CISPR 16-2-3

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INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

BASIC EMC PUBLICATION

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

CISPR 16-2-3:2016-09 RLV(en)

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IEC Central Office
3, rue de Varembé
CH-1211 Geneva 20
Switzerland

Tel.: +41 22 919 02 11
info@iec.ch
www.iec.ch

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY MEASURING APPARATUS AND METHODS –

Part 2-3: Methods of measurement of disturbances and immunity – Radiated disturbance measurements

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International Standard CISPR 16-2-3 has been prepared by CISPR subcommittee A: Radio-interference measurements and statistical methods.

This fourth edition edition cancels and replaces the third edition published in 2010, its Amendment 1:2010 and its Amendment 2:2014. This edition constitutes a technical revision.

This edition includes the following significant technical change with respect to the previous edition: addition of content on correction of the electric field strength to account for phase centre of log-periodic dipole array antennas.

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.*

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

FDIS	Report on voting
CISPR/A/1176A/FDIS	CISPR/A/1182/RVD

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

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

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

The committee has decided that the contents of this 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

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SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY MEASURING APPARATUS AND METHODS –

Part 2-3: Methods of measurement of disturbances and immunity – Radiated disturbance measurements

1 Scope

This part of CISPR 16 specifies the methods of measurement of radiated disturbance phenomena in the frequency range of 9 kHz to 18 GHz. The aspects of measurement uncertainty are specified in CISPR 16-4-1 and CISPR 16-4-2.

NOTE In accordance with IEC Guide 107 [13][1], CISPR 16-2-3 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 subcommittees are prepared to co-operate with product committees in the evaluation of the value of particular EMC tests for specific products.

2 Normative references

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.

CISPR 14-1:~~2005~~ 2016, *Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 1: Emission*

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 16-1-2:~~2003~~ 2014, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-2: Radio disturbance and immunity measuring apparatus – ~~Ancillary equipment –~~ Coupling devices for conducted disturbance measurements*
~~Amendment 1 (2004)~~
~~Amendment 2 (2006)~~

CISPR 16-1-4:2010, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-4: Radio disturbance and immunity measuring apparatus – ~~Ancillary equipment –~~ Antennas and test sites for radiated disturbance measurements*
CISPR 16-1-4:2010/AMD1:2012

CISPR 16-2-1:~~2008~~ 2014, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-1: Methods of measurement of disturbances and immunity – Conducted disturbance measurements*

CISPR TR 16-4-1, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-1: Uncertainties, statistics and limit modelling – Uncertainties in standardized EMC tests*

[1] Numbers in square brackets refer to the Bibliography.

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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~~ Measurement instrumentation uncertainty*

CISPR TR 16-4-5, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-5: Uncertainties, statistics and limit modelling – Conditions for the use of alternative test methods*

IEC 60050-161~~:1990~~, *International Electrotechnical Vocabulary – Chapter 161: Electromagnetic compatibility*
~~Amendment 1 (1997)~~
~~Amendment 2 (1998)~~

IEC 61000-4-3:2006, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*
IEC 61000-4-3:2006/AMD1:2007
IEC 61000-4-3:2006/AMD2:2010

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

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 60050-161, as well as the following apply.

3.1.1
absorber-lined OATS/SAC
OATS or SAC with ground plane partially covered by RF-energy absorbing material

3.1.2
ancillary equipment
transducers (e.g. current and voltage probes and artificial networks) connected to a measuring receiver or (test) signal generator and used in the disturbance signal transfer between the EUT and the measuring or test equipment

3.1.3
antenna beam
main lobe of the antenna pattern (gain pattern) of the receive antenna (usually the direction with maximum sensitivity or lowest antenna factor) that is directed towards the EUT

3.1.4
antenna beamwidth
angle between the half-power (3 dB) points of the main lobe of the antenna beam, when referenced to the maximum power of the main lobe

Note 1 to entry: It may be expressed for the H plane or for the E plane of the antenna.

Note 2 to entry: Antenna beamwidth is expressed in degrees.

3.1.5
associated equipment
AE
apparatus, that is not part of the system under test, but needed to help exercise the EUT

Note 1 to entry: This note applies to the French language only.

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3.1.6
auxiliary equipment
AuxEq
peripheral equipment that is part of the system under test

Note 1 to entry: This note applies to the French language only.

3.1.7
basic standard
standard that has a wide-ranging coverage or contains general provisions for one particular field

Note 1 to entry: A basic standard may function as a standard for direct application or as a basis for other standards.

[SOURCE: ISO/IEC Guide 2:1991, definition 5.1 [6]]

3.1.8
coaxial cable
cable containing one or more coaxial lines, typically used for a matched connection of ancillary equipment to the measuring equipment or (test-) signal generator providing a specified characteristic impedance and a specified maximum allowable cable transfer impedance

3.1.9
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

Note 1 to entry: This note applies to the French language only.

[SOURCE: CISPR 16-1-4:2010, 3.1.4]

3.1.10
conformity assessment
demonstration that specified requirements relating to a product, process, system, person or body are fulfilled

Note 1 to entry: The subject field of conformity assessment includes activities defined elsewhere in ISO/IEC 17000:2004 [7], such as testing, inspection and certification, as well as the accreditation of conformity assessment bodies.

[SOURCE: ISO/IEC 17000:2004, 2.1, modified – Note 2 has been deleted.]

3.1.11
continuous disturbance
RF disturbance with duration of more than 200 ms at the IF-output of a measuring receiver that causes a deflection on the meter of a measuring receiver in quasi-peak detection mode, and that does not decrease immediately

[SOURCE: IEC 60050-161:1990, 161-02-11, modified – The definition has been changed.]

3.1.12
emission
<electromagnetic> phenomenon by which electromagnetic energy emanates from a source

[SOURCE: IEC 60050-161:1990, 161-01-08]

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3.1.13
emission limit
<from a disturbing source> specified maximum emission level of a source of electromagnetic disturbance

[SOURCE: IEC 60050-161:1990, 161-03-12]

3.1.14
equipment under test
EUT
equipment (devices, appliances and systems) subjected to EMC (emission) compliance (conformity assessment) tests

Note 1 to entry: This note applies to the French language only.

3.1.15
fully-anechoic room
FAR
~~shielded~~ enclosure, whose six internal surfaces are lined with radio-frequency ~~energy~~ absorbing material (i.e. RF absorber) that ~~absorbs~~ attenuates electromagnetic energy in the frequency range of interest

Note 1 to entry: This note applies to the French language only.

3.1.16
loop-antenna system
LAS
antenna system consisting of three orthogonally-oriented loop antennas that are used to measure the three orthogonal magnetic dipole moments of an EUT located in the centre of the three loops

Note 1 to entry: This note applies to the French language only.

3.1.17
measurement, scan and sweep times

3.1.17.1
measurement time
T_m
effective, coherent time for a measurement result at a single frequency

– for the peak detector, the effective time to detect the maximum of the signal envelope,
– for the quasi-peak detector, the effective time to measure the maximum of the weighted envelope,
– for the average detector, the effective time to average the signal envelope,
– for the rms detector, the effective time to determine the rms of the signal envelope

Note 1 to entry: In some areas "measurement time" is also called dwell time.

3.1.17.2
scan
continuous or stepped frequency variation over a given frequency span

3.1.17.3
span
Δf
difference between stop and start frequencies of a sweep or scan

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3.1.17.4
sweep
continuous frequency variation over a given frequency span

3.1.17.5
sweep or scan rate
frequency span divided by the sweep or scan time

3.1.17.6
sweep or scan time
T_s
time between start and stop frequencies of a sweep or scan

3.1.17.7
observation time
T_o
sum of measurement times T_m on a certain frequency in case of multiple sweeps

Note 1 to entry: If n is the number of sweeps or scans, then $T_o = n \times T_m$.

3.1.17.8
total observation time
T_{tot}
effective time for an overview of the spectrum (either single or multiple sweeps)

Note 1 to entry: If c is the number of channels within a scan or sweep, then $T_{tot} = c \times n \times T_m$.

3.1.18
measuring receiver
instrument such as a tunable voltmeter, an EMI receiver, a spectrum analyzer or an FFT-based measuring instrument, with or without preselection, that ~~meets the relevant parts of~~ complies with CISPR 16-1-1

3.1.19
number of sweeps per time unit
n_S
reciprocal of the sum of sweep time and retrace time, i.e. 1/(sweep time + retrace time)

Note 1 to entry: Sweeps per second, for example.

3.1.20
open-area test site
OATS
~~facility used for measurements of electromagnetic fields the intention for which is to simulate a semi-free-space environment over a specified frequency range that is used for radiated emission testing of products. An OATS typically is located outdoors in an open area, and has an electrically-conducting ground plane.~~
facility for measurements and calibrations in which the ground reflection is made reproducible by a large flat electrically conducting ground plane

Note 1 to entry: An OATS can be used for radiated disturbance measurements, where it is also designated as a COMTS. An OATS can also be used for antenna calibrations, where it is designated as a CALTS.

Note 2 to entry: An OATS is an uncovered outdoor site, and is far enough away from buildings, electric lines, fences, trees, underground cables, pipelines, and other potentially reflective objects, so that the effects due to such objects are negligible. See CISPR 16-1-4 for guidance on the construction of an OATS.

Note 3 to entry: This note applies to the French language only.

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3.1.21
product standard
standard that specifies requirements to be fulfilled by a product or group of products, to establish its fitness for purpose

Note 1 to entry: A product standard may include, in addition to the fitness for purpose requirements, directly or by reference, aspects such as terminology, sampling, testing, packaging and labelling and, sometimes, processing requirements.

Note 2 to entry: A product standard can either be complete or not, according to whether it specifies all or only a part of the necessary requirements. In this respect, one may differentiate between standards such as dimensional, material and technical delivery standards.

[SOURCE: ISO/IEC Guide 2:2004, definition 5.4 [6]]

3.1.22
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) that ~~absorbs~~ attenuates 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

Note 1 to entry: This note applies to the French language only.

3.1.23
test configuration
combination that gives the specified measurement arrangement of the EUT in which an emission level is measured

3.1.24
weighting
pulse-repetition-frequency (PRF) dependent conversion (mostly reduction) of a peak-detected impulse voltage level to an indication that corresponds to the interference effect on radio reception

Note 1 to entry: For the analogue receiver, the psychophysical annoyance of the interference is a subjective quantity (audible or visual) usually not a certain number of misunderstandings of a spoken text.

Note 2 to entry: For the digital receiver, the interference effect is an objective quantity that may be defined by the critical bit error ratio (BER) or bit error probability (BEP) for that perfect error correction can still occur or by another, objective and reproducible parameter.

Note 3 to entry: Weighting of impulsive disturbance, for example.

3.1.24.1
weighted disturbance measurement
measurement of disturbance using a weighting detector

3.1.24.2
weighting characteristic
peak voltage level as a function of PRF for a constant effect on a specific radiocommunication system, i.e. the disturbance is weighted by the radiocommunication system itself

3.1.24.3
weighting detector
detector that provides an agreed weighting function

3.1.24.4
weighting factor
value of the weighting function relative to a reference PRF or relative to the peak value

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Note 1 to entry: Weighting factor is expressed in dB.

3.1.24.5
weighting function or weighting curve
relationship between input peak voltage level and PRF for constant level indication of a measuring receiver with a weighting detector, i.e. the curve of response of a measuring receiver to repeated pulses

3.1.25
measurement
process of experimentally obtaining one or more quantity values that can reasonably be attributed to a quantity

[SOURCE: 2.1 of ISO/IEC Guide 99:2007 [9][2], modified – Notes 1 to 3 have been deleted.]

3.1.26
test
technical operation that consists of the determination of one or more characteristics of a given product, process or service according to a specified procedure

Note 1 to entry: A test is carried out to measure or classify a characteristic or a property of an item by applying to the item a set of environmental and operating conditions and/or requirements.

[SOURCE: IEC 60050-151:2001, 151-16-13 [10]]

3.1.27
highest internal frequency
highest frequency generated or used within the EUT or the highest frequency at which the EUT operates or tunes

3.1.28
module
part of an EUT that provides a function and may contain radio-frequency sources

3.2 Abbreviated terms

The following abbreviations, not already provided in 3.1 are used in this standard.

AM	Amplitude modulation
APD	Amplitude probability distribution
AV	Average
BB	Broadband
CW	Continuous wave
FFT	Fast-Fourier transform
FM	Frequency modulation
IF	Intermediate frequency
ISM	Industrial, scientific or medical
LPDA	Log-periodic dipole array
NB	Narrowband
NSA	Normalized site attenuation
PRF	Pulse repetition frequency

[2] Figures in square brackets refer to the Bibliography.

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RBW	Resolution bandwidth
RF	Radio frequency
RGP	Reference ground plane
QP	Quasi-peak
TEM	Transverse electromagnetic
UFA	Uniform field area
VBW	Video bandwidth

4 Types of disturbance to be measured

4.1 General

This clause describes the classification of different types of disturbance and the detectors appropriate for their measurement.

4.2 Types of disturbance

For physical and psychophysical[3] reasons, dependent on the spectral distribution, measuring receiver bandwidth, the duration, rate of occurrence, and degree of annoyance during the assessment and measurement of radio disturbance, distinction is made between the following types of disturbance:

a) *narrowband continuous disturbance*, i.e. disturbance on discrete frequencies as, for example, the fundamentals and harmonics generated with the intentional application of RF energy with ISM equipment, constituting a frequency spectrum consisting only of individual spectral lines whose separation is greater than the bandwidth of the measuring receiver so that during the measurement only one line falls into the bandwidth in contrast to b);

b) *broadband continuous disturbance,* which normally is unintentionally produced by the repeated impulses of, for example, commutator motors, and which have a repetition frequency that is lower than the bandwidth of the measuring receiver so that during the measurement more than one spectral line falls into the bandwidth; and

c) *broadband discontinuous disturbance* is also generated unintentionally by mechanical or electronic switching procedures, for example by thermostats or programme controls with a repetition rate lower than 1 Hz (click-rate less than 30/min).

The frequency spectra of items b) and c) are characterized by having a continuous spectrum in the case of individual (single) impulses and a discontinuous spectrum in case of repeated impulses, both spectra being characterized by having a frequency range that is wider than the bandwidth of the measuring receiver specified in CISPR 16-1-1.

