



BSI Standards Publication

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 (CISPR 16-1-4:2010/A2:2017)

National foreword

This British Standard is the UK implementation of EN 55016-1-4:2010+A2:2017. It is identical to CISPR 16-1-4:2010, incorporating amendment A1:2012, corrigendum December 2010 and including amendment A2:2017. It supersedes BS EN 55016-1-4:2010+A1:2012, which will be withdrawn on 23 February 2020.

The start and finish of text introduced or altered by CISPR amendment 1 is indicated in the text by tags.

The text of CISPR amendment A2:2017 has been provided in its entirety at the beginning of this document. BSI's policy of providing consolidated content remains unchanged; however, in the interest of expediency, in this instance BSI have chosen to collate the relevant content at the beginning of this document.

The UK participation in its preparation was entrusted to Technical Committee GEL/210/11, EMC - Standards Committee.

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

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English Version

**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
(CISPR 16-1-4:2010/A2:2017)**

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 16-1-4:2010/A2:2017)

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 - Antennen und Messplätze für Messungen
der gestrahlten Störaussendung
(CISPR 16-1-4:2010/A2:2017)

This amendment A2 modifies the European Standard EN 55016-1-4:2010; it was approved by CENELEC on 2017-02-23. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this amendment the status of a national standard without any alteration.

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This amendment exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the CEN-CENELEC Management Centre has the same status as the official versions.

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

CEN-CENELEC Management Centre: Avenue Marnix 17, B-1000 Brussels

European foreword

The text of document CISPR/A/1194/FDIS, future CISPR 16-1-4:2010/A2, prepared by SC A "Radio interference measurements and statistical methods" of IEC/TC CISPR "International special committee on radio interference" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 55016-1-4:2010/A2:2017.

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standard or by endorsement
- latest date by which the national (dow) 2020-06-16
standards conflicting with the
document have to be withdrawn

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Endorsement notice

The text of the International Standard CISPR 16-1-4:2010/A2:2017 was approved by CENELEC as a European Standard without any modification.

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

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

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
CISPR 16-1-6	-	Specification for radio disturbance and immunity measuring apparatus and methods -- Part 1-6: Radio disturbance and immunity measuring apparatus - EMC-antenna calibration	EN 55016-1-6	-
+ A1	-		+ FprA1	-
CISPR 16-2-3	2010	Specification for radio disturbance and immunity measuring apparatus and methods -- Part 2-3: Methods of measurement of disturbances and immunity - Radiated disturbance measurements	EN 55016-2-3	2010
-	-		+ AC	2013

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FOREWORD

This amendment has been prepared by CISPR subcommittee 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:

FDIS	Report on voting
CISPR/A/1194/FDIS	CISPR/A/1203/RVD

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

The committee has decided that the contents of this amendment and the base publication will remain unchanged until the stability date indicated on the IEC website 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.

2 Normative references

Replace, in the existing list, the reference to CISPR 16-2-3 by the following:

CISPR 16-2-3:2010, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-3: Methods of measurement of disturbances and immunity – Radiated disturbance measurements*

Add, to the existing list, the following new normative reference:

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/AMD1:2016

3.1 Terms and definitions

Add, after the existing 3.1.27 added by Amendment 1, the following the new term and definition:

3.1.28

mechanical boresight

direction of the main beam, which is defined by the geometric properties of the antenna

3.2 Abbreviations

Add to the existing list the following new abbreviations:

RX Receive
TX Transmit

4.6 Frequency range 1 GHz to 18 GHz

Add, before the existing text, the following new title:

4.6.1 General

Delete, in the third sentence of the first paragraph of the existing subclause, the latter half of the sentence starting with “or provisions shall be made...”

Add at the end of the existing 4.6 the following new subclauses:

4.6.2 Receive antenna

4.6.2.1 General

The receive antenna shall be linearly polarized and shall be the same type as used for EUT emission measurements.

Some antenna models may have different versions with possibly different patterns and users are advised to verify this.

NOTE 1 “Antenna type” means a shape or a kind of antenna, for example horn and LPDA antenna.

NOTE 2 “Antenna model” means the specified manufacturer’s model number.

NOTE 3 “Version” means the specified manufacturer’s revision number, if applicable, of a particular antenna model number.

4.6.2.2 Receive antenna radiation pattern

E-plane and *H*-plane radiation patterns shall be measured with reference to the boresight.

The measurand is the antenna pattern in dB and as represented on the polar chart in Figure 43.

The normalization of this chart is to 0 dB.

The 0° angle shall be equal to the mechanical boresight.

The *E*-plane and *H*-plane radiation patterns of each individual antenna shall be recorded over the frequency range of the antenna with a step size of 500 MHz or smaller according to Annex I of CISPR 16-1-6:2014/AMD1:2016.

Type test results, including statistical data, supplied by the manufacturer may be used to provide evidence that the receive antenna radiation pattern requirements are met. Service measures shall be taken to assure pattern stability during the antenna life.

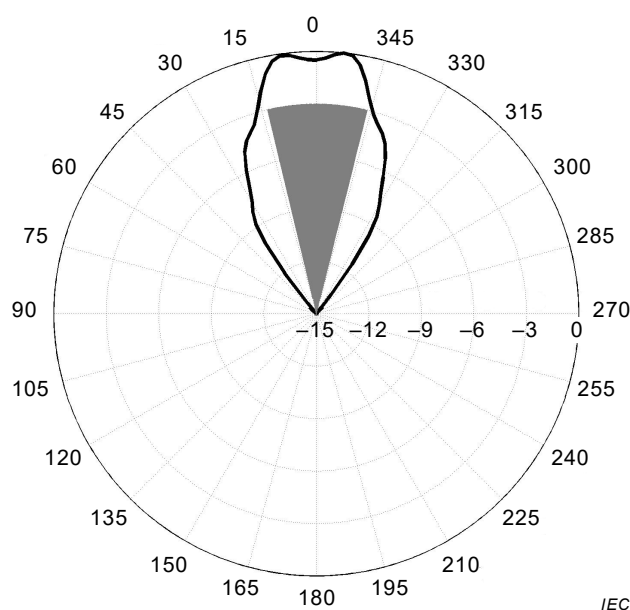


Figure 43 – RX antenna *E*-plane radiation pattern example with limit for 3 m distance and 2 m EUT width

NOTE In general, the boresight direction is the direction of maximum radiation from the antenna. However it may happen that the pattern has two radiation maxima and none of the maxima are in the direction of the mechanical boresight as in Figure 43.

