element of the antenna and then drop it vertically by a height of at least 1,5 m to the ground plane.
- 2) Place a second (transmitting) antenna vertically polarized at a horizontal distance of 10 m from the centre of the antenna under test with its tip 0,10 m from the ground plane. If the range of the site used for emission testing is 3 m, do this check using a distance of 3 m (if the conversion check has already been made at 10 m distance and shows a change of less than $\pm 0,5 \text{ dB}$, it is not necessary to take a separate measurement at 3 m). The specification of the transmitting antenna shall include the frequency range of the antenna under test.
- 3) Connect the transmitting antenna to a signal source, for example, a tracking generator, set the level of that generator in such a way that, over the frequency range of interest, the signal-to-ambient noise at the receiver is larger than 10 dB.
- 4) Record the voltage U_1 at the receiver over the frequency range of interest.
- 5) Invert the receiving antenna (rotate that antenna through 180°) without changing anything else in the set-up, in particular the receiving antenna cable, and without changing the setting of the signal source.
- 6) Record the voltage U_2 at the receiver over the frequency range.

7) The DM/CM conversion is sufficiently low if $|20 \log (U_1/U_2)| < 1$ dB.

NOTE 1 If the DM/CM conversion criterion is not met, ferrite rings around the antenna cable may reduce the DM/CM conversion. The addition of ferrites on the antenna cable may also be used to verify whether contribution a) has a non-negligible effect. Repeat the test with four ferrites spaced approximately 20 cm apart. If the criterion is met by using these rings, they should be present in the actual emission measurement. Likewise, the interaction with the cable can be reduced by extending the cable several metres behind the antenna before dropping to ground.

NOTE 2 If the receiving antenna is to be used in a fully anechoic chamber, the DM/CM check may be performed in that room with the receiving antenna at its usual location and the transmitting antenna in the centre of the test volume of that room. The room must comply with the ± 4 dB criterion.

NOTE 3 The measuring site of which the ground plane forms a part, or the fully anechoic room, should comply with their respective *NSA* (normalized site attenuation) requirements.

NOTE 4 The horizontal distance of 1,5 m over which the antenna cable runs horizontally behind the centre of the antenna should be kept as a minimum during actual vertically polarized radiated emissions measurements.

NOTE 5 It is not necessary to define a test set-up strictly because this effect is in large part due to the interaction of the antenna and the part of input cable that lies parallel to the antenna elements. There is a much smaller effect which is dependent on the uniformity of the field incident on the antenna in normal EMC set-ups on an OATS or in a fully anechoic room.

NOTE 6 For baluns which have the receive cable connector mounted on the side (90° to the antenna boom), a right angle connector should be used to reduce the movement of the cable.

4.4.4 Cross-polar response of antenna

When an antenna is placed in a plane-polarized electromagnetic field, the terminal voltage when the antenna and field are cross-polarized shall be at least 20 dB below the terminal voltage when they are co-polarized. It is intended that this test apply to log-periodic dipole array (LPDA) antennas for which the two halves of each dipole are in echelon. The majority of testing with such antennas is above 200 MHz, but the requirement applies below 200 MHz. This test is not intended for in-line dipole and biconical antennas because a cross-polar rejection greater than 20 dB is intrinsic to their symmetrical design. Such antennas and horn antennas must have a cross-polar rejection greater than 20 dB and a type test by the manufacturer should confirm this.

In order to achieve quasi-free space conditions, a high-quality anechoic chamber or towers of sufficient height above ground on an outdoor range can be used. To minimize ground reflections, set the antennas vertically polarized. A plane wave shall be set up at the antenna under test. The separation between the centre of the antenna under test and the source antenna shall be greater than one wavelength.

NOTE A good-quality site is needed to set up a plane wave at the antenna under test. The cross-polar discrimination afforded by the plane wave can be proven by transmitting between a pair of horn antennas or open-ended waveguides and checking that the combination of site error and inherent cross-polar performance of one horn antenna yields a suppression of the horizontal component by more than 30 dB. If the site errors are very low and if the horn antennas have identical performance, the cross-polar performance of one horn is approximately 6 dB lower than the combined cross-polar coupling of the pair of horns.

An interfering signal 20 dB lower in level than the desired signal gives a maximum error on the desired signal of $\pm 0,9$ dB. The maximum error occurs when the cross-polar signal is in phase with the co-polar signal. If the cross-polar response of the LPDA is worse than 20 dB, the operator must calculate the uncertainty and declare it with the result. For example a cross-polar level of 14 dB implies a maximum uncertainty of +1,6 dB to –1,9 dB. Take the larger value and assume a U-shaped distribution when calculating the standard uncertainty.