4.3 Detector functions

Depending on the types of disturbance, measurements may be carried out using a measuring receiver with:

a) an average detector generally used in the measurement of narrowband disturbance and signals, and particularly to discriminate between narrowband and broadband disturbance;

b) a quasi-peak detector provided for the weighted measurement of broadband disturbance for the assessment of audio annoyance to a radio listener, but also usable for narrowband disturbance;

c) an rms-average detector provided for the weighted measurement of broadband disturbance for the assessment of the effect of impulsive disturbance to digital radio communication services but also useable for narrowband disturbance;

[3] Psychophysical means psychological relationship between physical stimuli and sensory response.

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d) a peak detector that may be used for either broadband or narrowband disturbance measurement.

Measuring receivers incorporating these detectors are specified in CISPR 16-1-1.

5 Connection of measuring equipment

Concerning the connection of measuring equipment, measuring receivers and ancillary equipment such as antennas: the connecting cable between the measuring receiver and the ancillary equipment shall be shielded and its characteristic impedance shall be matched to the input impedance of the measuring receiver. The output of the ancillary equipment shall be terminated with the prescribed impedance.

6 General measurement requirements and conditions

6.1 General

Radio disturbance measurements shall be:

- reproducible, i.e. independent of the measurement location and environmental conditions, especially ambient noise; and
- free from interactions, i.e. the connection of the EUT to the measuring equipment shall influence neither the function of the EUT nor the accuracy of the measurement equipment.

These requirements may be met by observing the following conditions:

a) existence of a sufficient signal-to-noise ratio at the desired measurement level, e.g. the level of the relevant disturbance limit;

b) having a defined measuring set-up, termination and operating conditions of the EUT.

~~c) when using a spectrum analyzer or scanning receiver, due considerations shall be given to its particular operating and calibration requirements.~~

6.2 Disturbance not produced by the equipment under test

6.2.1 General

The measurement signal-to-noise ratio with respect to ambient noise shall meet the following requirements. Should the ~~spurious~~ ambient noise level exceed~~s~~ the required level, it shall be recorded in the test report.

6.2.2 Compliance (conformity assessment) testing

A test site shall permit emissions from the EUT to be distinguished from ambient noise. The ambient noise level should preferably be 20 dB, but at least be 6 dB below the desired measurement level. For the 6 dB condition, the apparent disturbance level from the EUT is increased by up to 3,5 dB. The suitability of the site for the required ambient level may be determined by measuring the ambient noise level with the test unit in place but not operating.

~~In the case of~~ When evaluating compliance ~~measurement according to~~ with a limit, the ambient noise level is permitted to exceed the preferred −6 dB level provided that the level of both ambient noise and source emanation combined does not exceed the specified limit. The EUT is then considered to meet the limit. ~~Other actions can also be taken; for example, reduce the bandwidth for narrowband signals and/or move the antenna closer to the EUT.~~ Further guidance on measurement of disturbances in the presence of ambient emissions is provided in Annex A.

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~~NOTE – If both the ambient field strength and field strength of ambient and EUT are measured separately, it may be possible to provide an estimate of the EUT field strength to a quantifiable level of uncertainty. Reference is made in this respect in Annex C of CISPR 11.~~

6.3 Measurement of continuous disturbance

6.3.1 Narrowband continuous disturbance

The receiver shall be kept tuned to the discrete frequency under investigation, and re-tuned if the frequency fluctuates.

6.3.2 Broadband continuous disturbance

For the assessment of broadband continuous disturbance whose level is not steady, the maximum reproducible measurement value shall be found. See 6.5.1 for further details.

6.3.3 Use of spectrum analyzers and scanning receivers

Spectrum analyzers and scanning receivers are useful for disturbance measurements, particularly in order to reduce measuring time. However, special consideration ~~must~~ shall be given to certain characteristics of these instruments, which include overload, linearity, selectivity, normal response to pulses, frequency scan rate, signal interception, sensitivity, amplitude accuracy and peak, average and quasi-peak detection. These characteristics are considered in Annex B.

6.4 ~~Operating conditions of the EUT~~ EUT arrangement and measurement conditions

The EUT shall be operated under the following conditions.

6.4.1 ~~Normal load conditions~~ General arrangement of the EUT

6.4.1.1 General

~~The normal load conditions shall be as defined in the manufacturer's product specification relevant to the EUT, and for EUTs not so covered, as indicated in the manufacturer's instructions.~~

Where not specified in the product standard, the EUT shall be configured as described below.

The EUT shall be installed, arranged and operated in a manner consistent with typical applications. Where the manufacturer has specified or recommended an installation practice, that practice shall be used in the test arrangement, where possible. This arrangement shall be typical of normal installation practice. Interface cables, loads, and devices shall be connected to at least one of each type of interface port of the EUT and, where practical, each cable shall be terminated in a device typical of actual usage.

Where there are multiple interface ports of the same type, additional interconnecting cables, loads and devices may have to be added to the EUT depending upon the results of preliminary tests. Connecting a cable or wire to just one of that type of port may be sufficient. The actual number of additional cables or wires may be limited to the condition where the addition of another cable or wire does not significantly affect the emission level, i.e. varies less than 2 dB, provided that the EUT remains compliant. The rationale for the selection of the configuration and loading of ports shall be included in the test report.

Interconnecting cables should be of the type and length specified in the individual equipment requirements. If the length can be varied, the length shall be selected to produce maximum disturbance.

If shielded or special cables are used during the tests to achieve compliance, then a note shall be included in the instruction manual advising of the need to use such cables.

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Excess lengths of cables shall be bundled at the approximate centre of the cable with the bundles 30 cm to 40 cm in length. If it is impractical to do so because of cable bulk or stiffness, the disposition of the excess cable shall be precisely noted in the test report.

The results of an evaluation of EUTs having one of each type of module can be applied to configurations having more than one of each of those modules. This is permissible because it has been found that disturbances from identical modules are generally not additive in practice. However, the 2 dB criteria defined in this clause shall be applied.

Any set of results shall be accompanied by a complete description of the cable and equipment orientation so that results can be reproduced. If specific conditions of use are required to meet the limits, those conditions shall be specified and documented; for example cable length, cable type, shielding and grounding. These conditions shall be included in the instructions to the user.

Equipment that is populated with multiple modules (drawer, plug-in card, board, etc.) shall be tested with a mix and number representative of that used in a typical installation. The number of additional boards or plug-in cards of the same type may be limited to the condition where the addition of another board or plug-in card does not significantly affect the emission level, i.e. varies less than 2 dB, provided that the EUT remains compliant. The rationale used for selecting the number and type of modules shall be stated in the test report.

A system that consists of a number of separate units shall be configured to form a minimum representative configuration. The number and mix of units included in the test configuration shall be representative of that used in a typical installation. The rationale used for selecting units shall be stated in the test report.

At least one module of each type shall be operative in each equipment evaluated in an EUT. For a system EUT, at least one of each type of equipment that can be included in the possible system configuration shall be included in the EUT.

The EUT position relative to the RGP shall be equivalent to that occurring in use. Therefore, floor-standing equipment is placed on, but insulated from, a RGP, and tabletop equipment is placed on a non-conductive table.

Equipment designed for wall-mounted or ceiling mounted operation shall be tested as tabletop EUT. The orientation of the equipment shall be consistent with normal installation practice.

Combinations of the equipment types identified above shall also be arranged in a manner consistent with normal installation practice. Equipment designed for both tabletop and floor standing operation shall be tested as tabletop equipment unless the usual installation is floor standing, then that arrangement shall be used.

The ends of signal cables attached to the EUT that are not connected to another unit or auxiliary equipment shall be terminated using the correct terminating impedance defined in the product standard.

Cables or other connections to associated equipment located outside the test area shall drape to the floor, and then be routed to the place where they leave the test volume.

Auxiliary equipment shall be installed in accordance with normal installation practice. Where this means that the auxiliary equipment is located on the test site, it shall be arranged using the same conditions applicable for the EUT (e.g distance from ground plane and insulation from the ground plane if floor standing, and layout of cabling).

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6.4.1.2 Tabletop arrangement

Equipment intended for tabletop use shall be placed on a non-conductive table. The size of the table will nominally be 1,5 m by 1,0 m, but may ultimately be dependent on the horizontal dimensions of the EUT.

All units forming the system under test (including the EUT, connected peripherals and auxiliary equipment or devices) shall be arranged according to normal use. Where not defined in the normal use, a nominal 0,1 m separation distance between the neighbouring units shall be defined for the test arrangement.

Intra-unit cables shall be draped over the back of the table. If a cable hangs closer than 0,4 m to the horizontal ground plane (or floor), the excess shall be folded at the cable centre into a bundle no longer than 0,4 m, such that the bundle is at least 0,4 m above the horizontal RGP.

Cables shall be positioned as for normal usage.

If the mains port input cable is less than 0,8 m long, (including power supplies integrated in the mains plug) an extension cable shall be used such that the external power supply unit is placed on the tabletop. The extension cable shall have characteristics similar to the mains cable (including the number of conductors and the presence of a ground connection). The extension cable shall be treated as part of the mains cable.

In the above arrangements, the cable between the EUT and the power accessory shall be arranged on the tabletop in the same manner as other cables connecting components of the EUT.

6.4.1.3 Floor-standing arrangement

The EUT shall be placed on the horizontal RGP, orientated for normal use, but separated from metallic contact with the RGP by up to 15 cm of insulation.

The cables shall be insulated (by up to 15 cm) from the horizontal RGP. If the equipment requires a dedicated ground connection, then this shall be provided and bonded to the horizontal ground plane.

Intra-unit cables (between units forming the EUT or between the EUT and auxiliary equipment) shall drape to, but remain insulated from, the horizontal RGP. Any excess shall either be folded at the cable centre into a bundle no longer than 0,4 m or arranged in a serpentine fashion. If an intra-unit cable length is not long enough to drape to the horizontal RGP but drapes closer than 0,4 m, then the excess shall be folded at the cable centre into a bundle no longer than 0,4 m. The bundle shall be positioned such that it is either 0,4 m above the horizontal RGP or at the height of the cable entry or connection point if this is within 0,4 m of the horizontal RGP.

For equipment with a vertical cable riser, the number of risers shall be typical of installation practice. Where the riser is made of non-conductive material, a minimum spacing of at least 0,2 m shall be maintained between the closest part of the equipment and the nearest vertical cable. Where the riser structure is conductive, the minimum spacing of 0,2 m shall be between the closest parts of the equipment and riser structure.

6.4.1.4 Combinations of tabletop and floor-standing equipment arrangement

Intra-unit cables between a tabletop unit and a floor standing unit shall have the excess folded into a bundle no longer than 0,4 m. The bundle shall be positioned such that it is either 0,4 m above the horizontal RGP or at the height of the cable entry or connection point if this is within 0,4 m of the horizontal RGP.

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6.4.2 Operation of the EUT

The operating conditions of the EUT shall be determined by the manufacturer according to the typical use of the EUT with respect to the expected highest level of emission. The determined operational mode and the rationale for the selected operating conditions shall be stated in the test report.

The EUT shall be operated within the rated (nominal) operating voltage range and typical load conditions (mechanical or electrical) for which it is designed. Actual loads should be used whenever possible. If a simulator is used, it shall represent the actual load with respect to its radio frequency and functional characteristics.

The test programmes or other means of exercising the equipment should ensure that various parts of a system are exercised in a manner that permits detection of all system disturbances.

6.4.3 EUT time of operation

The time of operation shall be, in the case of EUTs with a given rated operating time, in accordance with the marking. In all other cases, the ~~time is not restricted~~ EUT shall be continuously operated throughout the test.

6.4.4 EUT running-in time

No specific running-in time, prior to testing, is given, but the EUT shall be operated for a sufficient period to ensure that the modes and conditions of operation are typical of those during the life of the equipment. For some EUTs, special test conditions may be prescribed in the relevant ~~equipment publications~~ product standards.

6.4.5 EUT supply

The EUT shall be operated from a supply having the rated voltage of the EUT. If the level of disturbance varies considerably with the supply voltage, the measurements shall be repeated for supply voltages over the range of 0,9 to 1,1 times the rated voltage. EUTs with more than one rated voltage shall be tested at the rated voltage that causes maximum disturbance.

6.4.6 EUT mode of operation

The EUT shall be operated under practical conditions that cause the maximum disturbance at the measurement frequency.

6.4.7 Operation of multifunction equipment

Multifunction equipment which is subjected simultaneously to different clauses of a product standard, and/or different standards, shall be tested with each function operated in isolation, if this can be achieved without modifying the equipment internally. The equipment thus tested shall be deemed to have complied with the requirements of all clauses and/or standards when each function has satisfied the requirements of the relevant clause and/or standard.

For equipment where it is not practical to test with each function operated in isolation, or where the isolation of a particular function would result in the equipment being unable to fulfil its primary function, or where the simultaneous operation of several functions would result in saving measurement time, the equipment shall be deemed to have complied if it meets the provisions of the relevant clause and/or standard with the necessary functions operated.

6.4.8 Determination of arrangement(s) causing maximum emissions

Initial testing shall identify the frequency that has the highest disturbance relative to the limit. This identification shall be performed while operating the EUT in typical modes of operation

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and with cable positions in a test arrangement that is representative of typical installation practice.

The frequency of highest disturbance with respect to the limit shall be found by investigating disturbances at a number of significant frequencies. This provides confidence that the probable frequency of maximum disturbance has been found and that the associated cable, EUT arrangement and mode of operation has been identified.

For initial testing, the EUT should be arranged in accordance with the product standards as appropriate.

6.4.9 Recording of measurements

Of those disturbances above (L – 20 dB), where L is the limit level in logarithmic units, the disturbance levels and the frequencies of at least the six highest disturbances shall be recorded.

For radiated disturbances, the antenna polarization and height for each reported disturbance shall be recorded.

6.5 Interpretation of measuring results

6.5.1 Continuous disturbance

a) If the level of disturbance is not steady, the reading on the measuring receiver is observed for at least 15 s for each measurement. The highest readings shall be recorded, with the exception of any isolated clicks, which shall be ignored (see 4.4 of CISPR 14-1:2016).

b) If the general level of the disturbance is not steady, but shows a continuous rise or fall of more than 2 dB in the 15 s period, then the disturbance voltage levels shall be observed for a further period and the levels shall be interpreted according to the conditions of normal use of the EUT, as follows:

   1) if the EUT is one that may be switched on and off frequently, or the direction of rotation of which can be reversed, then at each frequency of measurement the EUT should be switched on or reversed just before each measurement, and switched off just after each measurement. The maximum level obtained during the first minute at each frequency of measurement shall be recorded;

   2) if the EUT is one that in normal use runs for longer periods, then it should remain switched on for the period of the complete test, and at each frequency the level of disturbance shall be recorded only after a steady reading (subject to the provision that item a) has been obtained).

c) If the pattern of the disturbance from the EUT changes from a steady to a random character part way through a test, then that EUT shall be tested in accordance with item b).

d) Measurements are taken throughout the complete spectrum and are recorded at least at the frequency with maximum reading and as required by the relevant CISPR publication.