4.6.2.3 Receive antenna radiation pattern requirements

The grey areas shown in the polar diagrams of Figures 44 and 45 are defined by the maximum height, h , and the maximum width, w , of the EUT and the test distance, d .

In order for the receive antenna to sufficiently illuminate the EUT, the half power beam-width of the receive antenna shall not fall inside this area in *E*-plane and *H*-plane cuts as shown in Figures 44 and 45.

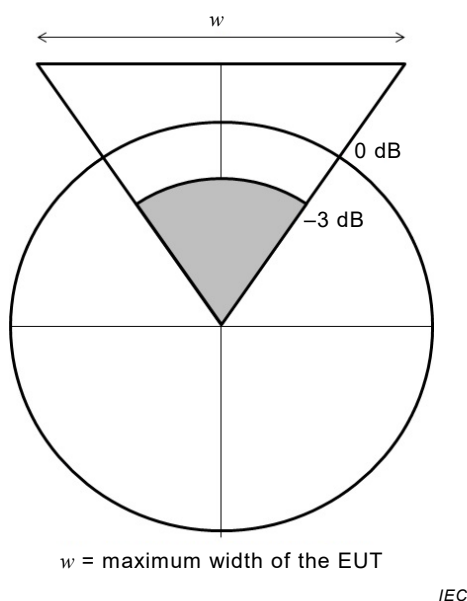


Figure 44 – Determination of maximum useable EUT width using half power beam-width

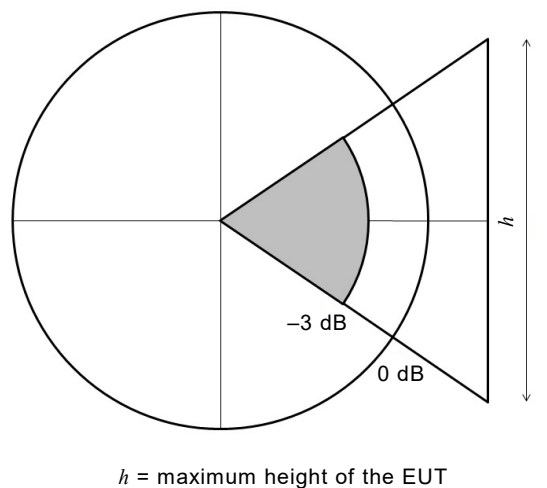


Figure 45 – Determination of maximum useable EUT height using half power beam-width

8.3.1 General

Add, between the third and fourth paragraphs, the following new paragraph and new NOTE 3:

When measuring the disturbance of an EUT size smaller than the validated diameter, the diameter of the validated test volume is assumed to apply. In this case the antenna position is adjusted such that the distance between the EUT and the antenna reference point is identical to the distance used for S_{VSWR} validation.

NOTE 3 For EUTs smaller than the validated test volume, the rationale is that the RX antenna position in relation to the front of the EUT be adjusted to remain at the distance used in S_{VSWR} validation. It is assumed that a smaller EUT will remain within the half power beam-width of the RX antenna and since the chamber is validated for the largest EUT and therefore the widest beam-width of the RX antenna, the requirements of 7.6.6.1 in CISPR 16-2-3:2010 are met.

8.3.3.1.1 General

Replace the existing text of this subclause by the following new paragraphs and note:

To provide illumination of all reflecting surfaces during this test, and to simulate the possible low-directivity radiation patterns exhibited by many EUTs, this subclause specifies characteristics for equipment used for S_{VSWR} testing. For this purpose, RX and TX antennas are used.

The following subclauses define the performance criteria for the TX antennas for the S_{VSWR} test. For the performance criteria of RX antennas see 4.6.2.3. Type test results supplied by the manufacturer may be used to provide evidence that the performance criteria are met.

The TX and RX patterns shall be measured according to Annex I of CISPR 16-1-6:2014/AMD1:2016.

For both the TX and RX antennas, one or more antennas can be used to cover the whole frequency range for the S_{VSWR} test.

NOTE It is assumed that both antennas also meet these requirements at all frequencies used for the S_{VSWR} test.

8.3.3.1.2 Test equipment for the standard S_{VSWR} procedure (i.e. 8.3.3.3)

Replace the existing title by the following new title:

8.3.3.1.2 Transmit antenna

8.3.3.1.2.1 General

Replace the existing text of this subclause by the following new text:

The antenna used as a transmit source shall be linearly polarized and shall have a radiation pattern with the following detailed characteristics.

Radiation pattern data shall be available with a frequency step size less than or equal to 1 GHz.

Different frequency step sizes are required due to the change of pattern with frequency. Typical TX antenna patterns do not change rapidly with frequency, while some LPDA RX antenna patterns do.

8.3.3.1.3 Test equipment for the reciprocal S_{VSWR} procedure (i.e. 8.3.3.4)

Replace the existing first sentence of this subclause, modified by Amendment 1, by the following new first sentence:

The antenna used to transmit into the test volume shall be the same type as used later for the emission measurements and shall meet the requirements of 4.6.2.

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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
(CISPR 16-1-4:2010)**

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 16-1-4:2010)

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 16-1-4:2010)

This European Standard was approved by CENELEC on 2010-06-01. 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.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CENELEC member into its own language and notified to the Central Secretariat has the same status as the official versions.

CENELEC members are the national electrotechnical committees of Austria, Belgium, Bulgaria, Croatia, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

CENELEC

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

Management Centre: Avenue Marnix 17, B - 1000 Brussels

Foreword

The text of document CISPR/A/885/FDIS, future edition 3 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 2010-06-01.

This European Standard supersedes EN 55016-1-4:2007 + A1:2008 + A2:2009.

This EN 55016-1-4:2010 includes the following significant technical change with respect to EN 55016-1-4:2007 + A1:2008 + A2:2009: provisions are added to address evaluation of a set-up table in the frequency range above 1 GHz.

It has the status of a basic EMC publication in accordance with IEC Guide 107, *Electromagnetic compatibility – Guide to the drafting of electromagnetic compatibility publications*.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN and CENELEC shall not be held responsible for identifying any or all such patent rights.