To add a signal of 0 dB to another of –14 dB, first convert to relative voltages by dividing by 20 and taking the anti-log. Then add the smaller signal to the unity signal. Take the log and multiply by 20. The result is the positive decibel error. Repeat, but subtracting the smaller signal from the unity signal to give the negative decibel error.

For the purpose of calculating the uncertainty of the result of a radiated emission, if the signal level measured in one polarization exceeds the signal measured in the orthogonal polarization by 6 dB or more, then an LPDA whose cross-polar discrimination is only 14 dB will have been deemed to have met the specification of 20 dB. If the difference between the VP and HP signal levels is less than 6 dB, additional uncertainty must be calculated if the sum of this difference and the cross-polarization is less than 20 dB.

A1 Text deleted **A1**

4.5 Frequency range 1 GHz to 18 GHz

Radiated emissions measurements above 1 GHz shall be made using calibrated, linearly polarized antennas. **A1** Examples are LPDA antennas, double-ridged guide horns and standard gain horns. **A1** The "beam" or main lobe of the pattern of any antenna used shall be large enough to encompass the EUT when located at the measuring distance, or provisions shall be made for "scanning" the EUT to locate the direction or source of its radiated emissions. The width of the main lobe is defined as the 3 dB beamwidth of the antenna, and information enabling the determination of this parameter should be given in the antenna documentation. The aperture dimensions of these horn antennas shall be small enough so that the measurement distance R_m in metres is equal to or greater than the following minimum distance:

$$R_m \geq D^2/2\lambda$$

where

D is the largest dimension of the aperture in metres of the antenna;

λ is the free space wavelength in metres at the frequency of measurement.

In case of dispute, measurements made with a standard gain horn antenna or a similar precisely calibrated horn antenna shall take precedence.

A1 Text deleted **A1**

4.6 Special antenna arrangements

4.6.1 Loop antenna system

In the frequency range 9 kHz to 30 MHz, the interference capability of the magnetic field component of the radiation of a single (EUT) can be determined by using a special loop antenna system (LAS). In the LAS, this capability is measured in terms of the currents induced by the magnetic field in the loop antennas of the LAS. The LAS allows indoor measurements.

The LAS consists of three circular, mutually perpendicular large-loop antennas (LLAs), having a diameter of 2 m, supported by a non-metallic base. A full description of the LAS is given in Annex C.

The EUT is positioned in the centre of the LAS. The maximum dimensions of the EUT are limited so that the distance between the EUT and an LLA is at least 0,20 m. Guidelines for the routing of signal cables are given in Clause C.3, Note 2, and Figure C.6. Cables should be routed together and leave the loop volume in the same octant of the cell and no closer than 0,4 m to any of the LAS loops.

The three mutually perpendicular LLAs allow measurement of the interference capability of all polarizations of the radiated field with the prescribed accuracy, and without rotation of the EUT or changing the orientation of the LLAs.

Each of the three LLAs shall comply with the validation requirements given in Clause C.5.

NOTE Circular LLAs having a diameter different from the standardized diameter of 2 m may be used, provided their diameter $D \leq 4$ m and the distance between the EUT and a LA is at least $0,10(D)$ m. Correction factors for non-standardized diameters are given in Clause C.6.

5 Test sites for measurement of radio disturbance field strength for the frequency range of 30 MHz to 1 000 MHz

An environment is required which assures valid, repeatable measurement results of disturbance field strength from equipment. For equipment which can only be tested in its place of use, different provisions have to be utilized.

5.1 Open area test site

Disturbance field-strength measurements are normally performed at an open area test site. Open area test sites are areas characteristic of cleared level terrain. Such test sites shall be void of buildings, electric lines, fences, trees, etc. and free from underground cables, pipelines, etc., except as required to supply and operate the equipment under test (EUT). Refer to Annex D for specific construction recommendations for open area test sites for electromagnetic field tests in the range of 30 MHz to 1 GHz. The site validation procedure for open area test sites is given in 5.6 with further details in Annex E. Annex F contains the acceptability criterion.

5.2 Weather protection enclosure

Weather protection is desirable if the test site is used throughout the year. A weather protection structure could either protect the whole test site including EUT and field strength measuring antenna or the EUT only. The materials used shall be RF transparent in order to cause no undesirable reflections and attenuation of the emitted field from the EUT.

The structure shall be shaped to allow easy removal of snow, ice or water. For further details, see Annex D.

5.3 Obstruction-free area

For open area test sites, an obstruction-free area surrounding the EUT and field-strength measuring antenna is required. The obstruction-free area should be free from significant scatterers of electromagnetic fields, and should be large enough so that scatterers outside the obstruction-free area will have little effect on the fields measured by the field-strength measuring antenna. To determine the adequacy of this area, site validation tests should be performed.