6.5.2 Discontinuous disturbance

There is currently no requirement for the measurement of radiated discontinuous disturbances.

6.5.3 Measurement of the duration of disturbance

The duration of a disturbance shall be known in order to measure it correctly and to determine if it is discontinuous. The duration of a disturbance may be measured in one of the following ways:

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- through the connection of an oscilloscope to a measuring receiver's IF output to allow monitoring of the disturbance in the time-domain;
- through the tuning of either an EMI receiver or a spectrum analyzer to the disturbance frequency without frequency scanning (i.e. 'zero-span' mode) to allow monitoring of the disturbance in the time-domain; or
- through the use of the time-domain output of an FFT-based measuring receiver.

Guidance for the determination of the appropriate measurement time can be found in 8.3.

6.6 Measurement times and scan rates for continuous disturbance

6.6.1 General

For both manual measurements and automated or semi-automated measurements, measurement times and scan rates of measuring and scanning receivers shall be set so as to measure the maximum emission. Especially, where a peak detector is used for pre-scans, the measurement times and scan rates have to take the timing of the emission under test into account. More detailed guidance about performing automated measurements can be found in Clause 8.

6.6.2 Minimum measurement times

~~Clause B.7 provides a table of the minimum sweep times or the fastest – practically achievable – scan rates.~~

The minimum measurement (dwell) times are given in Table 1. From Table 1, the minimum scan times for measurements over a complete CISPR band have been derived in Table 2. These minimum measurement (dwell) times for scanning receivers and FFT-based measuring instruments in Table 1 and the scan times for spectrum analyzers in Table 2 apply to CW signals.

In addition, the test report shall include the value of the measurement instrumentation uncertainty corresponding to the used test set-up, calculated as per the requirements of CISPR 16-4-2.

Table 1 – Minimum measurement times for the four CISPR bands

Frequency band		Minimum measurement time T_m
A	9 kHz to 150 kHz	10,00 ms
B	0,15 MHz to 30 MHz	0,50 ms
C and D	30 MHz to 1 000 MHz	0,06 ms
E	1 GHz to 18 GHz	0,01 ms

Table 2 – Minimum scan times for the three CISPR bands with peak and quasi-peak detectors

Frequency band		Scan time T_S for peak detection	Scan time T_S for quasi-peak detection
A	9 kHz to 150 kHz	14,1 s	2 820 s = 47 min
B	0,15 MHz to 30 MHz	2,985 s	5 970 s = 99,5 min = 1 h 39 min
C and D	30 MHz to 1 000 MHz	0,97 s	19 400 s = 323,3 min = 5 h 23 min

~~The scan times in Table 1 apply to the measurement of CW signals.~~ Depending on the type of disturbance, the scan time may have to be increased – even for quasi-peak measurements. In

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extreme cases, the measurement time T_m at a certain frequency may have to be increased to 15 s, if the level of the observed emission is not steady (see 6.5.1). However isolated clicks are excluded.

Scan rates and measurement times for use with the average detector are given in Annex C.

Most product standards call out quasi-peak detection for compliance measurements, which can be very time-consuming if time-saving procedures are not applied (see Clause 8). Before timesaving procedures can be applied, the emission has to be detected using a pre-scan. To ensure that, e.g. intermittent signals are not missed during an automated scan, the considerations in 6.6.3 to 6.6.5 shall be accounted for.

6.6.3 Scan rates for scanning receivers and spectrum analyzers

One of two conditions needs to be met to ensure that signals are not missed during automated scans over frequency spans:

- for a single sweep: the measurement time at each frequency ~~must~~ shall be larger than the intervals between pulses for intermittent signals;
- for multiple sweeps with maximum hold: the observation time at each frequency should be sufficient for intercepting intermittent signals.

The frequency scan rate is limited by the resolution bandwidth of the instrument and the video bandwidth setting. If the scan rate is chosen too fast for the given instrument state, erroneous measurement results will be obtained. Therefore, a sufficiently long sweep time needs to be chosen for the selected frequency span. Intermittent signals may be intercepted by either a single sweep with sufficient observation time at each frequency or by multiple sweeps with maximum hold. Usually for an overview over unknown emissions, the latter will be highly efficient: as long as the spectrum response changes, there may still be intermittent signals to discover. The observation time shall be selected according to the periodicity at which interfering signals occur. In some cases, the sweep time may have to be varied in order to avoid synchronization effects.

When determining the minimum sweep time for measurements with a spectrum analyzer or scanning EMI receiver, based on a given instrument setting and using peak detection, two different cases have to be distinguished. If the video bandwidth is selected to be **wider** than the resolution bandwidth, the following expression can be used to calculate the minimum sweep time:

$$T_{\mathrm{s\,min}} = k \times \frac{\Delta f}{B_{\mathrm{res}}^2} \tag{1}$$

where

$T_{\mathrm{s\,min}}$	is the minimum sweep time,
Δf	is the frequency span,
B_{res}	is resolution bandwidth, and
k	is a constant of proportionality, related to the shape of the resolution filter; this constant assumes a value between 2 and 3 for synchronously-tuned, near-Gaussian filters. For nearly rectangular, stagger-tuned filters, k has a value between 10 and 15.

If the video bandwidth is selected to be equal to or smaller than the resolution bandwidth, the following expression can be used to calculate the minimum sweep time:

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$$T_{\text{s min}} = k \times \frac{\Delta f}{B_{\text{res}}\, B_{\text{video}}} \tag{2}$$

where B_{video} is the video bandwidth.

Most spectrum analyzers and scanning EMI receivers automatically couple the sweep time to the selected frequency span and the bandwidth settings. Sweep time is adjusted to maintain a calibrated display. The automatic sweep time selection can be overridden if longer observation times are required, e.g. to intercept slowly varying signals.

In addition, for repetitive sweeps, the number of sweeps per second will be determined by the sweep time $T_{\text{s min}}$ and the retrace time (time needed to retune the local oscillator and to store the measurement results, etc.).

6.6.4 Scan times for stepping receivers

Stepping EMI receivers are consecutively tuned to single frequencies using predefined step sizes. While covering the frequency range of interest in discrete frequency steps, a minimum dwell time at each frequency is required for the instrument to accurately measure the input signal.

For the actual measurement, a frequency step size of roughly 50 % of the resolution bandwidth used or less (depending on the resolution filter shape) is required to reduce measurement uncertainty for narrowband signals due to the step-width. Under these assumptions the scan time $T_{\text{s min}}$ for a stepping receiver can be calculated using the following equation:

$$T_{\text{s min}} = T_{\text{m min}} \times \frac{\Delta f}{0{,}5\, B_{\text{res}}} \tag{3}$$

where $T_{\text{m min}}$ is the minimum measurement (dwell) time at each frequency.

In addition to the measurement time, some time has to be taken into consideration for the synthesizer to switch to the next frequency and for the firmware to store the measurement result, which in most measuring receivers is automatically done so that the selected measurement time is the effective time for the measurement result. Furthermore, the selected detector, e.g. peak or quasi-peak, determines this time period as well.

For purely broadband emissions, the frequency step size may be increased. In this case, the objective is to find the maxima of the emission spectrum only.

6.6.5 Strategies for obtaining a spectrum overview using the peak detector

For each pre-scan measurement, the probability of intercepting all critical spectral components of the EUT spectrum shall be equal to 100 % or as close to 100 % as possible. Depending on the type of measuring receiver and the characteristics of the disturbance, that may contain narrowband and broadband components, two general approaches are proposed:

– stepped scan: the measurement (dwell) time shall be long enough at each frequency to measure the signal peak, e.g. for an impulsive signal the measurement (dwell) time should be longer than the reciprocal of the repetition frequency of the signal.
– swept scan: the measurement time ~~must~~ shall be larger than the intervals between intermittent signals (single sweep) and the number of frequency scans during the observation time should be maximized to increase the probability of signal interception.

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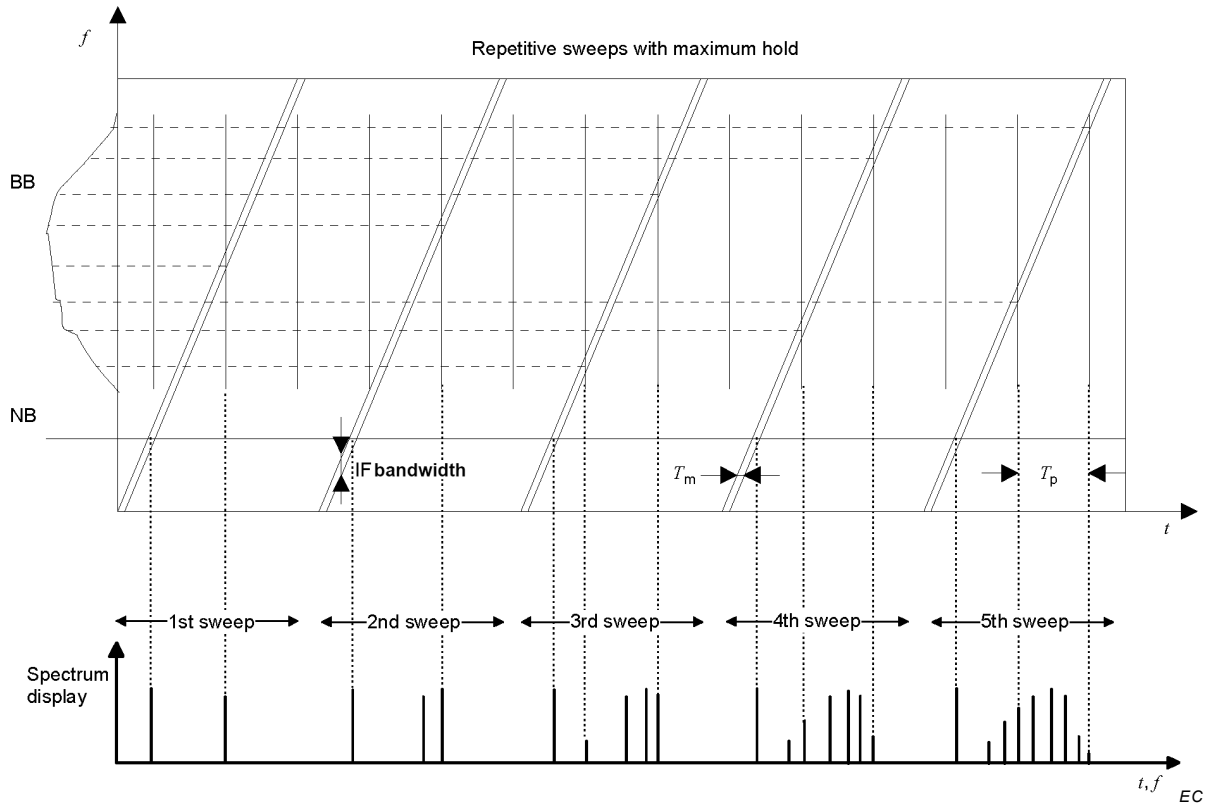
Figure 1, Figure 2, and Figure 3 show examples of the relationship between various time-varying emission spectra and the corresponding display on a measuring receiver. In each case, the upper part of the figure shows the position of the receiver bandwidth as it either sweeps or steps through the spectrum.



Key:

T_o is the pulse-repetition interval of the impulsive signal. A pulse occurs at each vertical line of the spectrum versus time display (upper part of the figure).

Figure 1 – Measurement of a combination of a CW signal (NB) and an impulsive signal (BB) using multiple sweeps with maximum hold

If the type of emission is unknown, multiple sweeps with the shortest possible sweep time and peak detection facilitate determining the spectrum envelope. A short single sweep is sufficient to measure the continuous narrowband signal content of the EUT spectrum. For continuous broadband and intermittent narrowband signals, multiple sweeps at various scan rates using a “maximum hold” function may be necessary to determine the spectrum envelope. For low repetition impulsive signals, many sweeps will be necessary to fill up the spectrum envelope of the broadband component.

The reduction of measurement time requires a timing analysis of the signals to be measured. This can be done either with a measuring receiver that provides a graphical signal display, used in zero-span mode or using an oscilloscope connected to the IF or video output of the receiver, and with an example shown in Figure 2.

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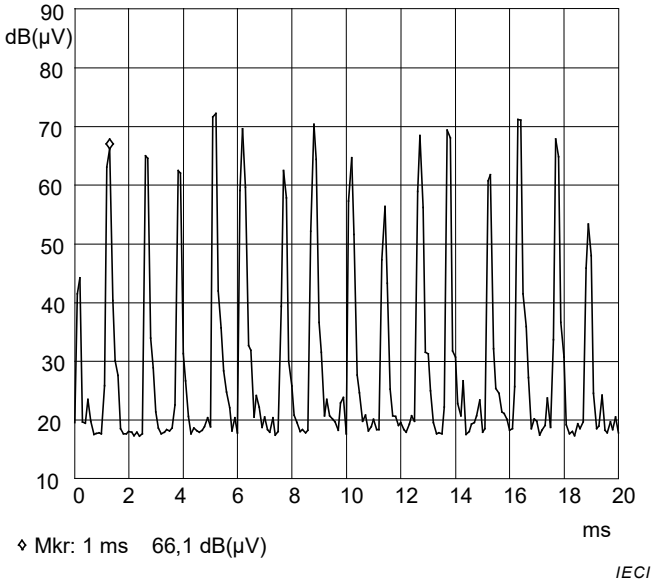

NOTE Disturbance from a d.c. collector motor; due to the number of collector segments, the pulse repetition frequency is high (approximately 800 Hz) and the pulse amplitude varies considerably. Therefore for this example, the recommended measurement (dwell) time with the peak detector is >10 ms.