The following dates were fixed:

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at national level by publication of an identical
national standard or by endorsement (dop) 2011-03-01
- latest date by which the national standards conflicting
with the EN have to be withdrawn (dow) 2013-06-01

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard CISPR 16-1-4:2010 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following note has to be added for the standard indicated:

[1] IEC 61169-8 NOTE Harmonized as EN 61169-8.

Foreword to amendment A1

The text of document CISPR/A/995/FDIS, future amendment 1 to edition 3 of CISPR 16-1-4, prepared by SC A "Radio-interference measurements and statistical methods" of IEC/TC CISPR "International special committee on radio interference" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 55016-1-4:2010/A1:2012.

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Endorsement notice

The text of the International Standard CISPR 16-1-4:2010/A1:2012 was approved by CENELEC as a European Standard without any modification.

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

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.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
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	EN 55016-1-1	-
CISPR 16-1-5	2003	Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-5: Radio disturbance and immunity measuring apparatus - Antenna calibration test sites for 30 MHz to 1 000 MHz	EN 55016-1-5	2004
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	EN 55016-2-3	-
CISPR/TR 16-3		Specification for radio disturbance and immunity measuring apparatus and methods - Part 3: CISPR technical reports	-	-
CISPR 16-4-2	-	Specification for radio disturbance and immunity measuring apparatus and methods - Part 4-2: Uncertainties, statistics and limit modelling - Uncertainty in EMC measurements	EN 55016-4-2	-
IEC 60050-161	-	International Electrotechnical Vocabulary (IEV) - Chapter 161: Electromagnetic compatibility	-	-
IEC 61000-4-20	-	Electromagnetic compatibility (EMC) - Part 4-20: Testing and measurement techniques - Emission and immunity testing in transverse electromagnetic (TEM) waveguides	EN 61000-4-20	-

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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

1 Scope

This part of CISPR 16 specifies the characteristics and performance of equipment for the measurement of radiated disturbances in the frequency range 9 kHz to 18 GHz. Specifications for antennas and test sites are included.

NOTE In accordance with IEC Guide 107, CISPR 16-1-4 is a basic EMC publication for use by product committees of the IEC. As stated in Guide 107, product committees are responsible for determining the applicability of the EMC standard. CISPR and its sub-committees are prepared to co-operate with product committees in the evaluation of the value of particular EMC tests for specific products.

The requirements of this publication apply 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 16-1-5:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-5: Radio disturbance and immunity measuring apparatus – Antenna calibration test sites for 30 MHz to 1 000 MHz*

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

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

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

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

3 Terms, definitions and abbreviations

For the purposes of this document, the following terms, definitions and abbreviations apply, as well as those of CISPR 16-1-1, CISPR 16-1-5, and IEC 60050-161.

3.1 Terms and definitions

3.1.1

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, hybrid antenna and horn antenna.

3.1.2

balun

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

3.1.3

calibration test site

CALTS

open area test site with metallic ground plane and tightly specified site attenuation performance in horizontal and vertical *E*-field (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.

3.1.4

common mode absorption device

CMAD

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

3.1.5

compliance test site

COMTS

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

3.1.6

cross-polar response

measure of the rejection by the antenna of the cross-polarized field, when the antenna is rotated in a linearly polarized electromagnetic field that is uniform in phase and amplitude over the aperture of the antenna under test

3.1.7

fully-anechoic room

FAR

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

3.1.8

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".

3.1.9

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.

3.1.10

insertion loss

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, $|1/S_{21}|$.

3.1.11

low-uncertainty antenna

robust biconical or LPDA antenna that meets the balance and cross-polar performance requirements of this standard, and whose antenna factor has an uncertainty of less 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.2.3.

3.1.12

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.

3.1.13

reflection coefficient

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} .

3.1.14

scattering parameters (*S*-parameters)

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

3.1.15

semi-anechoic chamber

SAC

shielded enclosure in which all surfaces except the metal floor are covered with material that absorbs electromagnetic energy (i.e. RF absorber) in the frequency range of interest

3.1.16

short-open-load-through calibration method

SOLT

through-open-short-match calibration method

TOSM

calibration method for a vector network analyzer 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, and requires twelve reference measurements to perform the calibration.

3.1.17

site attenuation

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

3.1.18

site insertion loss

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

3.1.19

test volume

volume in a 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 a FAR.

3.1.20

through-reflect-line (TRL) calibration

calibration method for a vector network analyzer 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.

3.1.21

vector network analyzer

VNA

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

3.1.22

antenna factor

AF

F_a

ratio of the electric field strength of an incident plane wave to the voltage induced across a specified load (typically 50 Ω) connected to the antenna

NOTE 1 F_a is affected by the load impedance connected to the antenna radiating elements, and is frequency dependent. For a biconical antenna this impedance could be up to 200 Ω . For antennas with no balun the impedance is equal to the load impedance, typically 50 Ω .

NOTE 2 Usually, the AF is defined for the plane wave incident from the direction corresponding with the maximum gain of the antenna and at a specified point of the antenna.

NOTE 3 The AF has the physical dimension of inverse metres (m^{-1}) and measured data are normally expressed in dB(m^{-1}). In radiated emission measurements, if F_a is known, the strength of an incident field, E , can be estimated from a reading, V , of a measuring receiver connected to the antenna as follows:

$$E = V + F_a$$

where E is in dB($\mu V/m$), V is in dB(μV) and F_a is in dB(m^{-1}).

3.1.23

antenna factor, free-space

$F_{a\text{ fs}}$

AF of an antenna located in a free-space environment

NOTE $F_{a\text{ fs}}$ is a measurand for uncertainty calculation for antenna calibration. For NSA measurements $F_{a\text{ fs}}$ is an input quantity for uncertainty calculation.

3.1.24

antenna pair reference site attenuation

A_{APR}

set of site attenuation measurement results for both vertical and horizontal polarizations using a pair of antennas separated by a defined 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 A_{APR} is a measurand for uncertainty calculation.

NOTE 2 A_{APR} measurements are used for comparison to corresponding site attenuation measurements of a COMTS to evaluate the performance of the COMTS.