Since the magnitude of the field scattered from an object depends on many factors (size of the object, distance from the EUT, orientation with respect to the EUT, conductivity and permittivity of the object, frequency, etc.), it is impractical to specify a reasonable obstruction-free area which is necessary and sufficient for all applications. The size and shape of the obstruction-free area are dependent upon the measurement distance and whether or not the EUT will be rotated. If the site is equipped with a turntable, the recommended obstruction-free area is an ellipse with the receiving antenna and EUT at the two foci and having a major axis equal to twice the measurement distance and a minor axis equal to the product of the measurement distance and the square root of 3 (see Figure 2).

For this ellipse, the path of the undesired ray reflected from any object on the perimeter is twice the length of the direct ray path between the foci. If a large EUT is installed on the turntable, the obstruction-free area must be expanded so that the obstruction clearance distances exist from the perimeter of the EUT.

If the site is not equipped with a turntable, that is, the EUT is stationary, the recommended obstruction-free area is a circular area such that the radial distance from the boundary of the EUT to the boundary of the area is equal to the measurement distance multiplied by 1,5 (see Figure 3). In this case, the antenna is moved around the EUT at the separation distance.

The terrain within the obstruction-free area should be flat. Small slopes needed for adequate drainage are acceptable. The flatness of the metallic ground plane, if used, is discussed in Clause D.2. Measuring apparatus and test personnel should be situated outside the obstruction free area.

5.4 Ambient radio frequency environment of a test site

The ambient radio frequency levels at a test site shall be sufficiently low compared to the levels of measurements to be performed. The quality of the site in this respect may be assessed in four categories, listed below in their order of merit:

- a) the ambient emissions are 6 dB or more below the measurement levels;
- b) some ambient emissions are within 6 dB of the measurement levels;
- c) some ambient emissions are above the measurement levels, but are either aperiodic (i.e., sufficiently long in time between transmissions to allow a measurement to be made) or continuous, but only on limited identifiable frequencies;
- d) the ambient levels are above the measurement levels over a large portion of the measurement frequency range and occurring continuously.

The selection of a test site should ensure that the accuracy of the measurement is maintained given the environment and the degree of engineering skill available.

NOTE For perfect results, an ambient level 20 dB below the emission level measured is recommended.

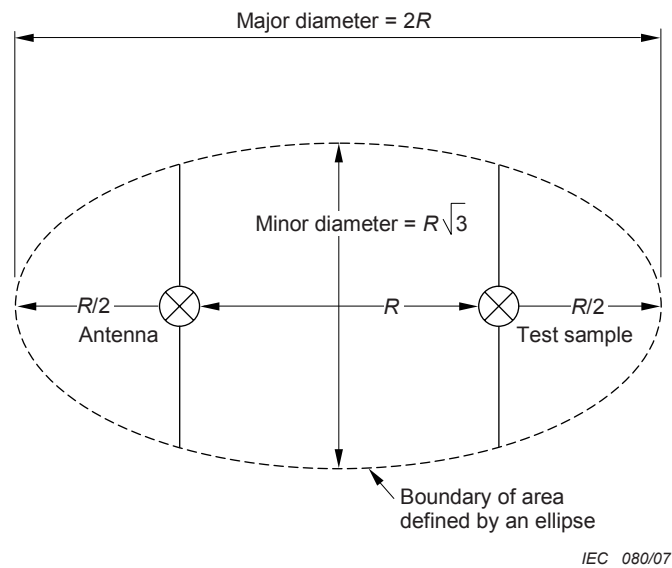


Figure 2 – Obstruction-free area of a test site with a turntable (see 5.3)