Figure 2 – Example of a timing analysis

From such a timing analysis, pulse durations and pulse repetition frequencies can be determined and scan rates or dwell times selected, and according to the following:

– for **continuous unmodulated narrowband** disturbances, the fastest scan time possible for the selected instrument settings may be used;

– for **pure continuous broadband** disturbances, e.g. from ignition motors, arc welding equipment, and collector motors, a stepped scan (with peak or even quasi-peak detection) for sampling of the emission spectrum may be used. In this case the knowledge of the type of disturbance is used to draw a polyline (piecewise) curve as the spectrum envelope (see Figure 3). The step size shall be chosen so that no significant variations in the spectrum envelope are missed. A single swept measurement, if performed slowly enough, will also yield the spectrum envelope;

– for **intermittent narrowband** disturbances with unknown frequencies either fast short sweeps involving a “maximum hold” function (see Figure 4) or a slow single sweep may be used. A timing analysis may be required prior to the actual measurement to ensure proper signal interception;

– **intermittent broadband** disturbances shall be measured with discontinuous disturbance analysis procedures, as described in CISPR 16-1-1.

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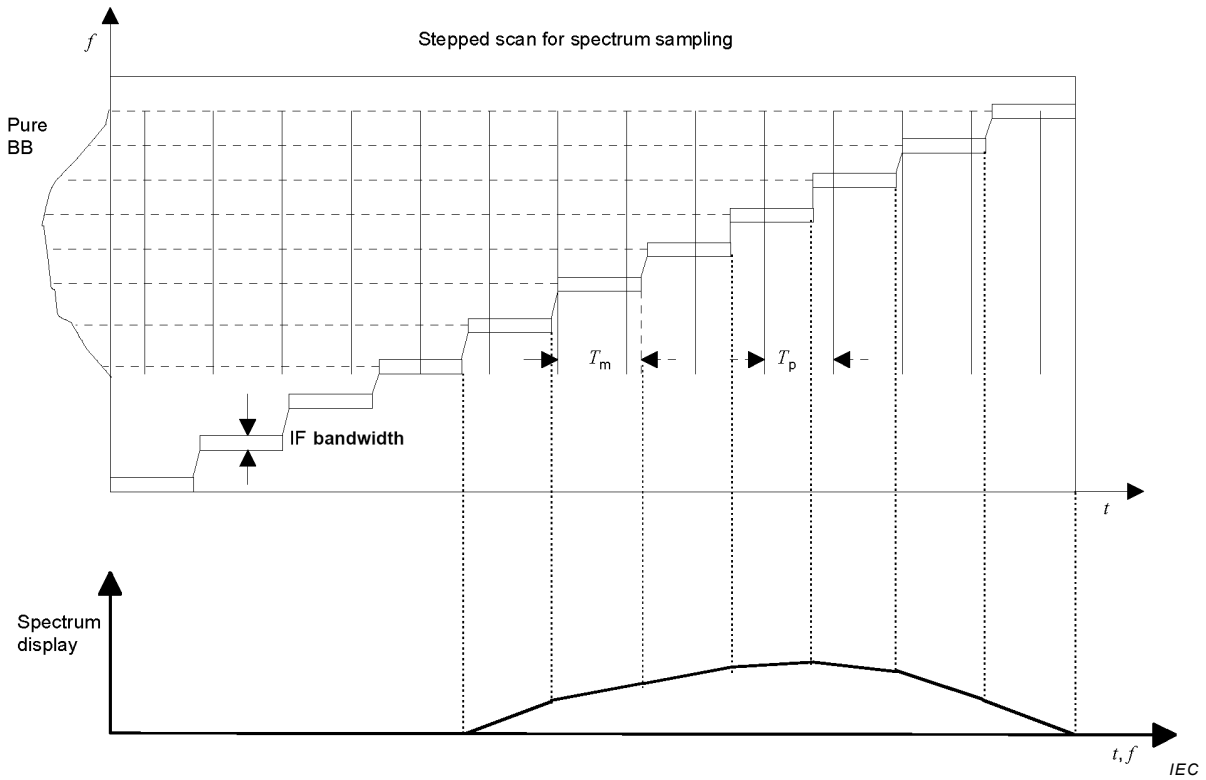

~~NOTE~~ The measurement (dwell) time T_m shall be longer than the pulse repetition interval T_p, which is the inverse of the pulse repetition frequency.

Figure 3 – A broadband spectrum measured with a stepped receiver

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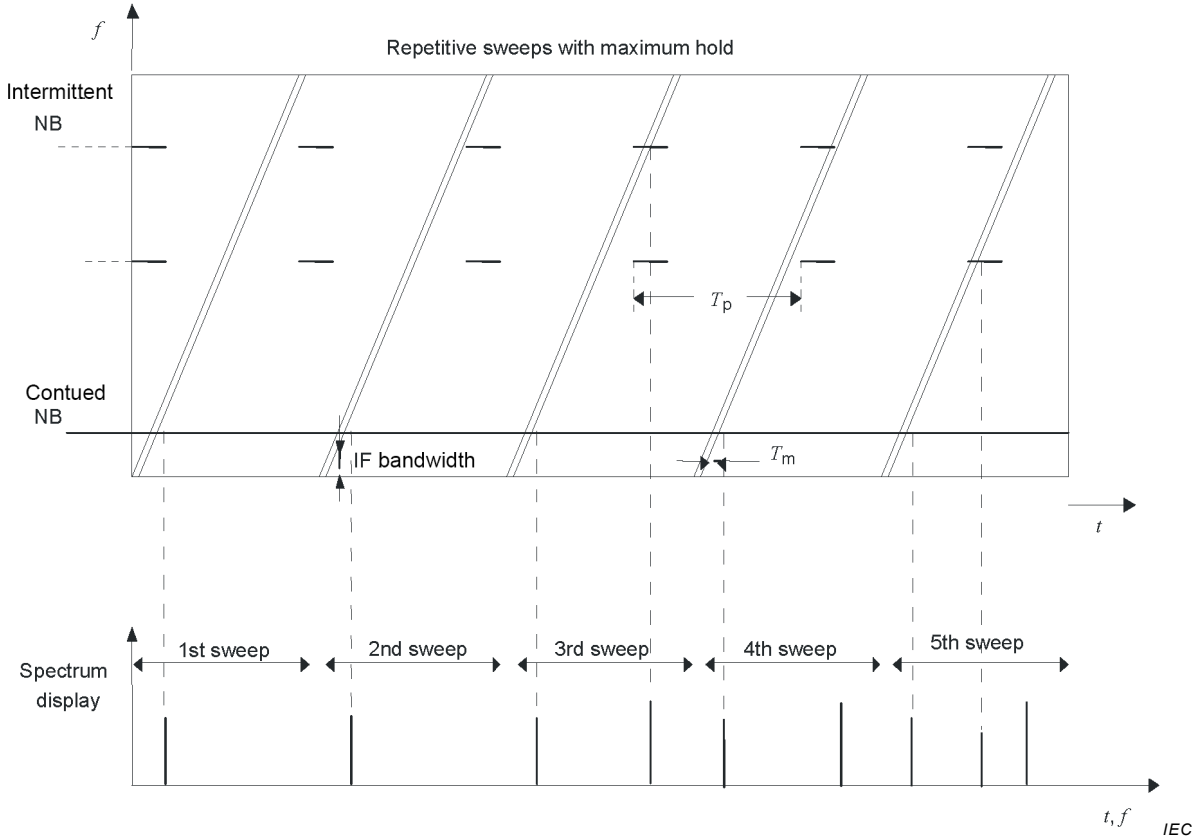

NOTE 1 The number of sweeps required or the sweep time may have to be increased, depending on pulse duration and pulse repetition interval.

NOTE 2 In this example, five sweeps are required for all spectral components to be intercepted.

Figure 4 – Intermittent narrowband disturbances measured using fast short repetitive sweeps with maximum hold function to obtain an overview of the emission spectrum

6.6.6 Timing considerations using FFT-based instruments

FFT-based measuring instruments may combine the parallel calculation at N frequencies and a stepped scan. For this purpose the frequency range of interest is subdivided into a number of segments N_{seg} that are scanned sequentially. The procedure is shown in Figure 5 for three segments. The total scan time for the frequency range of interest T_{scan} is calculated as:

$$T_{scan} = T_m N_{seg} \quad (4)$$

where

T_m is the measurement time for each segment, and

N_{seg} is the number of segments.

FFT-based measuring instruments may also provide methods to improve the frequency resolution across a given frequency range. In general, an FFT-based measuring instrument will have a fixed frequency step $f_{step\ FFT}$ that is determined by the number of frequencies of the FFT. Increased frequency resolution is achieved by performing repeat calculations over a given frequency range. For each repeat calculation, the lowest frequency is incremented by a frequency step, $f_{step\ final}$.

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Hence the first calculation over the given frequency range considers the following frequencies:

f_{min},
$f_{\text{min}} + f_{\text{step FFT}}$,
$f_{\text{min}} + 2f_{\text{step FFT}}$,
$f_{\text{min}} + 3f_{\text{step FFT}} \cdots$

The second calculation over the given frequency range considers the following frequencies:

$f_{\text{min}} + f_{\text{step final}}$,
$f_{\text{min}} + f_{\text{step final}} + f_{\text{step FFT}}$,
$f_{\text{min}} + f_{\text{step final}} + 2f_{\text{step FFT}}$,
$f_{\text{min}} + f_{\text{step final}} + 3f_{\text{step FFT}} \cdots$

This procedure, applied for a step ratio of 3, is displayed in Figure 6.

The scan time T_{scan} is calculated as:

$$T_{\text{scan}} = T_{\text{m}} \frac{f_{\text{step FFT}}}{f_{\text{step final}}} \tag{5}$$

where

T_{m} is the measurement time, and

$\frac{f_{\text{step FFT}}}{f_{\text{step final}}}$ is the step ratio.

For a system that combines both methods the scan time T_{scan} is calculated as:

$$T_{\text{scan}} = T_{\text{m}} N_{\text{seg}} \frac{f_{\text{step FFT}}}{f_{\text{step final}}} \tag{6}$$

NOTE 1 FFT-based measuring instruments may combine both methods, the stepped scan as well as a method to improve the frequency resolution.

NOTE 2 Additional background information on the definition of the FFT-based receiver can be found in CISPR TR 16-3 [3].

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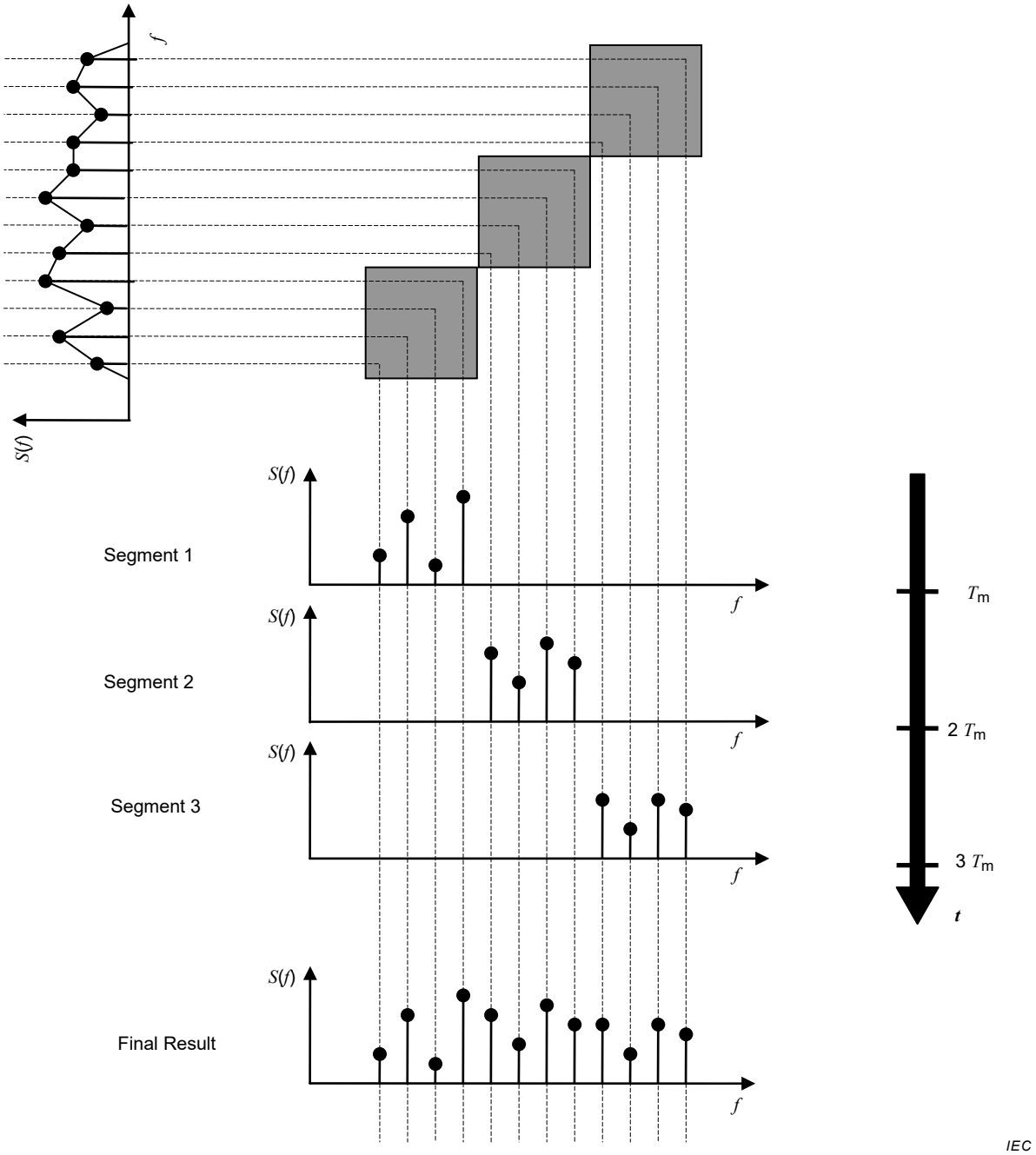