3.1.25

antenna reference point

midpoint of an antenna from which the distance to the EUT or second antenna is measured

NOTE The antenna reference point is either defined by the manufacturer using a marker on LPDA antennas or by the calibration laboratory.

3.1.26

ideal open-area test site

open-area test site having a perfectly flat, perfectly conducting ground plane of infinite area, and with no reflecting objects except the ground plane

NOTE An ideal OATS is a theoretical construct that is used in the definition of the measurand A_{APR} and in the calculation of the theoretical normalized site attenuation A_N for ground plane sites.

3.1.27

reference test site

REFTS

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

3.2 Abbreviations

A1 The following are abbreviations used in this standard that are not already given in 3.1. **A1**

EUT	Equipment under test
FSOATS	Free-space OATS
LAS	Loop antenna system
LLA	Large-loop antenna
LPDA	Log-periodic dipole array
NSA	Normalised site attenuation
OATS	Open-area test site
A1 RSM	Reference site method A1
SA	Site attenuation

A1 *Text deleted* **A1**

S_{VSWR}	Site voltage standing wave ratio
VSWR	Voltage standing wave ratio

4 Antennas for measurement of radiated radio disturbance

4.1 General

Antennas of the type that are used for radiated emission measurements, having been calibrated, shall be used to measure the field strength, taking into account their radiation patterns and mutual coupling with their surroundings. 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.

The antenna shall be linearly polarized. 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.

The accuracy of field-strength measurement of a uniform field of a sine-wave signal 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.

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

4.2 Physical parameter for radiated emission measurements

The physical parameter for radiated emission measurements made against an emission limit expressed in volts per metre is E -field 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.

4.3 Frequency range 9 kHz to 150 kHz

4.3.1 General

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

4.3.2 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 magnetic field strength is $\mu\text{A/m}$. In logarithmic units H is in $\text{dB}(\mu\text{A/m})$, or 20 times the log of the measured field strength level. 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 E -field strength in $\text{dB}(\mu\text{V/m})$, i.e. assuming that the ratio of the E and H components is $120 \pi \Omega$ or 377Ω . Calculations for H are as follows:

$$H = \frac{E}{377 \Omega} \quad (1)$$

where H is typically in $\mu\text{A/m}$ and E in $\mu\text{V/m}$.

For measurements in dB:

$$H = E - 51,5 \quad (2)$$

where H is in $\text{dB}(\mu\text{A/m})$ and E in $\text{dB}(\mu\text{V/m})$.

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

4.3.3 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.

4.4 Frequency range 150 kHz to 30 MHz

4.4.1 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 E -field on a monopole (rod) antenna. The type of antenna used shall be stated with the results of the measurements.

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 Capacitance Substitution Method (ECSM) has greater uncertainties for monopole lengths greater than one-eighth of a wavelength.

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

4.4.2 Magnetic antenna

For the measurement of the magnetic component of the radiation, an electrically-screened loop antenna, as described in 4.3.2 shall be used.

NOTE Tuned electrically balanced loop antennas may be used to make measurements of magnetic field strengths as low as $-51,5 \text{ dB}(\mu\text{A/m})$ using QP detection in the frequency range 1,6 MHz to 30 MHz, i.e. lower than with untuned electrically-screened loop antennas where the noise level is approximately 25 dB higher.

4.4.3 Balance/cross-polar performance of antennas

If a balanced E -field antenna is used, it shall comply with the requirement of 4.5.4. If a balanced magnetic field antenna is used, it shall comply with the requirement of 4.3.3.

4.5 Frequency range 30 MHz to 1 000 MHz

4.5.1 General

In this frequency range, the measurements are of the E -field, so magnetic field antennas are not included. The antenna shall be a dipole-like antenna designed to measure the E -field, and the free-space antenna factor shall be used. The antenna types include:

- a) tuned dipole antennas, whose element pairs are either straight rods or conical in shape;
- b) dipole arrays such as the log-periodic dipole array (LPDA) antennas, comprising a series of staggered sets of straight rod elements;
- c) and hybrid antennas.

4.5.2 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 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 should be included in the reported radiated emissions measurement uncertainty budget.

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 within a margin of $\pm 1 \text{ dB}$.

4.5.3 Antenna characteristics

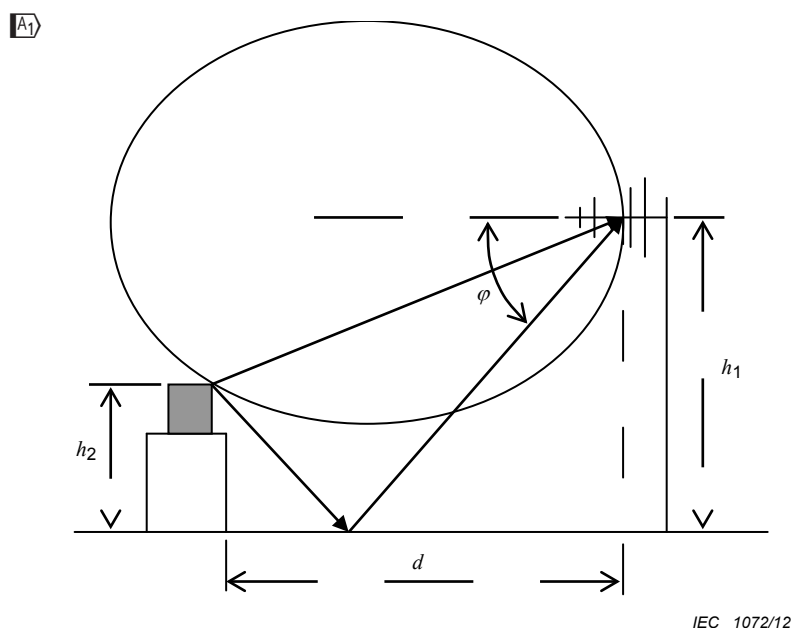
Given that at the frequencies in the range 300 MHz to 1 000 MHz, the sensitivity of the simple dipole antenna is low, a more complex antenna may be used. Such an antenna shall have characteristics as follows.

- a) The antenna shall be linearly polarized, which shall be evaluated by applying the cross-polarization test procedure of 4.5.5.
- 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 4.5.4. 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 main lobe 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 1).

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

Emission measurements are performed with the antenna horizontally and vertically polarized. 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 polarization.