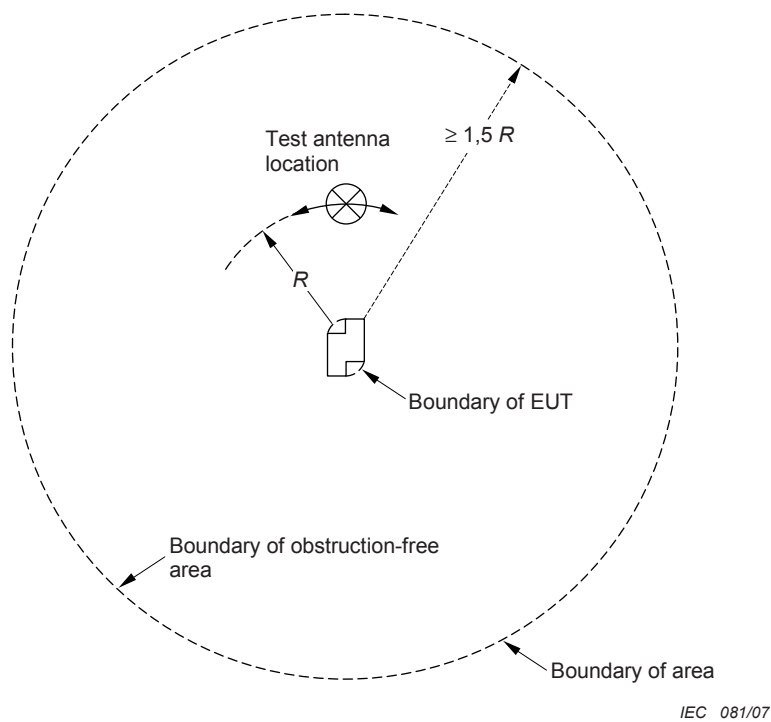


Figure 3 – Obstruction-free area with stationary EUT (see 5.3)

5.5 Ground plane

The ground plane may be composed of a wide range of material from earth to highly conductive, metallic material. The plane can be at earth level or elevated on a suitably sized platform or roof site. A metal ground plane is preferred, but for certain equipment and applications, it may not be recommended by certain product publications. Adequacy of the metal ground plane will be dependent on whether the test site meets the site validation requirements in 5.6. If no metallic material is used, caution is required to select a site that does not change its reflective characteristics with time, weather condition, or, due to buried metallic material such as pipes, conduits, and non-homogeneous soil. Such sites generally give different site attenuation characteristics compared to those with metallic surfaces.

5.6 Open area site validation procedure

The validation procedure and the requirements for the normalized site attenuation given here are used to qualify a test site when a metallic ground plane is specified. For other test sites, the validation procedure is of an informative nature, and will in general also identify possible site irregularities that should be investigated. Validation procedures applicable to absorber lined rooms are given in subclause 5.8.

The validation of an open area test site is performed with two antennas oriented horizontally and vertically with respect to the ground, as shown in Figures 4 and 5, respectively. The open area site attenuation is obtained from the ratio of the source voltage (V_i) connected to a transmitting antenna and the received voltage (V_r) as measured on the receiving antenna terminals. The voltage measurements are performed in a $50\ \Omega$ system. Suitable corrections for cable losses is required if V_r and V_i are not measured at the input and output of the transmit and receive antenna, respectively. This site attenuation ratio is then divided by the product of the antenna factors for the two antennas used. The resulting answer is the normalized site attenuation (NSA) and is expressed in dB. The site is considered suitable when the measured vertical and horizontal NSA 's are within ± 4 dB of the values given in Tables E.1, E.2, and E.3, as appropriate. If the ± 4 dB criterion is exceeded, the test site must be investigated per Clause E.4.

NOTE The basis for the 4 dB site acceptability criterion is given in Annex F.

The deviation between a measured NSA value and the theoretical value shall not be used as a correction for a measured EUT field strength. This procedure shall be used only for validating a test site.

Table E.1 is used for broadband antennas such as biconical and log periodic arrays both horizontally and vertically aligned with respect to the ground plane. Table E.2 is for tuned half-wave dipoles aligned horizontally with respect to the ground plane. Table E.3 is for tuned half-wave dipoles vertically aligned with respect to the ground plane. Note that in Table E.3, there are restrictions in the scan height h_2 . This takes into account the fact that the lowest tip of the receive dipole is kept 25 cm or more from the ground plane.

NOTE The reason for the different Tables E.1 and E.2/E.3 is that different geometrical parameters are chosen for a broadband antenna and a tuned half-wave dipole, primarily because of practical restrictions needed for the latter.