Figure 5 – FFT scan in segments

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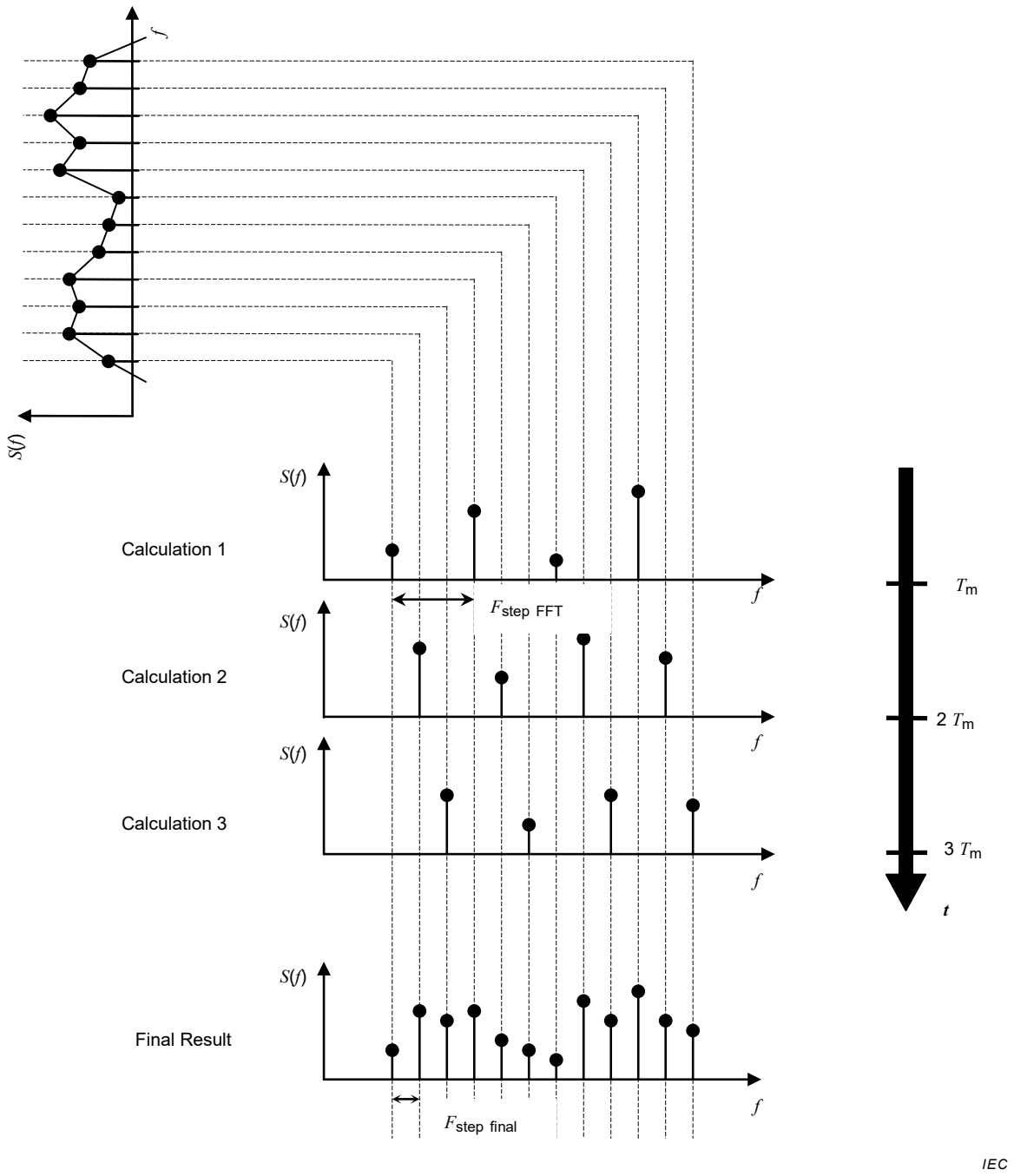

Figure 6 – Frequency resolution enhanced by FFT-based measuring instrument

7 Measurement of radiated disturbances

7.1 Introductory remarks

This clause sets forth the general procedures for the measurement of the field strength of radio disturbance produced by devices and systems. Experience with radiated disturbance measurements is less extensive than that of voltage measurements. The radiated disturbance measurement procedures are therefore open to revision and extension as knowledge and experience are accumulated. In particular, attention shall be given to the effect of leads and

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cables associated with the EUT. Table 3 provides a summary list of CISPR radiated emission test sites and test methods and the related cross-references to subclauses within this document or to other documents.

For some products, it may be required to measure the electric, the magnetic, or both components of the radiated disturbance. Sometimes a measurement of a quantity related to radiated power is more appropriate. Normally measurements should be made of both the horizontal and vertical components of the disturbance with respect to the reference ground plane. The results of measurements of either the electric or magnetic components may be expressed in peak, quasi- peak, average or rms values.

The magnetic component of the disturbance is normally measured at frequencies up to 30 MHz. In magnetic field measurements only the horizontal component of the field at the position of the receiving antenna is measured when using the distant antenna procedure. If the loop antenna system (LAS) is used, the three orthogonal magnetic dipole moments of the EUT are measured. (Note that in the single antenna method, the horizontal component of the field at the position of the antenna is determined by the horizontal and vertical dipole moments of the EUT because reflection plays a part.)

Table 3 – Applicable frequency ranges and document references for CISPR radiated emission test sites and test methods

Site / method	9 kHz to 30 MHz	30 MHz to 1 000 MHz	1 GHz to 18 GHz
Outdoor site	tbd	7.3.8	n/a
LAS	7.2	n/a	n/a
OATS or SAC	tbd	7.3	n/a
FAR	n/a	7.4	7.6
Common RE/RI	n/a	7.5 (RI start 80 MHz)	n/a
Absorber-lined OATS	n/a	n/a	7.6
In-situ	7.7.2	7.7.3, 7.7.4.2	7.7.3, 7.7.4.3
Substitution	n/a	7.8	7.8
Reverberation chamber	n/a	7.9 (Start 80 MHz)	7.9
TEM waveguide	IEC 61000-4-20	7.10	7.10
n/a = not applicable; tbd = to be determined or is under consideration			

7.2 Loop-antenna system measurements (9 kHz to 30 MHz)

7.2.1 General

The loop antenna system (LAS) considered in this subclause is suitable for indoor measurement of the magnetic field strength emitted by a single EUT in the frequency range 9 kHz to 30 MHz. The magnetic field strength is measured in terms of the currents induced into the LAS by the magnetic disturbance field of the EUT. The LAS shall be validated regularly using the method described in CISPR 16-1-4. CISPR 16-1-4 also gives a complete description of the LAS and a relation between the measuring results obtained with the LAS and those obtained as described in this subclause.

7.2.2 General measurement method

Figure 7 shows the general concept of measurements made with the LAS. The EUT is placed in the centre of the LAS. The current induced by the magnetic field from the EUT into each of the three large loop antennas of the LAS is measured by connecting the current probe of the large loop antenna to a measuring receiver (or equivalent). During the measurements, the EUT remains in a fixed position.

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The currents in the three large loop antennas, originating from the three mutually orthogonal magnetic field components, are measured in sequence. Each current level measured shall comply with the emission limit, expressed in dB(μA), as specified in the product standard. The emission limit shall apply for an LAS having large loop antennas with the standardized diameter of 2 m.

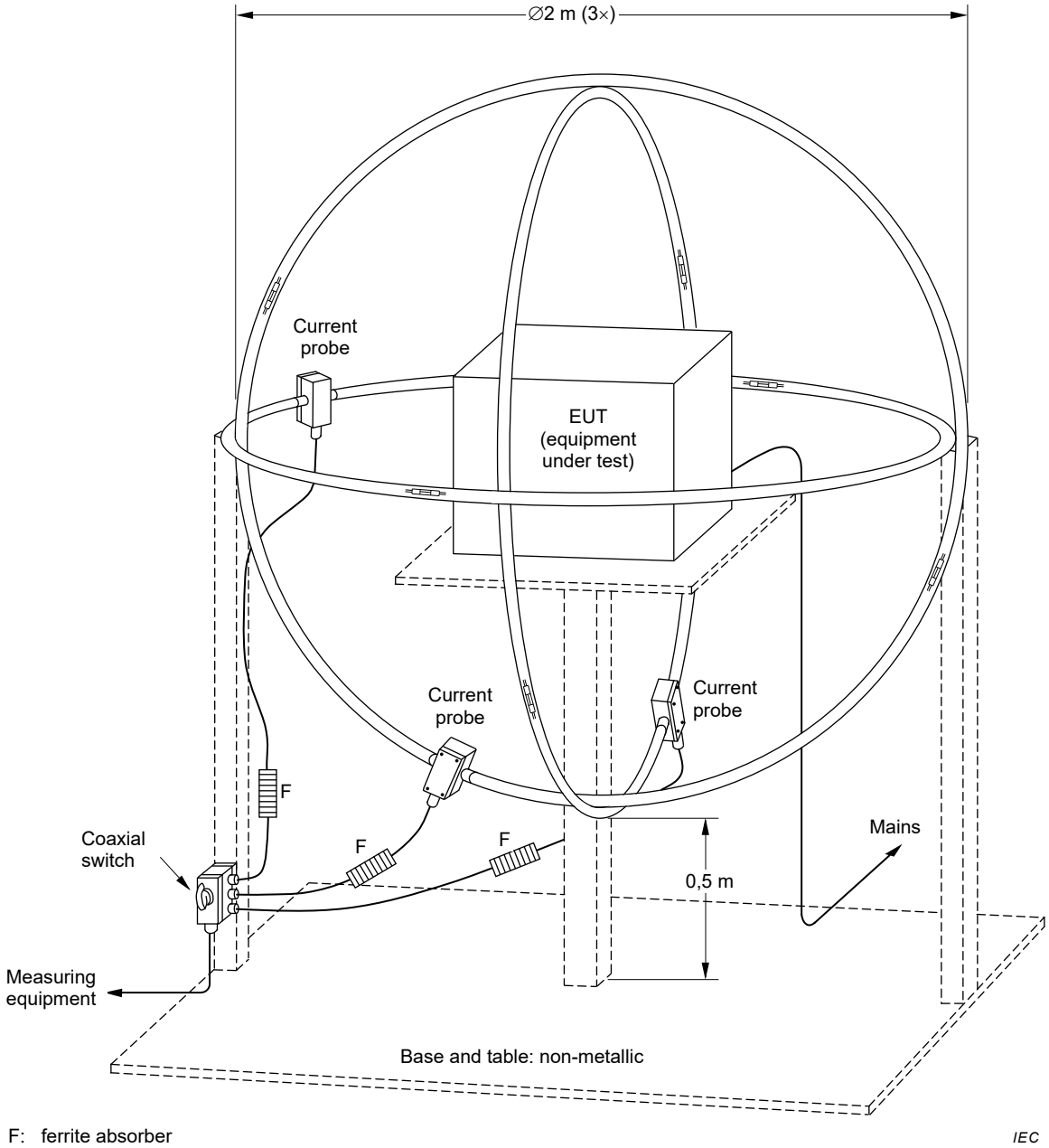

Figure 7 – Concept of magnetic field induced current measurements made with the loop antenna system

7.2.3 Test environment

The distance between the outer perimeter of the LAS and nearby objects, such as floor and walls, shall be at least 0,5 m. The currents induced in the LAS by an RF ambient field shall be judged in accordance with CISPR 16-1-4.

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7.2.4 Configuration of the equipment under test

To avoid unwanted capacitive coupling between the EUT and the LAS, the maximum dimensions of the EUT shall allow a distance of at least 0,20 m between the EUT and the standardized 2 m large loop antennas of the LAS.

The position of the mains lead shall be optimized for maximum current induction. In general, this position will not be critical when the EUT complies with the conducted emission limit.

In case of a large EUT, the diameter of the loop antennas of the LAS may be increased up to 4 m. In that case:

a) the current values measured shall be corrected in accordance with Clause B.6 of CISPR 16-1-2:2014; and

b) the maximum dimensions of the EUT shall allow a distance between the EUT and the large loops of at least (0,1 $\times$ D) m, where D is the diameter of the non-standardized loop.

7.2.5 Measurement uncertainty for LAS

General and basic considerations about uncertainties of emission measurements are given in CISPR 16-4-1.

7.3 Open-area test site or semi-anechoic chamber measurements (30 MHz to 1 GHz)

7.3.1 Measurand

The quantity to be measured is the maximum electric field strength emitted by the EUT 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, over all angles in the azimuth plane. This quantity shall be determined with the following provisions:

a) the frequency range of interest is 30 MHz to 1 000 MHz;

b) the quantity shall be expressed in terms of field strength units that correspond with the units used to express the limit levels for this quantity;

c) a SAC/OATS measurement site and positioning table shall be used that complies with the applicable CISPR validation requirements;

d) a measuring receiver compliant with CISPR 16-1-1 shall be used;

e) the use of alternative measurement distances, such as 3 m or 30 m instead of 10 m, shall be considered as alternative measurement methods;

f) the measurement distance is the horizontal projection of the distance between the boundary of the EUT and the antenna reference point to the ground plane;

g) the EUT is configured and operated in accordance with the CISPR specifications;

h) free-space antenna factors shall be used.

The measurand E is derived from the maximum voltage reading V_r by using the free-space antenna factor F_a:

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$$E = V_r + A_c + F_a \tag{7}$$

where

E is the field strength in dB(μV/m) as in the measurand description;

V_r is the maximum received voltage in dB(μV) using the procedure as in the measurand description;

A_c is the loss in dB of the measuring cable between antenna and receiver;

~~F_a is the free-space antenna factor of the receive antenna in dB(m^{-1}).~~

~~NOTE~~ Free-space antenna factors are used as a figure of merit for the antenna. It should be noted the field strength is measured above a ground plane, not in a free-space environment

In an EMC disturbance measurement the electric field strength is required at a given distance from the boundary of the EUT. The test distance is measured from the reference point of the antenna to the boundary of the EUT (see Figure 8). In the case of a difference between the reference point on an antenna and the phase centre, a correction factor may be applied to obtain the field strength at the test distance.

NOTE 1 See also 7.5.2.2 and A.6.2 of CISPR 16-1-6:2014 [2] about corrections of field strength results for antenna phase centre variations.