IEC 1072/12

Figure 1 – 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 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:

$$\varphi > \tan^{-1} \frac{h_1 + h_2}{d} \quad (3)$$

- 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:

$$2\varphi > \left(\tan^{-1} \frac{h_1 + h_2}{d} \right) - \left(\tan^{-1} \frac{h_1 - h_2}{d} \right) \quad (4)$$

where

$\overline{A_1} h_2$ is the height of the equipment under test;

$\overline{A_1} h_1$ 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 from the radiation patterns and applied as $\overline{A_1}$ a correction with associated $\overline{A_1}$ or as directivity uncertainties. Example uncertainty 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 polarization, 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 items 1) and 2), 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.

$\overline{A_1}$ Note deleted $\overline{A_1}$

- 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.

4.5.4 Balance of antenna

4.5.4.1 General

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 electromagnetic fields that 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 E -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.

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

4.5.4.2 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.

- a) Set the receiving antenna under test vertically polarized with its centre at a height of 1,5 m above the ground plane. Extend a 1,5 m $\pm$ 0,1 m length of the antenna cable behind the rear active element of the receiving antenna at a height of 1,5 m above the ground plane and then allow it to drop vertically to the ground plane.
- b) Place a second (transmitting) antenna vertically polarized at a horizontal distance of 10 m from the centre of the antenna under test. The transmitting antenna shall be positioned such that the end of its largest active element is at a height of 0,10 m above 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 difference between U_1 and U_2 of less than $\pm 0,5$ 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.
- c) 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.
- d) Record the voltage U_1 at the receiver over the frequency range of interest.
- e) 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.
- f) Record the voltage U_2 at the receiver over the frequency range.
- g) 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 the contribution of item a) of 4.5.4.1 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 used in a FAR, the DM/CM check may be performed in that $\boxed{A_1}$ FAR $\boxed{A_1}$ with the receiving antenna at its usual location and the transmitting antenna in the centre of the test volume of that $\boxed{A_1}$ FAR $\boxed{A_1}$. The $\boxed{A_1}$ FAR $\boxed{A_1}$ should comply with the ± 4 dB $\boxed{A_1}$ site validation criterion $\boxed{A_1}$.

NOTE 3 The measuring site of which the ground plane forms a part, or the $\boxed{A_1}$ FAR $\boxed{A_1}$, should comply with their respective $\boxed{A_1}$ site validation $\boxed{A_1}$ 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 strictly define a test set-up because this effect is dominated by the interaction of the antenna and that part of the antenna cable that lies parallel to the antenna elements. There is a much smaller effect that is dependent on the uniformity of the field incident on the receiving antenna in normal EMC set-ups on an OATS or in a FAR.

NOTE 6 For baluns that 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.

4.5.5 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 applies to log-periodic dipole array (LPDA) antennas for which the two halves of each dipole are in echelon. A test method to establish this requirement for LPDA antennas is presented. The majority of testing with such antennas is above 200 MHz, but the requirement applies over the entire frequency range of 30 MHz to 1 000 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 shall have a cross-polar rejection greater than 20 dB and a type test by the manufacturer should confirm this.

In order to achieve $\langle A_1 \rangle$ quasi free-space conditions $\langle A_1 \rangle$, a $\langle A_1 \rangle$ high-quality fully anechoic room $\langle A_1 \rangle$ 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 shall 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 subtract the smaller signal from the unity signal to give the negative decibel error.

For the purpose of calculating the uncertainty of a radiated emission measurement, 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 vertically and horizontally polarized signal levels is less than 6 dB, additional uncertainty shall be calculated if the sum of this difference and the cross-polarization is less than 20 dB.

4.6 Frequency range 1 GHz to 18 GHz

Radiated emissions measurements above 1 GHz shall be made using calibrated, linearly polarized antennas. Examples are LPDA antennas, double-ridged guide horns and standard gain horns. 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. For horn antennas, the following condition shall be satisfied:

$$d \geq \frac{D^2}{2\lambda} \quad (5)$$

where

- d is the measurement distance (m);
- D is the largest dimension of the aperture of the antenna (m); and
- λ is the free space wavelength at the frequency of measurement (m).

4.7 Special antenna arrangements – 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 measures the current induced by the magnetic field component of the single EUT. 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 Note 2 of Clause C.3, 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.4.

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 in m between the EUT and a LLA is at least $0,10 \times D$. 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

5.1 General

A1 An environment is required that assures valid, repeatable measurement results of disturbance field strength from an EUT. For an EUT that can only be tested at its place of use, other provisions shall be utilized (i.e. see details on in-situ measurements in CISPR 16-2-3). **A1**

5.2 OATS

5.2.1 General

A1 An OATS is an area characterized by cleared level terrain and the presence of a ground plane. To meet the validation requirements of this standard, a metallic ground plane is recommended. Such a test site shall be free of buildings, electric lines, fences, trees, etc. and free from underground cables, pipelines, etc., except as required to supply and operate the EUT. Refer to Annex D for specific construction recommendations of an OATS for disturbance field-strength

measurements in the range of 30 MHz to 1 000 MHz. The site validation procedures for an OATS are given in 5.4.4 and 5.4.5. Annex F explains the basis for the acceptability criterion. [A1](#)

5.2.2 Weather protection enclosure

Weather protection is desirable if the test site is used throughout the year. A weather protection structure could protect either 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 (see 5.3.1).