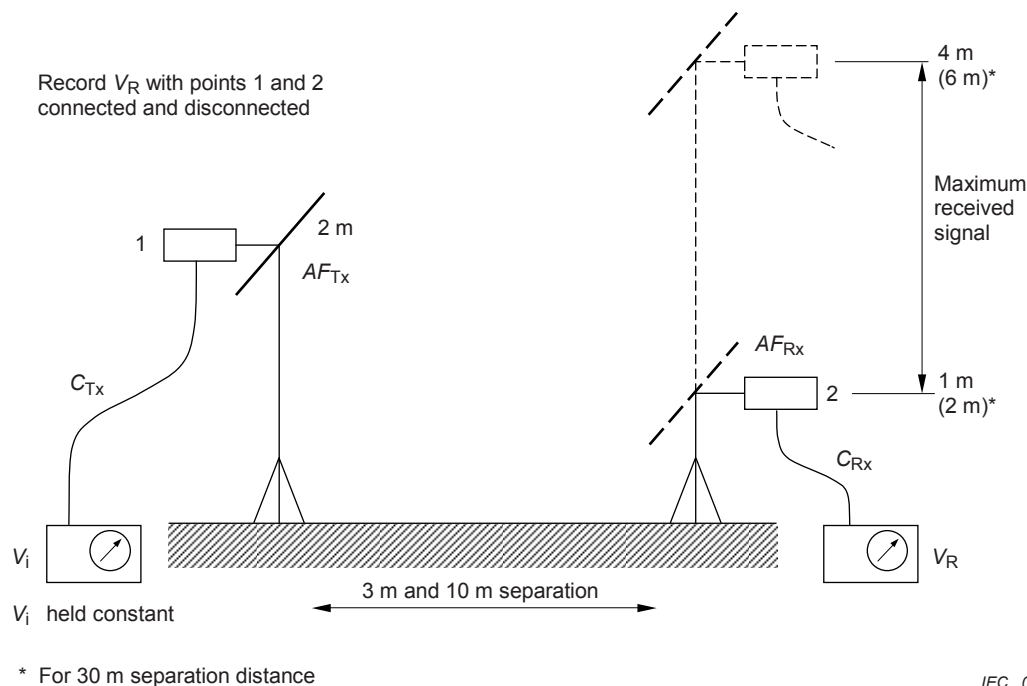


Figure 4 – Configuration of equipment for measuring site attenuation in horizontal polarization (see 5.6 and Annex E)

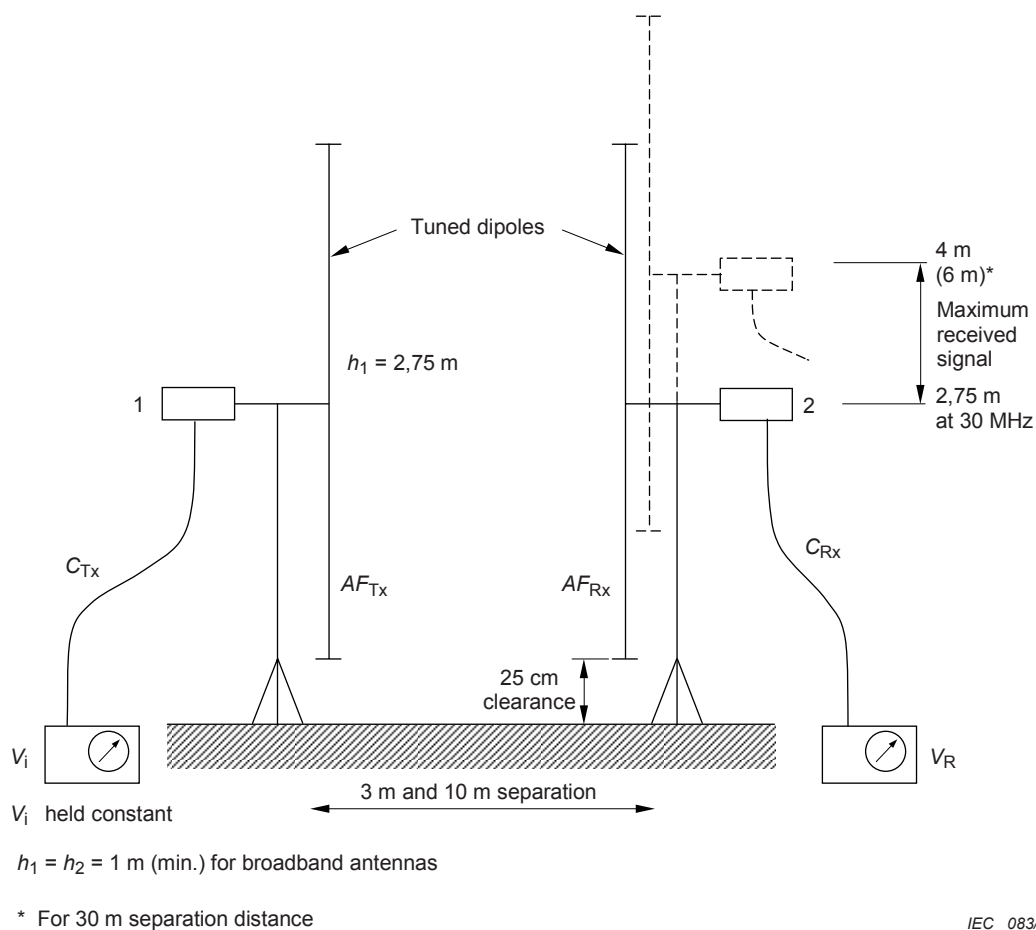


Figure 5 – Configuration of equipment for measuring site attenuation in vertical polarization using tuned dipoles (see 5.6 and Annex E)

NSA for frequencies other than those shown in the tables may be found using straight-line interpolation between the tabulated values.