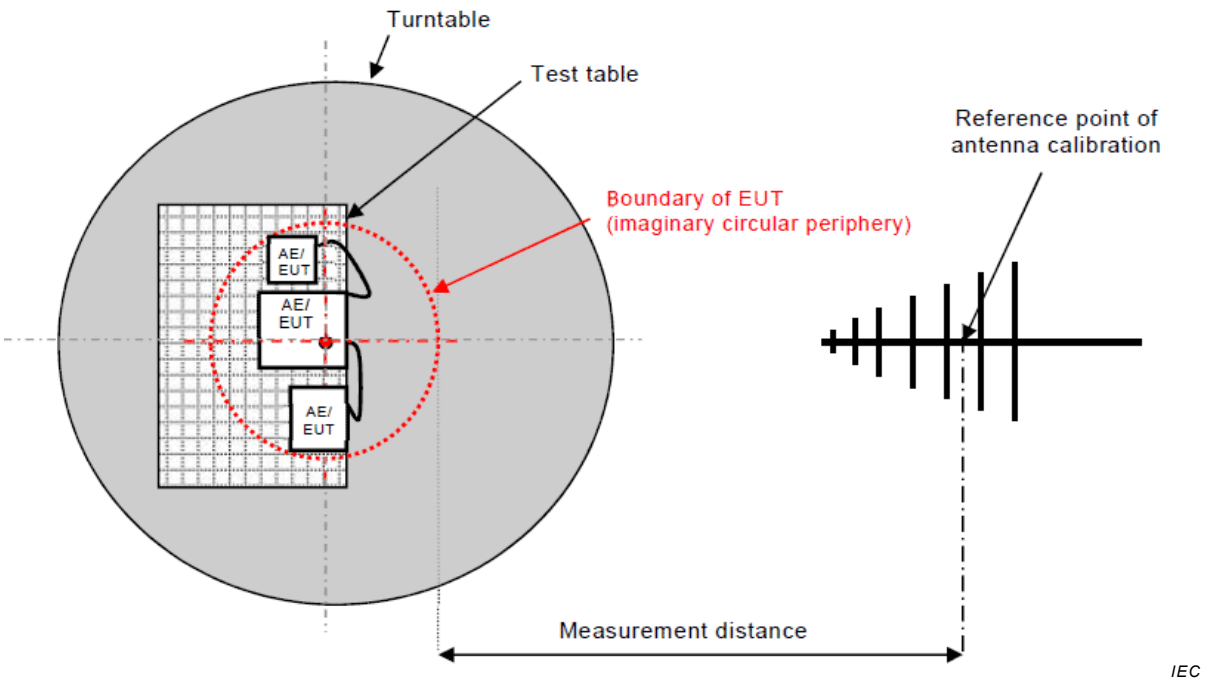

Figure 8 – Measurement distance

As an example, consider a typical log-periodic dipole array (LPDA) antenna that has a separation of approximately 0,6 m between the dipole that is responsive to the field at 200 MHz and the dipole that is responsive at 1 000 MHz. For the measurement of the emission at a distance d = 3 m from the EUT, at a frequency of 200 MHz, the electric field strength will be measured at a distance of approximately 3,3 m from P2 in Figure 9, according to the value of d_{phase} from Equation (11), where P2 is the boundary of the EUT.

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For a given frequency, the following correction, ΔE in dB, shall be added to the measured electric field strength:

$$\Delta E = 20 \lg \left(\frac{d_{\text{phase}}}{d} \right) \tag{8}$$

Referring to Figure 9 the distance from P2 to the resonant element at a given frequency is d_{phase} given by Equation (9). Point P1 is the manufacturer's mark or the centre of the antenna, $d_{1\text{P}}$ is the distance from the tip of the antenna to P1 and d_{1f} is the distance from the tip of the antenna to the phase centre position at frequency f.

$$d_{\text{phase}} = d + (d_{1f} - d_{1\text{P}}) \tag{9}$$

where

$$d_{1f} = \frac{(l_f - l_{\text{min}})(d_{\text{max}} - d_{\text{min}})}{l_{\text{max}} - l_{\text{min}}} + d_{\text{min}} \tag{10}$$

l_f is the length of the dipole element that is nominally resonant at frequency f in MHz and is equal to 0,9 × 150/f in m, where 0,9 is a generic shortening factor due to the finite radius of the dipole [11];

l_{min} and l_{max} are lengths of the dipoles having minimum and maximum lengths (i.e. the dipoles are resonant at approximately the upper and lower operating frequencies, respectively);

d_{min} and d_{max} are the distances from the minimum and maximum length dipoles to the antenna tip, respectively.

For hybrid antennas the phase center position d_{phase} is determined using information supplied by the antenna manufacturer. In case of tabular form the antenna manufacturer shall provide d_{1f} for the frequency range 100 MHz to 300 MHz with a maximum frequency step of 20 MHz.

It is assumed in Equation (8) that the field point is in the far-field of the antenna. In a near-field situation, usually for less than half a wavelength, the measurement for A_{APR} (see Equation (35) of CISPR 16-1-4:2010/AMD1:2012) takes near-field effects into account. For more detail, including corrections for tapered LPDA sections of hybrid antennas, see 7.5.2.2 of CISPR 16-1-6:2014 [2]. Linear interpolation is used to estimate the phase centre position for frequencies between the resonant frequencies of the elements at the ends of the operating frequency range.

If a phase centre correction is not applied it shall be considered in the measurement instrumentation uncertainty budget in accordance with CISPR 16-4-2.

NOTE 2 The antenna calibration laboratory may provide the electric field strength correction for specific measurement distances (e.g. 3 m and 10 m) by equivalent corrections of the antenna factor for these distances.

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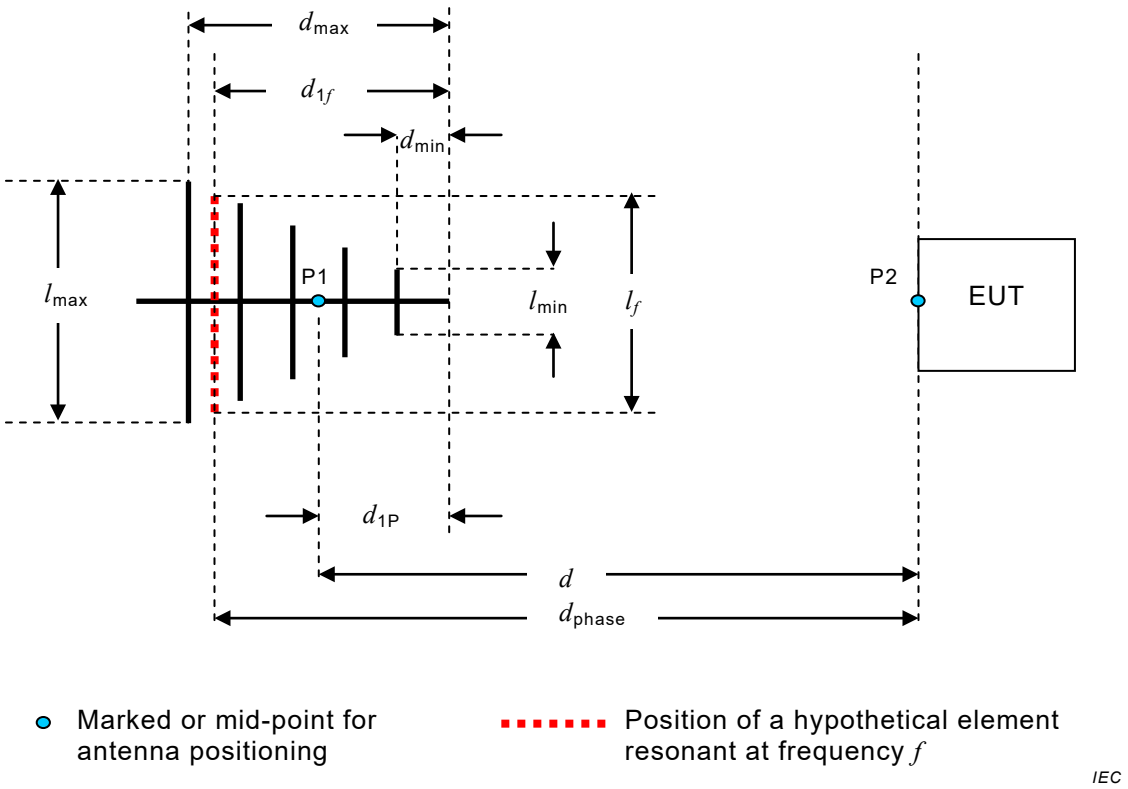

Figure 9 – Separation distance relative to the phase centre of an LPDA antenna

7.3.2 Test site requirements

The test site shall conform to the relevant specifications of CISPR 16-1-4 for its physical and electrical properties, and for its validation.

7.3.3 General measurement method

Figure 10 shows the concept of measurements made on an open-area test site (OATS) or in a semi-anechoic chamber (SAC) with the direct and ground reflected rays arriving at the receiving antenna.

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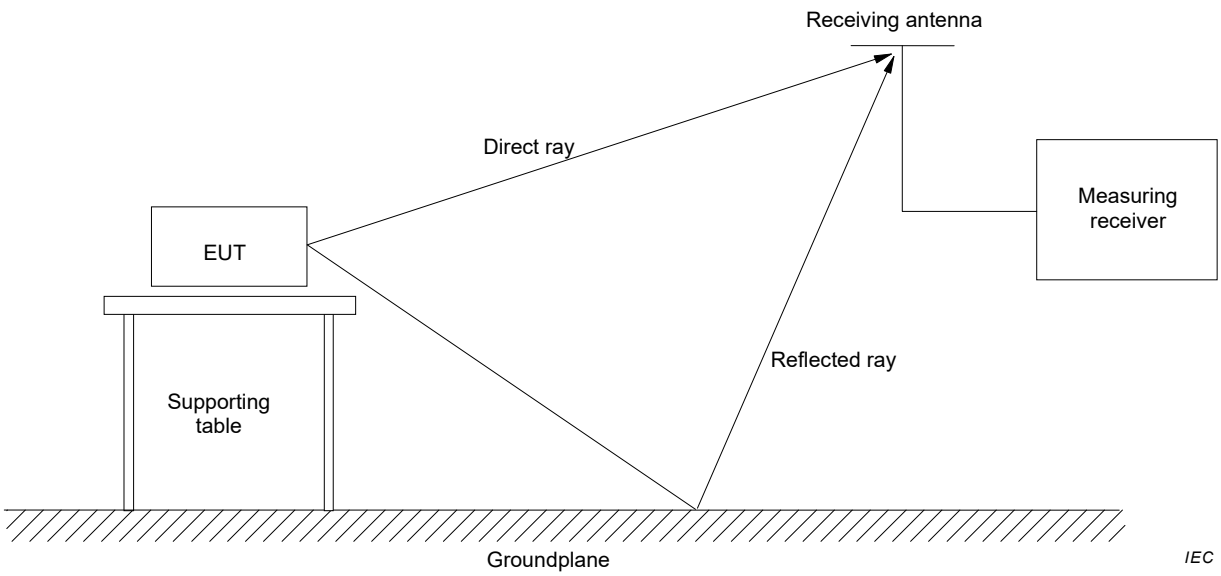

Figure 10 – Concept of electric field strength measurements made on an open-area test site (OATS) or semi-anechoic chamber (SAC) showing the direct and reflected rays arriving at the receiving antenna

The EUT is configured at a specified height above the ground plane and configured to represent normal operating conditions. The antenna is positioned at the specified separation distance. The EUT is rotated in the horizontal plane and the maximum reading noted. The height of the antenna is adjusted so that the direct and reflected rays approach or meet in-phase addition. The procedural steps may be interchanged and may need to be repeated to find the maximum disturbance. For practical reasons, the height variation is restricted, and, therefore, perfect in-phase addition may not be achieved.

7.3.4 Measurement distance

An EUT subject to a radiated disturbance limit at a specified distance should be measured at that distance unless to do so would be impractical because of equipment size, etc. The measurement distance is the distance between the projection of closest point of the EUT to the antenna and the projection of the calibration reference point of the antenna on the ground plane. If the antenna reference point is not specified in the antenna calibration report, for log-periodic antennas the reference point is a point along the horizontal antenna boom midway between the dipole elements that correspond to a half wavelength at the centre frequency of antenna frequency range.

NOTE The centre frequency is defined by: ~~log~~ lg (f_{centre}) = (~~log~~ lg f_{min} + ~~log~~ lg f_{max})/2; f_{centre} = $10^{\cancel{\log}\ \lg (f\ centre)}$.

A distance of 10 m is preferred at most outdoor sites since at this distance the expected level of the disturbance being measured is sufficiently above the general ambient noise level to permit useful testing. Distances of less than 3 m or greater than 30 m are not generally used. If a measurement distance other than the specified distance is necessary, the results should be extrapolated using the procedures specified in the product standards. If no guidance is given, suitable justification for extrapolation shall be provided. In general, extrapolation does not follow a simple inverse distance law.

Where possible, measurement should be made in the far field. The far-field region may be defined by the following conditions. The measurement distance d is selected so that:

a) $d \geq \lambda/6$. At this distance $E/H = Z_0 = 120\ \pi = 377\ \Omega$, that is electrical and magnetic field strength components are perpendicular to each other, and the measurement error is in the order of 3 dB if the EUT is regarded as being a tuned dipole antenna; or

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b) $d \geq \lambda$, a condition for a plane wave, where the error is in the order of 0,5 dB if the EUT is regarded as a tuned dipole antenna; or

c) $d \geq 2D^2 / \lambda$, where D is the largest dimension of either the EUT or the antenna determining the minimum aperture for the illumination of the EUT, which applies to cases, where $D >> \lambda$.

7.3.5 Antenna height variation

For electric field-strength measurements, the antenna height above the ground plane shall be varied within a specified range to obtain the maximum reading that will occur when the direct and reflected rays are in phase. As a general rule, for measurement distances up to and including 10 m, the antenna height for electric field strength measurements shall be varied between 1 m and 4 m. At greater distances of up to 30 m, preferably the height shall be varied between 2 m and 6 m. It may be necessary to adjust the minimum antenna height above ground down to 1 m in order to maximize the reading. These height scans apply for both horizontal and vertical polarization, except that for vertical polarization, the minimum height shall be increased so that the lowest point of the antenna clears the site ground surface by at least 25 cm.

7.3.6 Product specification details

7.3.6.1 General

In addition to specifying the detailed measurement method and the disturbance parameters to be measured, the product standards shall include other relevant details as outlined below.

7.3.6.2 Test environment

The influence of the test environment shall be considered so as to ensure correct functioning of the EUT. Important parameters in the physical environment shall be specified, e.g. temperature and humidity.