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

5.2.3 Obstruction-free area

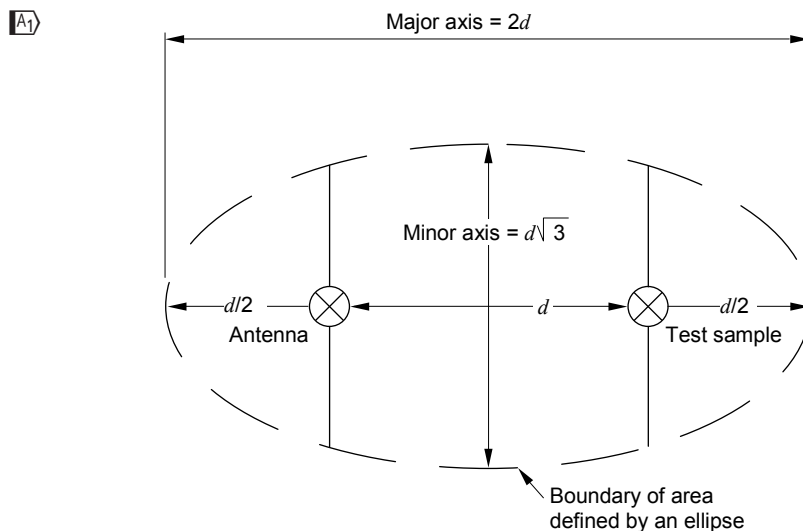
For open area test sites, an obstruction-free area surrounding the EUT and field-strength measuring antenna is required. The obstruction-free area shall be free from significant scatterers of electromagnetic fields, and shall be large enough so that scatterers outside the obstruction-free area will have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

[A1](#) For this ellipse, the length of the path taken by the undesired indirect ray reflected from any object on the perimeter is twice the length of the path taken by the direct ray between the foci. If a large EUT is installed on the turntable, the obstruction-free area shall be expanded so that the obstruction clearance distances exist from the perimeter of the EUT. [A1](#)

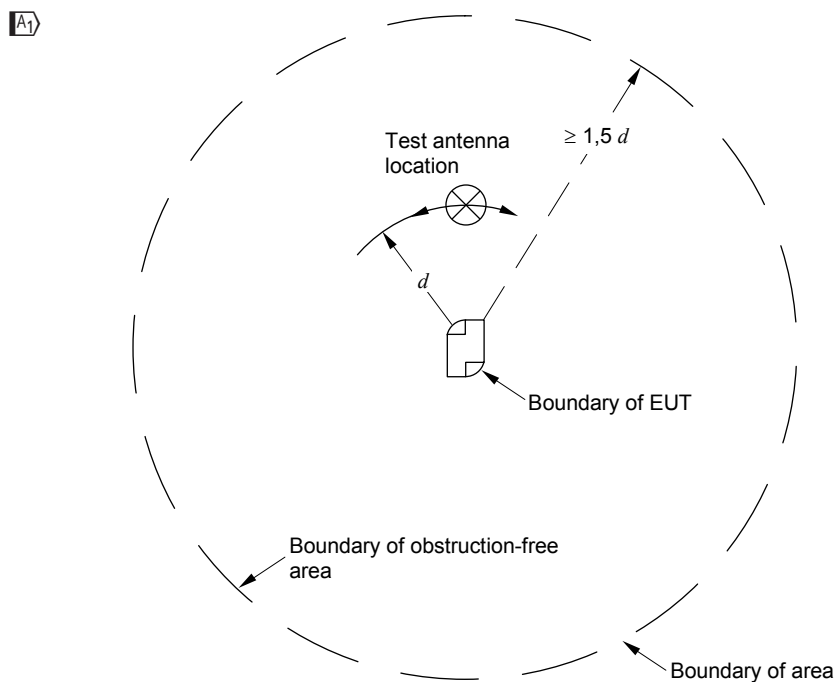
If the site is not equipped with a turntable, that is, the EUT is stationary, the recommended obstruction-free area is a circular area such that the radial distance from the boundary of the EUT to the boundary of the area is greater than or equal to the measurement distance multiplied by 1,5 (see Figure 3). In this case, the antenna is moved around the EUT at the [A1](#) measurement distance. [A1](#)

The terrain within the obstruction-free area shall 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 shall be situated outside the obstruction free area.



IEC 1073/12

Figure 2 – Obstruction-free area of a test site with a turntable (see 5.2.3) **A1**



IEC 1074/12

Figure 3 – Obstruction-free area with stationary EUT (see 5.2.3) **A1**

5.2.4 Ambient radio frequency environment of a test site

A1 The ambient radio frequency levels at an OATS shall be sufficiently low compared to the levels of measurements to be performed. The quality of the site in this regard may be evaluated under four categories, listed below in order of merit: **A1**

- the ambient emissions are 6 dB or more below the measurement levels;
- 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.

A1 NOTE A measured ambient level of 20 dB or more below the emission limit is considered optimum. **A1**

5.2.5 Ground plane

A1 The OATS ground plane can be at earth level or elevated on a suitably sized platform or horizontal rooftop site. A metal ground plane is preferred, but for certain equipment and applications, product publications may recommend other site types. Adequacy of the metal ground plane will be dependent on whether the test site meets the site validation requirements of 5.4. If metallic material is not used, caution is required to select a site that does not change its reflective characteristics with time, weather conditions, or effects due to buried metallic material such as pipes, conduits, and non-homogeneous soil. Such sites generally give different SA characteristics compared to those with metallic surfaces. **A1**

A1 Text deleted **A1**

5.3 **A1** Suitability of other test sites **A1**

5.3.1 **A1** Other ground-plane test sites **A1**

A1 There are many different test sites and facilities that have been constructed and used to make radiated emission measurements. Most are protected from the weather and the adverse effects of the radio frequency ambient. In a SAC, all walls and the ceiling are equipped with appropriate absorbing material. The floor consists of a metallic ground plane to emulate an OATS. A SAC isolates the receiving antenna from the RF ambient environment, and permits EUT testing independent of weather conditions.

Whenever construction material encloses a ground-plane test site, it is possible that the results of a validation measurement at a single location, as specified in 5.4.5, are not adequate to show acceptability of such an alternative site.

To evaluate suitability of an alternative ground-plane test site, the procedure of 5.4.6 shall be used, which is based on making multiple validation measurements throughout a volume occupied by the EUT. These validation measurement results shall all be within a tolerance of ± 4 dB for a site to be judged suitable as an equivalent to an OATS.

NOTE SACs typically meet the site quality categories listed in 5.2.4. **A1**

5.3.2 **A1** Test sites without ground plane (FAR) **A1**

A1 A fully-absorber-lined shielded enclosure, also known as a fully-anechoic room (FAR), can be used for radiated emission measurements. When a FAR site is used, appropriate radiated emission limits shall be defined in relevant standards (generic, product or product family standards). Compliance of an EUT with the requirements for the protection of radio-services (limits) shall be evaluated at FAR sites using similar methods as for tests done at an OATS. **A1**

A1 A FAR is intended to simulate a free-space environment such that only the direct ray from the transmitting antenna or EUT reaches the receiving antenna. All indirect and reflected waves shall be minimized by appropriate placement of absorbing material on all walls, ceiling and floor of a FAR. Like a SAC, a FAR isolates the receiving antenna from the RF ambient environment, and permits EUT testing independent of weather conditions.