The legend for each table is as follows:

- R Horizontal separation distance between the projection of the transmit and receive antennas on the ground plane (metres).
- h_1 Height of the centre of the transmit antenna above the ground plane (metres).
- h_2 Range of heights of the centre of the receive antenna above the ground plane (metres). The maximum received signal in this height scan range is used for NSA measurements.
- f_m Frequency in MHz.
- A_N NSA (see Equation (1), below).

NOTE The spacing R between log-periodic *array* antennas is measured from the projection on to the ground plane of the mid-point of the longitudinal axis of each antenna.

It is recommended that horizontal NSA measurements be performed first. Since such measurements are less sensitive than that for vertical polarization in finding test anomalies, the measured NSA should readily be within ± 4 dB of that shown in Tables E.1, E.2 and E.3. If not, recheck measurement technique, instrumentation drift and antenna factor calibrations. If the ± 4 dB criterion is still exceeded, a significant site anomaly is present which should be readily apparent and corrective action taken before proceeding to the vertical polarization NSA measurement.

5.6.1 General NSA measurement

For each polarization measurement, the NSA procedure requires two different measurements of V_R which is the voltage received. The first reading of V_R is with the two coaxial cables disconnected from the two antennas and connected to each other via an adapter. The second reading of V_R is taken with the coaxial cables reconnected to their respective antennas and the maximum signal measured when the receive antenna is scanned in height. (1 m to 4 m for 3 m and 10 m separation distances and either 1 m to 4 m or 2 m to 6 m for the 30 m separation.) For both of these measurements, the signal source voltage, V_i , is kept constant. The first reading of V_R is called V_{DIRECT} and the second is V_{SITE} . These are used in the following Equation (1) for the measured NSA, A_N ; all terms are in dB.

$$A_N = V_{\text{DIRECT}} - V_{\text{SITE}} - AF_T - AF_R - \Delta AF_{\text{TOT}} \quad (1)$$

where

- AF_T is the transmit antenna factor;
- AF_R is the receive antenna factor;
- ΔAF_{TOT} is the mutual impedance correction factor.

Note that the first two terms represent the actual measurement of site attenuation, i.e., $V_{\text{DIRECT}} - V_{\text{SITE}}$ is equal to the classical view of site attenuation, which is constituted by the insertion loss of the propagation path with the inclusion of the properties of the two antennas used. Theoretical values for ΔAF_{TOT} are given in Table E.4. AF_T and AF_R shall be measured.

Note that: $V_{\text{DIRECT}} = V_i - C_T - C_R$

where

C_T and C_R are the cable losses which do not need to be measured separately. The mutual impedance correction factor in Table E.4 applies only to the recommended site geometry of 3 m separation, horizontal polarization and the use of half-wavelength tuned dipoles.

To accomplish these *NSA* measurements, two techniques can be used, depending on the instrumentation available and whether a broadband or tuned dipole is used. Both methods give essentially equal results if used correctly as outlined in Annex E. Briefly, each method is described as follows:

a) Discrete frequency method

For this method, specific frequencies given in Tables E.1, E.2 or E.3 are measured in turn. At each frequency, the receive antenna is scanned over the height range given in the appropriate table to maximize the received signal. These measured parameter values are inserted in Equation (1) to obtain the measured *NSA*. Annex E contains a suggested procedure approach to record the data, calculate the measured *NSA*, and then compare it with the theoretical *NSA*.

b) Swept frequency method

For this method, measurements using broadband antennas may be made using automatic measuring equipment having a peak hold (maximum hold), storage capability, and a tracking generator. In this method, both antenna height and frequency are scanned or swept over the required ranges. The frequency sweep speed shall be much greater than the antenna height scan rate. Otherwise the procedure is the same as in a). A detailed procedure is given in Annex E.

5.6.2 Antenna factor determination

Accurate antenna factors are necessary in measuring *NSA*. In general, antenna factors provided with the antenna are inadequate unless they are specifically or individually measured. Linearly polarized antennas are required. A useful antenna calibration method is contained in Annex E. Manufacturer's antenna factors may account for losses due to the balun among other features. If a separate balun or any integrally associated cables are used, their effects must be accounted for. The formula to use for tuned half-wave dipoles is also contained in Annex E.

5.6.3 Site attenuation deviations

If measurements of *NSA* deviate by more than ± 4 dB, several items should be re-checked first:

- a) measurement procedure;
- b) accuracy of antenna factors;
- c) drift in signal source or accuracy of receiver or spectrum analyzer input attenuator and reading.

If no errors are found in a), b) and c), then the site is at fault and detailed investigation of possible causes of site variability should be made. Annex F contains the errors that can occur with *NSA* measurements.