The electromagnetic environment needs special consideration to ensure accurate disturbance measurements. The ambient radio noise and signal levels measured at the test site with the EUT de-energized should be at least 6 dB below the limit. It is recognized that this is not always realizable at all frequencies. However, in the event that the measured levels of the ambient plus EUT radio noise emissions are not above the limit, the EUT shall be considered to be in compliance with the limit. See 6.2.2 and Annex A for further guidance about ambient levels and resulting measurement errors.

If the ambient field-strength level at frequencies within the specified measurement ranges, at the specified measurement distance, exceeds the limit(s), the following alternatives may be used to show compliance of the EUT:

a) Perform measurements at a closer distance and extrapolate results to the distance at which the limit is specified. ~~The extrapolation formula shall be as recommended by the product standard, or shall be verified by measurements at no less than three different distances;~~ Extrapolate the results using one of the following methods:

   1) determine L_2 corresponding to the close-in distance d_2 by applying the relation $L_2 = L_1(d_1/d_2)$, where L_1 is the specified limit in µV/m at the distance d_1;

      NOTE This extrapolation method can only be used when both d_1 and d_2 are in the far-field zone of the EUT at all frequencies of measurement.

   2) use the formula as recommended by the product standard;

   3) determine the limit L_2 at a distance d_2 applying an extrapolation formula verified by measurements at no less than three different distances.

b) In the frequency bands where the ambient noise values are exceeded (measured values higher than 6 dB below the limit), the disturbance values of the EUT may be interpolated

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from the adjacent disturbance values. The interpolated value shall lie on the curve describing a continuous function of the disturbance values adjacent to the ambient noise.

c) Perform measurements in critical frequency bands during hours when broadcast stations are off the air and the ambients from industrial equipment are lower.

d) Compare the amplitude of the EUT disturbance at the frequency under investigation with the amplitude of the disturbance on adjacent frequencies, in a shielded room or absorber-lined shielded room. The amplitude of the EUT disturbance at the frequency under investigation can be estimated by measuring the amplitude of the adjacent frequency disturbance and making a comparison.

e) Consider the directions of strong ambient signals in orienting the axis of an ~~open field area test site~~ OATS, so that the orientation of the receiving antenna on the site discriminates against such signals as far as possible.

f) Use a narrower instrument bandwidth for narrowband disturbances from the EUT occurring near an RF ambient when both are within the standard bandwidth.

7.3.6.3 Configuration of ~~equipment under test~~ EUT

~~The operating conditions of the EUT shall be specified, e.g. the characteristics of the input signals, the modes of operation, the arrangement of components, the lengths and types of interconnecting cables, etc.~~

~~The testing of individual and multi-component systems shall satisfy the following two conditions:~~

~~a) the system is configured for use in a typical manner;~~

~~b) the system is configured in a manner that will maximize disturbances.~~

~~The term **system** refers to the EUT in combination with the components that are connected to the EUT and all required connecting cables.~~

~~The term **configuration** refers to the orientation of the EUT, the other components of the system, the interconnecting cables, and the power mains leads that comprise the system. During all measurements, the configuration of the system shall be adjusted so that the above two conditions, the condition a) being satisfied first and followed by condition b), are fulfilled, within the guidelines described in the following paragraphs.~~

~~The term **typical** is used to describe the arrangement of how the EUT will actually be used. Guidelines for setting up a typical configuration are outlined below.~~

~~For equipment designed to be part of a multi-unit system, the EUT shall be installed in a typical system and configured in accordance with the manufacturer's instructions. It shall also be operated in a manner that is representative of the typical usage for that EUT. During all tests, the EUT and all system components shall be manipulated within the confines of typical usage to maximize each disturbance.~~

~~Interface cables shall be connected to each interface port on the EUT. The effect of varying the position of each cable shall be investigated to find the configuration that maximizes each disturbance as constrained by its typical configuration in actual use. The number of manipulations may be limited if a few such cable configurations will lead to maximum disturbances over the frequency range investigated.~~

~~Interface cables shall be of the type and length specified by the equipment manufacturer. Any excess length of each cable shall be separately bundled in a serpentine fashion at the approximate centre of the cable with the bundle 30 cm to 40 cm in length. If it is impractical to do so because of cable bulk or stiffness, or because the testing is being done at a user installation, disposition of the excess cable length is left to the discretion of the test engineer and should be noted in the test report. Different requirements for excess cabling may be specified in the product standard.~~

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~~Cables shall not be placed underneath, on top of the EUT, or on system components, unless it is appropriate to do so, e.g. a cable is normally routed through overhead cable racks or under the ground plane. Cables shall be positioned adjacent to the exterior cabinets of the EUT and all system components only if typically used in that manner. The EUT should be investigated in different modes of operation.~~

~~For an EUT normally operated on top of a table, radiated emission tests should be performed with the EUT on a non-conducting table, the top of which is of suitable size. The table should be placed on a remotely controlled rotating platform constructed with non-conducting materials. The top of the rotating platform should normally be less than 0,5 m above the ground plane and the height of the table and platform together 0,8 m above the ground plane. If the rotating platform is at the same elevation as the ground plane, its surface shall be of conducting material and the 0,8 m height shall be measured with respect to the top of the rotating platform. An EUT normally placed on the floor will be tested on the floor. A flush-mounted rotating platform (turntable) is useful in this situation. An EUT that may normally be placed either on the floor or table-top shall be tested as a table-top device.~~

~~The EUT shall be grounded in accordance with the manufacturer's requirements and conditions of intended use. If the EUT is operated without a ground connection, it shall be tested ungrounded. When the EUT is furnished with a grounding terminal or internally grounded lead that is to be connected in actual installation conditions, the ground lead or connection shall be connected to a ground plane (or facility for earth ground), simulating actual installation conditions. Any internally grounded lead included in the plug end of the a.c. mains cord of the EUT shall be connected to ground through the mains power service. Except at the manufacturer's intended grounding locations, a floor standing EUT shall be insulated from the ground plane by a dielectric material with thickness of up to 15 cm.~~

The EUT operating conditions and arrangement are detailed in 6.4.

Ferrite clamp type CMADs are used to reduce the influence of cables outside the test volume on radiated disturbance measurement results. If CMADs are used, the cable leaving the test volume shall enter the CMAD at the point where it reaches the ground plane as shown in Figure 11. The CMAD shall always be placed flat on the ground plane. The part of the cable between the exit point of the CMAD and the exit point of the turntable shall be kept as short as possible. Each cable shall be treated with a separate CMAD. Cables with diameters larger than the cable openings of commercially available CMADs do not have to be treated with CMADs.

In order to avoid saturation, high common mode current power cables (e.g. the output port of inverters) should not be treated with CMADs unless the CMADs in use are specifically designed for high common mode currents.

For EUTs with up to three cables leaving the test volume, each cable shall be treated with a CMAD during radiated disturbance measurements. This requirement applies to any type of cable (e.g. power, telecommunication, and control). For a test set-up with more than three cables leaving the test volume, only the three cables from which the highest emission is expected need to be equipped with CMADs. The cables on which the CMADs have been applied shall be documented in the test report.

NOTE The limitation of the number of CMADs is discussed in [12]. In comparing large versus small size EUTs, as well as EUTs with one versus two cables, the author concluded that a small EUT with only one cable leaving the test volume is worst case. The author's investigation covered application of CMADs to tabletop equipment with three cables or less.

General information on the purpose and application of ferrite-type CMADs is provided in 4.9.1 of CISPR TR 16-3:2010 [3].

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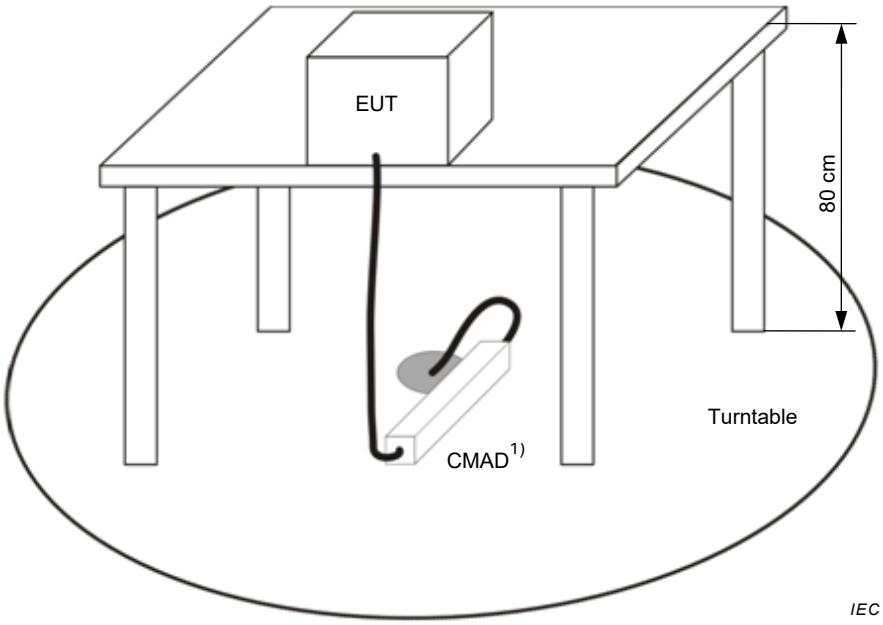

[1)] CMADs shall comply with the relevant specifications of CISPR 16-1-4. Their use shall be documented in the test report.

Figure 11 – Position of CMAD for table-top equipment on OATS or in SAC

7.3.7 Measurement instrumentation

The measurement instrumentation, including antennas, shall conform to the relevant requirements in CISPR 16-1-1 and CISPR 16-1-4.

7.3.8 Field-strength measurements on other outdoor sites

Outdoor test sites similar to an open-area test site but without any metal ground plane may be prescribed for some products, for practical reasons, e.g. ISM equipment and motor vehicles. The provisions given in 7.3.4 to 7.3.7 shall remain applicable.

7.3.9 Measurement uncertainty for OATS and SAC

General and basic considerations about uncertainties for emission measurements are given in CISPR 16-4-1. Uncertainty aspects specific to radiated emission measurements on an OATS or SAC (30 MHz to 1 GHz) are given in CISPR 16-4-2.

7.4 Fully-anechoic room measurements (30 MHz to 1 GHz)

7.4.1 Test set-up and site geometry

The same type of antenna shall be used for EUT emission testing as the receive antenna used for the FAR site validation testing. The antenna height is fixed at the geometrical middle height of the test volume. Measurement ~~will be done~~ are carried out in horizontal and vertical polarization of the receive antenna. Emission should be measured while the turntable rotates with the EUT in each of at least three successive azimuth positions (0°, 45°, 90°), when continuous rotation is not required. Figure 12 illustrates the typical FAR site geometry, and the relevant dimensions.

The EUT shall be placed on a turntable. Figure 12, Figure 13 and Figure 14 explain the different dimensions within the FAR. The turntable, antenna mast and supporting floor shall be in place during the site validation procedure, and consist largely of material transparent to electromagnetic waves. The distances a, b, c and e may be limited by the size of the test

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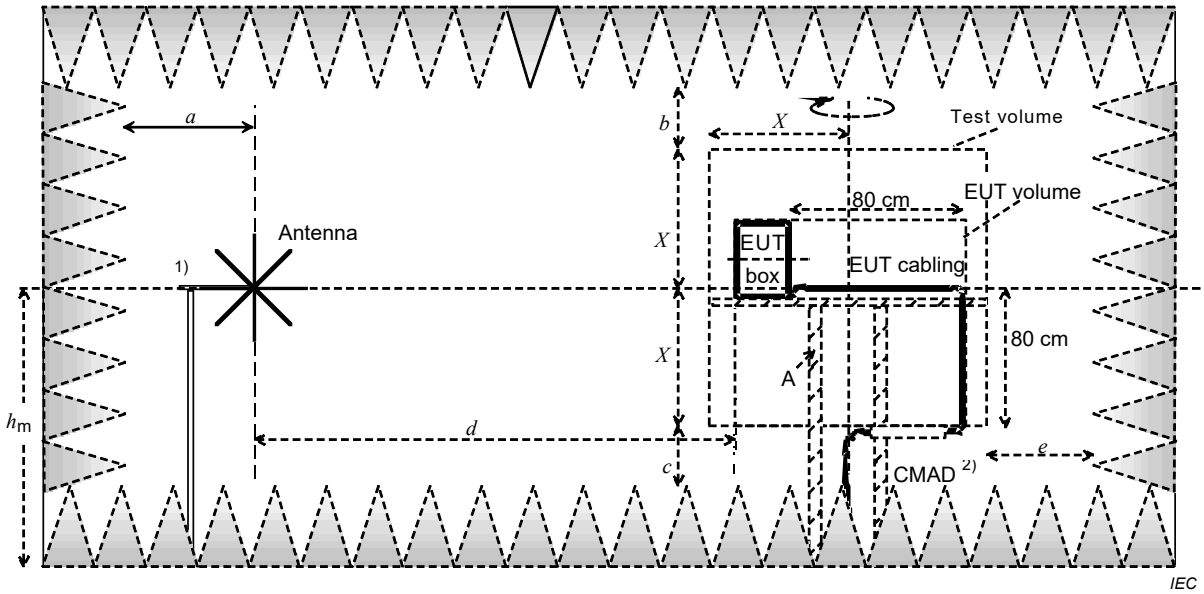
volume. The level of the bottom plane (absorber height plus c) ~~will be~~ is the level for floor-standing equipment (transport pallet height ~~will be~~ is outside the test volume).



Key

A	turntable and EUT support fixture
2X	1,5 m, 2,5 m, 5 m – corresponds to test distance used (3 m, 5 m, or 10 m respectively)
h_m	middle level of the test volume
a, b, c, e	≥0,5 m recommended (≥1 m is more convenient), the actual value is consistent with the FAR validation procedure of CISPR 16-1-4
d	3 m, 5 m, or 10 m

1) The antenna and cable layout shall be validated together and used in the same configuration during EUT test. The antenna together with the cable may have to be moved for the alignment of the required test distance during the EUT test.

2) CMADs shall ~~be used in accordance with the applicable product standard~~ comply with the relevant specifications of CISPR 16-1-4. Their use ~~(if required)~~ shall be documented in the test report.