NOTE FARs typically meet the site quality categories listed in 5.2.4. **A1**

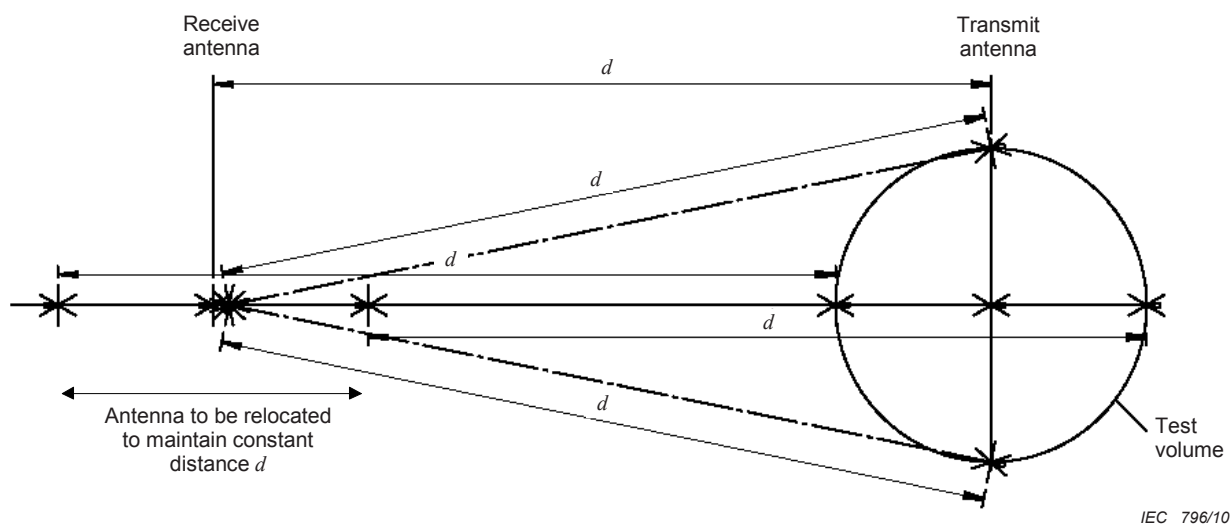


Figure 6 – Typical antenna positions for alternative test site – Vertical polarization NSA measurements

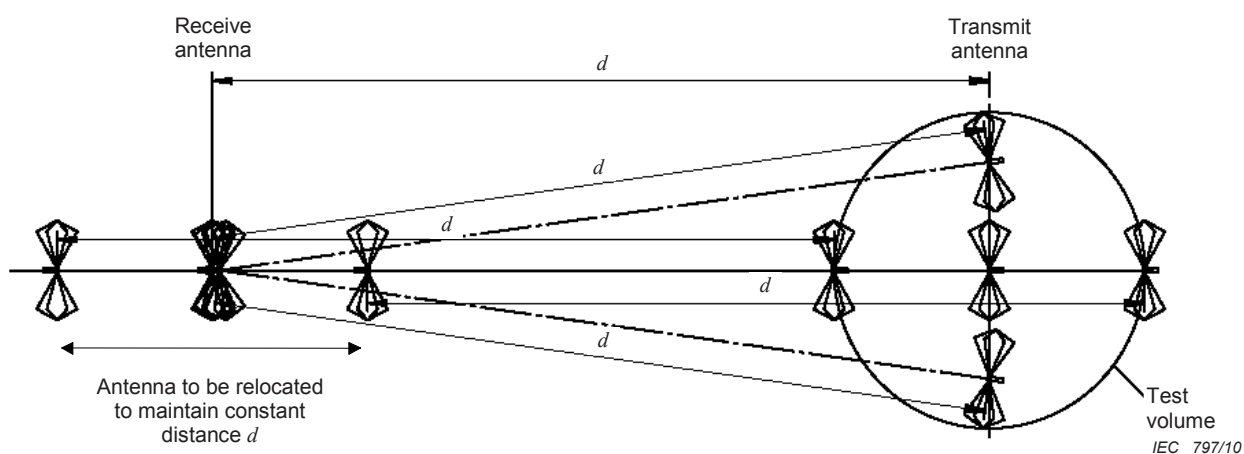
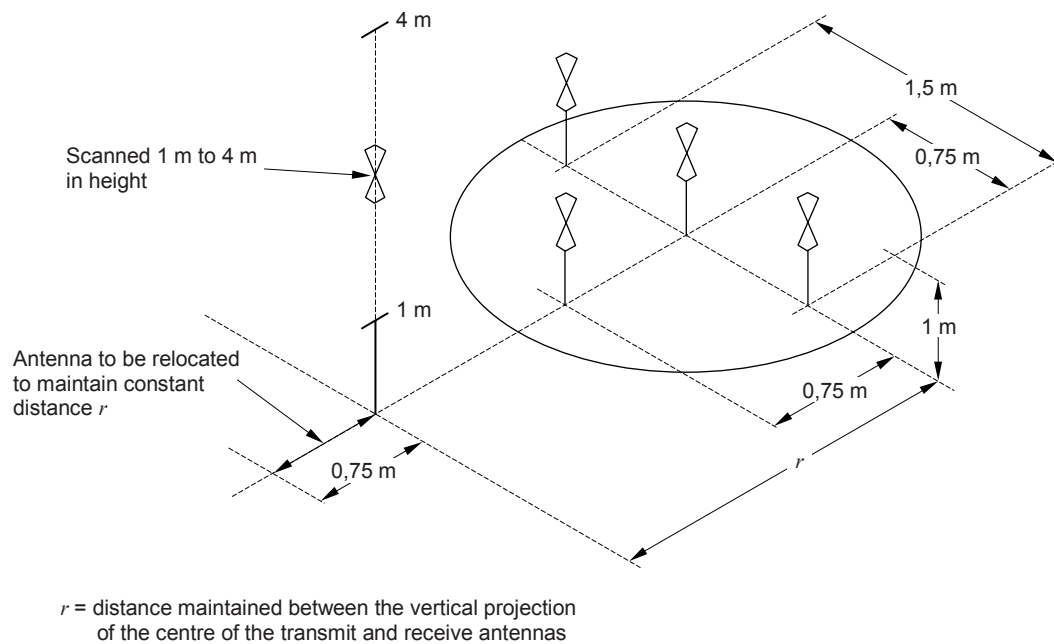