Note that since the vertical polarization is generally the more critical measurement, site anomalies should be investigated using this more sensitive measurement rather than the horizontal polarization results. Key items to investigate include:

- a) ground plane size and construction inadequacy;
- b) objects at the perimeter of the site that may be causing undesired scattering;
- c) all-weather cover;

- d) ground plane discontinuity at the turntable circumference when the turntable surface is conductive and at the same elevation as the ground plane;
- e) thick dielectric ground plane covers;
- f) openings in ground plane for stairways.

5.7 Test site suitability with ground-plane

There are many different test sites and facilities that have been constructed to make radiated emission measurements. Most are protected from the weather and the adverse effects of the radio frequency ambient. These include all weather-covered open area test sites and absorber-lined shielded rooms.

Whenever construction material encloses a test site, there is the possibility that the results of a single normalized site attenuation (NSA) measurement, as specified in 5.6, are not adequate to show such alternative site suitability.

To assess alternative test site suitability, the following procedure is recommended. It is based on making multiple NSA measurements throughout a volume occupied by the EUT. These NSA measurements shall all come within the error budget of ± 4 dB to be judged suitable as an equivalent to an open area test site.

The discussion in this section concerns alternative test sites which have a conducting ground plane.

5.7.1 Normalized site attenuation for alternative test sites

For an alternative test site a single NSA measurement is insufficient to pick up possible reflections from the construction and/or RF-absorbing material comprising the walls and ceiling of the facility. For these sites a "test volume" is defined as that volume traced out by the largest equipment or system to be tested as it is rotated about its centre location through 360° , such as by a turntable. In evaluating horizontal and vertical polarization, such as illustrated in Figures 6a and 6b, it may require a maximum of 20 separate site attenuation measurements, i.e. five positions in the horizontal plane (centre, left, right, front, and rear, measured with respect to the centre and a line drawn from the centre to the position of the measuring antenna), for two polarizations (horizontal and vertical), and for two heights (1 m and 2 m horizontal, 1 m and 1,5 m vertical).

These measurements are carried out with a broadband antenna and distances are measured with respect to the centre of the antenna. The transmit and receive antennas shall be aligned with the antenna elements parallel to each other and orthogonal to the measurement axis.

For vertical polarization, the off-centre positions of the transmit antenna are at the periphery of the test volume. Furthermore, the lower tip of the antenna shall be greater than 25 cm from the floor, which may require the centre of the antenna to be slightly higher than 1 m for the lowest height measurement.

For horizontal polarization measurements in the left and right positions if the distance between the construction and/or absorbing material on the side walls and EUT periphery is $\langle A_1 \rangle$ at least 1 m $\langle A_1 \rangle$, the centre of the antenna is moved towards to central position so that the extreme tip of the antenna is either at the periphery or distant from the periphery by not more than 10 % of the test volume diameter. The front and rear positions are at the periphery of the test volume.

The number of required measurements can be reduced under the following circumstances.

- a) The vertical and horizontal polarization measurements in the rear position may be omitted if the closest point of the construction and/or absorbing material is at a distance greater than 1 m from the rear boundary of the test volume.

NOTE Radiated emission sources located near dielectric interfaces have been shown to have variations in current distribution that can affect the radiated properties of the source at that location. When EUT can be located near these interfaces, additional site attenuation measurements are required.

- b) The total number of horizontal polarization measurements along the test volume diameter joining the left and right positions may be reduced to the minimum number necessary for the antenna footprints to cover 90 % of the diameter.
- c) The vertical polarization measurements at the 1,5 m height may be omitted if the top of the EUT, including any table mounting, is less than 1,5 m in height.
- d) If the test volume is no larger than 1 m in depth, by 1,5 m in width, by 1,5 m in height, including table if used, horizontal polarization measurements need only be made at the centre, front and rear positions but at the height of both 1 m and 2 m. If item a) above applies, the rear position may be omitted. This will require a minimum of eight measurements: four positions vertical polarization (left, centre, right, and front) for one height, and four positions horizontal polarization (centre and front) for two heights; see Figures 6c and 6d.

NSA measurements shall be performed with the transmit and receive antenna separation held constant according to Tables 1 and 2. Note that these tables have been modified to accommodate these NSA measurements by adding values for an additional transmit height and to limit the 30 m scan height to between 1 m and 4 m. The receive antenna must be moved to maintain the appropriate separation along a line towards the turntable centre (see Figures 6a, 6b, 6c and 6d). The alternative test site is considered suitable for performing radiated emission testing if all NSA measurements prescribed above meet the requirements of 5.7.2 and the ground plane requirements of 5.7.3 below.

NOTE Studies are underway to determine if any further tests are required to show alternate test site suitability.

5.7.2 Site attenuation

A measurement site shall be considered acceptable for radiated electromagnetic field measurements if the measured horizontal and vertical NSA measurements are within ± 4 dB of the theoretical normalized site attenuation for an ideal site.