Figure 12 – Typical FAR site geometry, where a, b, c, e depend upon the room performance

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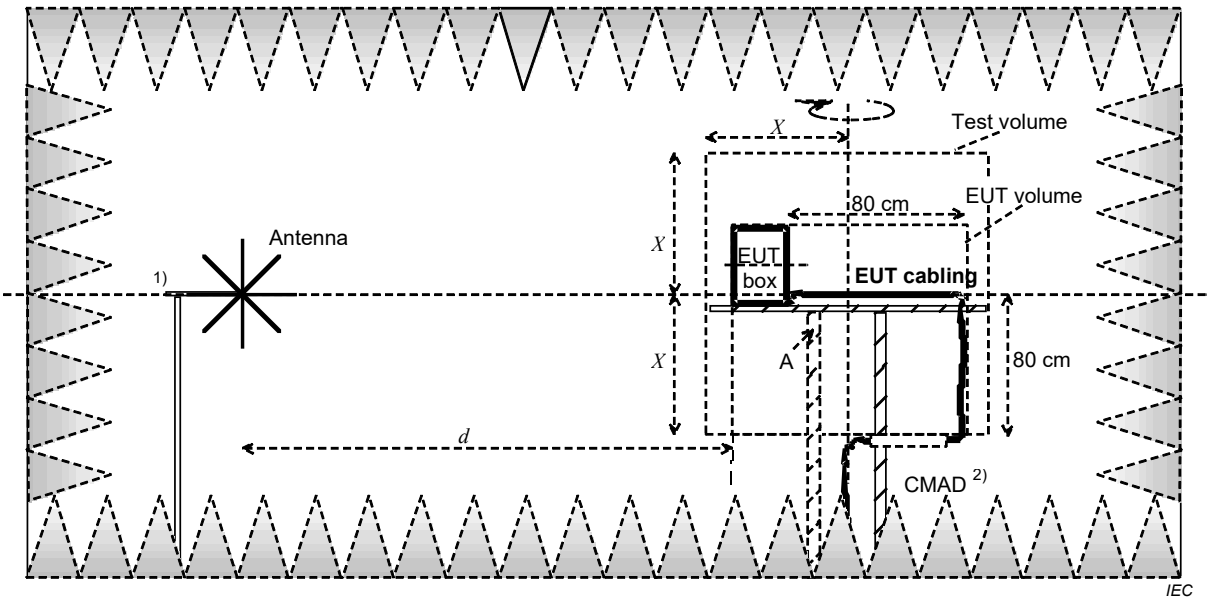

Key

A turntable and EUT support fixture

2X 1,5 m, 2,5 m, 5 m

d 3 m; 5 m, or 10 m (for 3 m, 5 m, or 10 m test distance, respectively)

1) The antenna cable layout shall be the same as in the site validation procedure (see Figure 12).

2) CMADs shall ~~be used in accordance with the applicable product standard~~ comply with the relevant specifications of CISPR 16-1-4. Their use ~~(if required)~~ shall be documented in the test report.

Figure 13 – Typical test set-up for table-top equipment within the test volume of a FAR

The test distance is measured from the reference point of the antenna to the boundary of the EUT. In the case of a difference between the reference point on an antenna and the phase centre, a correction factor may be applied to obtain the field strength at the test distance.

~~The correction factor, C_{dr}, in dB, in Equation (5), may be added to the field strength in order to reduce its uncertainty. In the calibration procedure for the antenna a phase correction factor C_{dr} is measured for each frequency. The measurement procedure is defined within the antenna calibration, or calculated from the mechanical spacing of the log-periodic elements along with the antenna factor F_a. The two factors (C_{dr}, and F_a) in dB are added to the output voltage of the antenna to get the field strength, per Equation (6). If a phase centre correction is not included, an additional term must be included in the uncertainty budget.~~

For a given frequency, the correction ΔE in dB in Equation (8) shall be added to the measured electric field strength in order to reduce its uncertainty. The correction of electric field strength is applied to account for the phase centre correction of LPDA antennas and the log-periodic part of hybrid antennas.

$$C_{dr} = 20\log\left[\left(d + P_f - r\right)/d\right] \quad \text{~~(5)~~}$$

~~The field strength is given by:~~

$$E_f = V_f + F_a + C_{dr} \quad \text{~~(6)~~}$$

~~where~~

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~~f is the frequency (MHz);~~

~~d is the required separation point from the EUT boundary to the reference point on the antenna (m);~~

~~P_f is the phase centre position as a function of frequency, (m from tip of antenna);~~

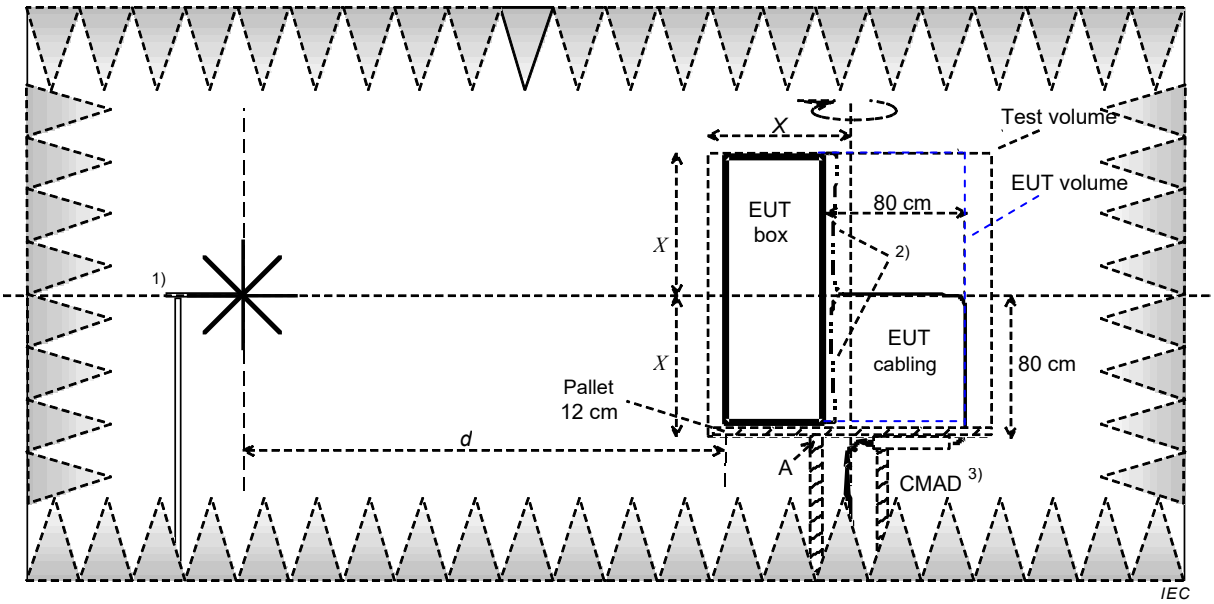
~~r is the distance of the reference point on the antenna from the antenna tip (m);~~

~~E_f is the E-field at distance d from the source [dB(μV/m)];~~

~~V_f is the voltage at the output of the antenna at frequency f [dB(μV)];~~

~~C_{dr} is the phase centre correction factor (dB);~~

~~F_a is the antenna factor (free space) for the E-field at the phase centre [dB(m^{-1})].~~



Key

A turntable and EUT support fixture

2X 1,5 m, 2,5 m, 5 m

d 3 m, 5 m, or 10 m for 3 m, 5 m, or 10 m test distance, respectively

Pallet of 12 cm (10 cm to 14 cm) is a compromise between metal- and wooden ground plane.

1) The antenna cable layout shall be the same as in the validation procedure (see Figure 12).

2) The cable layout depends on the location of the cable outlets and shall be close to the surface of the housing.

3) CMADs ~~are to be used in accordance with the applicable product standard~~ shall comply with the relevant specifications of CISPR 16-1-4. Their use ~~(if required) must~~ shall be documented in the test report.

Figure 14 – Typical test set-up for floor-standing equipment within the test volume of a FAR

7.4.2 EUT position

Figure 13 and Figure 14 illustrate test set-ups in a FAR for typical table-top and floor-standing EUTs, respectively. The EUT shall be configured, installed, arranged and operated in a manner consistent with typical applications. The entire EUT shall fit in the test volume. Associated equipment that is required to exercise the EUT, but does not form part of it, shall be located outside the screened room.

Interface cables shall be connected to each type of interface port of the EUT. If the EUT consists of separate devices, the space between the devices shall be in the volume

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configuration, but with 10 cm separation if possible. Interconnecting cables shall be bundled. The bundle shall be 30 cm to 40 cm long and longitudinal to the cable.

To improve the measurement repeatability, the following guidelines shall be applied:

a) The EUT (including the cables laid out according to 7.4.3) shall be placed so that its centre is at the same height as the centre of the test volume. A non-conductive support of a suitable height may be used to achieve this.

b) Where it is not physically possible to elevate a large EUT to the centre of the test volume (Figure 12 and Figure 13), the EUT may remain on a non-conductive transport pallet during the test (Figure 14). The height of the pallet shall be recorded in the test report.

The installation specifications for some floor-standing equipment require the unit to be installed and bonded directly to a conductive floor. The following considerations apply for testing of floor-standing equipment in a FAR: if FAR test results for floor-standing equipment intended to be installed and bonded directly to a conductive floor show non-compliance with an emissions limit applicable to FAR sites, actual emissions may be lower if the EUT were tested on a ground plane that better simulates the final installation environment. This is particularly true if the emissions are at a frequency below 200 MHz, horizontal polarization, and the source of emissions is from a location on the equipment that would correspond to a height above ground of 0,4 m or less in a typical installation. The reader is advised that prior to a determination of non-compliance based on FAR measurements, additional investigation in a ground plane test environment (i.e. an open-area test site or semi-anechoic chamber) is recommended, to better simulate the final intended installation condition for the equipment.

7.4.3 Cable layout and termination

In EMC testing, the reproducibility of measurement results is often poor due to differences in cable layout and termination, when one single EUT is measured at various test-sites. The following listed items are general conditions for the test set-up in order to provide good reproducibility (see Figure 13 and Figure 14). Ideally all radiation to be measured should only be emitted from the test volume. The cables used during the test shall be in accordance with manufacturer‘s specifications. The EUT may employ non-terminated cables if cable terminations are not available. The specifications of the cables and terminations used during testing shall be clearly described in the test report.

a) The cables that are connected to the EUT and auxiliary equipment or power supply shall include a length of 0,8 m run horizontally and 0,8 m run vertically (without any bundling) inside the test volume (see Figure 13 and Figure 14). Any cable length in excess of 1,6 m with a relative tolerance of ±5 % shall be routed outside the test volume.

b) If the manufacturer specifies a shorter length than 1,6 m, then, where possible, it shall be oriented such that half of its length is horizontal and half is vertical in the test volume.

c) Cables that are not exercised through associated equipment during the test ~~must~~ shall be appropriately terminated:

   1) coaxial (shielded) cables with coaxial terminator with correct impedance (50 Ω or 75 Ω);

   2) shielded cables with more than one inner wire ~~must~~ shall have common mode (line to reference earth/ground) and differential-mode (line to line) termination in accordance with the manufacturer’s specifications;

   3) unshielded cables ~~must~~ shall have differential mode termination as well as common-mode termination in accordance with the manufacturer’s specifications.

d) If the EUT needs associated equipment in order to be operated properly, special care shall be taken that no emission of that equipment can influence the radiation measurement. Associated equipment shall be located outside the screened room wherever possible. Measures against RF-leakage into the FAR through the interconnection cables ~~must~~ shall be taken.

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e) The test set-up, including cable layout~~, specifications~~ and details of attached cables and terminations,~~ and measures taken to suppress the emission influence of the cable length outside the test volume (for instance the use of ferrite clamps)~~ are specified in the different product standards.

f) Ferrite clamp type CMADs are used to reduce the influence of cables outside the test volume on radiated disturbance measurement results. The cable leaving the test volume shall enter the CMAD at the point where it reaches the bottom of the test volume (turntable) as shown in Figure 12, Figure 13 and Figure 14. Each cable shall be treated with a separate CMAD. Cables with diameters larger than the cable openings of commercially available CMADs need not be treated with CMADs.

In order to avoid saturation, high common mode current power cables (e.g. output port of inverters) should not be treated with CMADs, unless the CMADs in use are specifically designed for high common mode currents.

For EUTs with up to three cables leaving the test volume, each cable shall be treated with a CMAD during radiated disturbance measurements. This requirement applies to any type of cable (e.g. power, telecommunications and control). For a test set-up with more than three cables leaving the test volume only the three cables from which the highest emission is expected need to be equipped with CMADs. The cables on which the CMADs have been applied shall be documented in the test report.

General information on the purpose and application of ferrite-type CMADs is provided in 4.9.1 of CISPR TR 16-3:2014 [2].

Due to the different nature of the many possible EUTs, product standards may deviate considerably from the requirements of this subclause (e.g. 10.5 of CISPR 22:2008 [4]).

7.4.4 Measurement uncertainty for FAR

General and basic considerations about uncertainties of emission measurements are given in CISPR 16-4-1. Conditions for the use of alternative test methods are given in CISPR 16-4-5. An example of an uncertainty budget for an emission measurement at a 3 m distance in a FAR is given in CISPR 16-4-2.

7.5 Radiated emission measurement method (30 MHz to 1 GHz) and radiated immunity test method (80 MHz to 1 GHz) with common test set-up in semi-anechoic chamber

7.5.1 Applicability

As an alternative to different test set-ups for radiated emissions and radiated immunity testing, at the discretion of product committees, testing to both requirements may be performed using a common EUT arrangement in accordance with the provisions of this clause. The test arrangement described in this clause is applicable when radiated emissions and immunity testing of the EUT using the same configuration and test set-up is technically justified. This test arrangement is considered to be most applicable to EUTs of simple configuration, e.g. single enclosure, combination of small enclosures, less than five cables connected to the EUT. This alternative test arrangement is allowed for EUTs whose product emissions standards permit radiated emission tests at 3 m separation distance.

The radiated immunity test may be performed with absorbing material covering portions of the ground plane between the EUT and the transmitting antenna, if necessary to achieve field uniformity, as described in IEC 61000-4-3 (i.e. absorber-lined SAC, analogous to absorber-lined OATS). For emission measurements, the normalized site attenuation characteristics of the SAC without the ground-plane absorber shall satisfy the requirements of CISPR 16-1-4.

7.5.2 EUT perimeter definition and antenna-to-EUT separation distance

Radiated emission and immunity tests shall be made with the receive or transmit antenna located at a horizontal distance of 3 m plus half of the maximum width of the EUT being tested, measured from the centre of the EUT. The antenna reference point used when

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