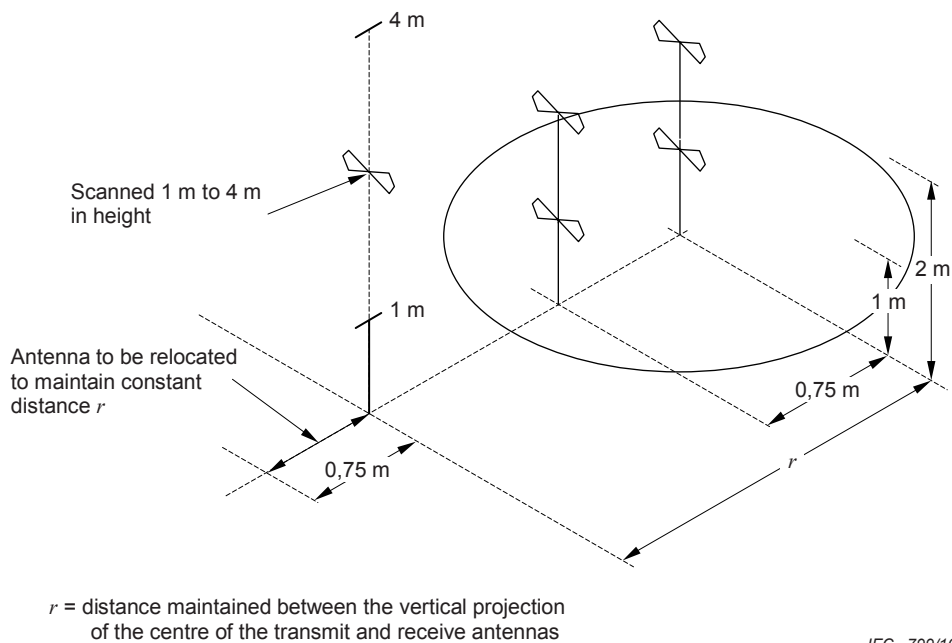
Figure 7 – Typical antenna positions for alternative test site – Horizontal polarization NSA measurements



IEC 798/10

NOTE EUT does not exceed a volume of 1 m depth, 1,5 m width, 1,5 m height, with the periphery greater than 1 m from the closest material that may cause undesirable reflections.

Figure 8 – Typical antenna positions for alternative test site – Vertical polarization NSA measurements for a smaller EUT



IEC 799/10

NOTE EUT does not exceed a volume of 1 m depth, 1,5 m width and 1,5 m height, with the periphery greater than 1 m from the closest material that may cause undesirable reflections.

Figure 9 – Typical antenna positions for alternative test site – Horizontal polarization NSA measurements for a smaller EUT

5.4 Test site validation

5.4.1 General

 Three methods for site validation are defined in this standard:

- NSA method with tuned dipoles;
- NSA method with broadband antennas;
- Reference site method (RSM) with broadband antennas.

Validations for test sites with a ground plane (i.e. OATS and SAC) are introduced in 5.4.2 and 5.4.3, followed by detailed procedures for the RSM in 5.4.4 and for the NSA method in 5.4.5. Validation of a SAC and a weather-protection enclosed OATS requires additional measurements as described in 5.4.6.

Table 7 summarizes the site validation methods applicable for these specific test site types. As shown in this table, two or three site validation methods are described for each of these test site types. These methods are deemed to be equivalent for the purposes of this standard; meaning compliance with the validation criterion can be evaluated using only one method. Furthermore, no one of these documented methods is defined as the reference method.

**Table 7 – Site validation methods applicable
for OATS, OATS-based, SAC and FAR site types**

Test site type	Applicability of site validation methods		
	Tuned dipoles	Broadband antennas	Broadband antennas
	NSA	NSA	RSM
OATS	Yes	Yes	Yes
OATS with weather protection	No	Yes	Yes
SAC	No	Yes	Yes
FAR	No	Yes	Yes



5.4.2 Overview of test site validations

 The validation of a test site is performed using two co-polarized antennas. The validation shall be performed separately for both horizontal and vertical polarizations.

SA is obtained from the difference of:

- the source voltage level, V_i , applied to a transmitting antenna;
- the maximum received voltage level, V_R , measured on the terminals of a receiving antenna during a specified antenna height scan.

The voltage measurements are performed in a 50 Ω system.

The measured SA of an OATS (as in 5.2) and other ground-plane test sites (as in 5.3.1) is compared to the SA characteristics obtained at an ideal OATS – this is the definition of the measurand for test site validations. The result of this comparison is the SA deviation, ΔA_S , in dB; see Equations (26) and (27). The site is considered suitable when the SA deviation results are within a tolerance of ± 4 dB.

If the ± 4 dB tolerance is exceeded, the test site configuration shall be investigated as described in 5.4.5.3.

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

A1 Additionally, SA deviations shall not be used to correct field-strength measurement data for an EUT. The procedures of 5.4 shall be used only for test site validations. **A1**

5.4.3 **A1** Principles and values of the NSA method for OATS and SAC **A1**

A1 NSA values calculated at specific frequencies are provided in Tables 8 and 9 for tuned dipole antennas, and Table 10 for broadband antennas. The quantities d , h_1 , h_2 , f_M and A_N , which are used in these tables, are identified at the end of Table 8.

NOTE 1 NSA values for frequencies other than shown in the Tables 8, 9, and 10 can be obtained using linear interpolation between the tabulated values.

NOTE 2 The spacing d between the log-periodic dipole array antenna pairs is measured from the projection on the ground plane of the mid-point of the longitudinal axis of each antenna.

NOTE 3 The spacing d between biconical antennas, is measured from the element centre-line axes at the feedpoint.

For measurements in each polarization, the NSA method requires two different measurements of the received voltage, V_R ; Figures 29 and 30 illustrate the set-ups for these measurements. **A1**