5.7.3 Conducting ground plane

A conducting ground plane is required at a radiated emission test site. The conducting ground plane shall extend at least 1 m beyond the periphery of the EUT and the largest measurement antenna, and cover the entire area between the EUT and the antenna. It shall be of metal with no holes or gaps having longitudinal dimensions larger than one-tenth of a wavelength at the highest frequency of measurement. A larger size conducting ground plane may be required if the NSA measurements do not meet the ± 4 dB criterion.

NOTE Ongoing studies may indicate the need for specifying minimum conductive ground plane size.

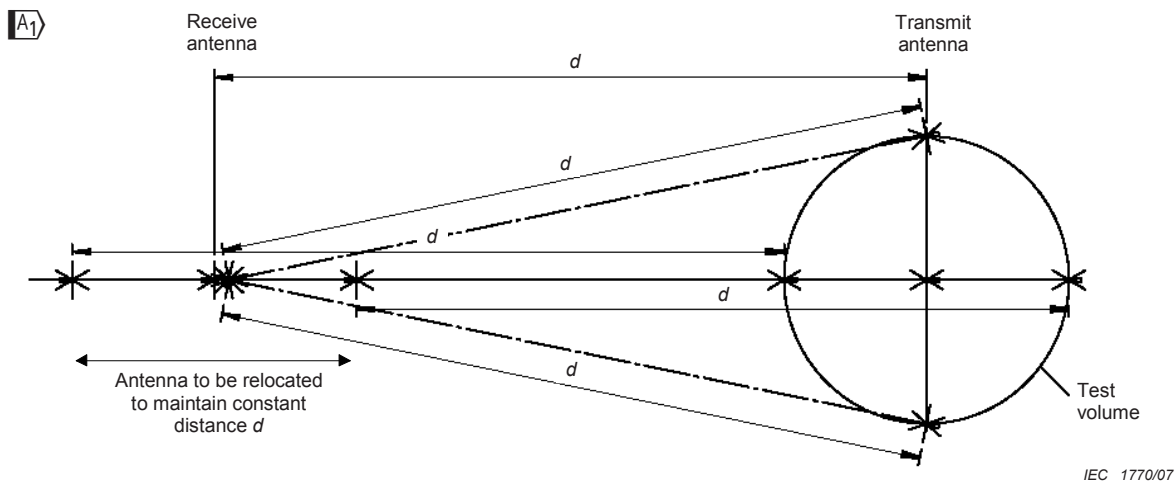


Figure 6a – Typical antenna positions for alternative test site – Vertical polarization NSA measurements

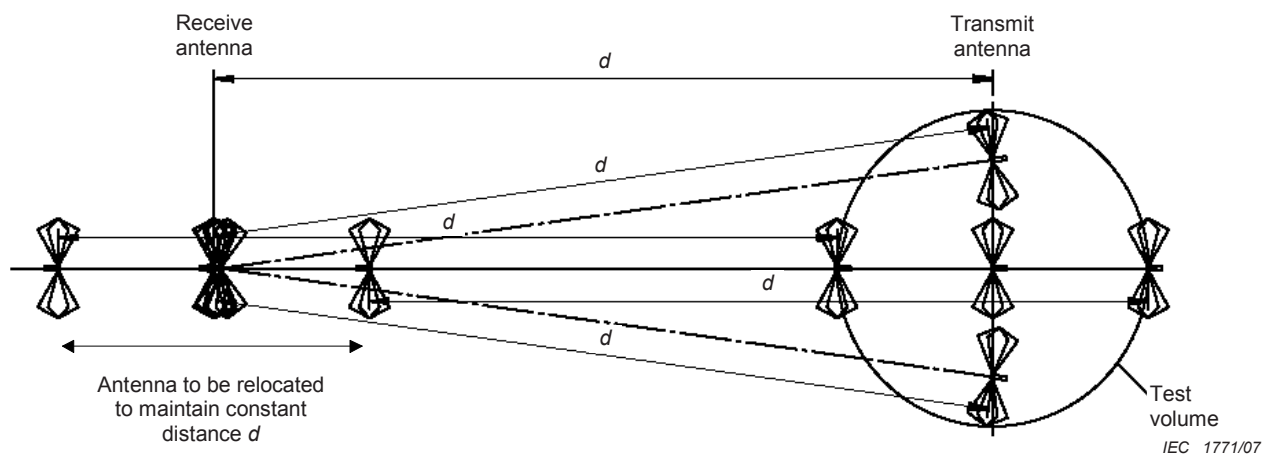


Figure 6b – Typical antenna positions for alternative test site – Horizontal polarization NSA measurements

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