CISPR 16-2-3

Edition 4.0 2016-09
REDLINE VERSION

INTERNATIONAL STANDARD

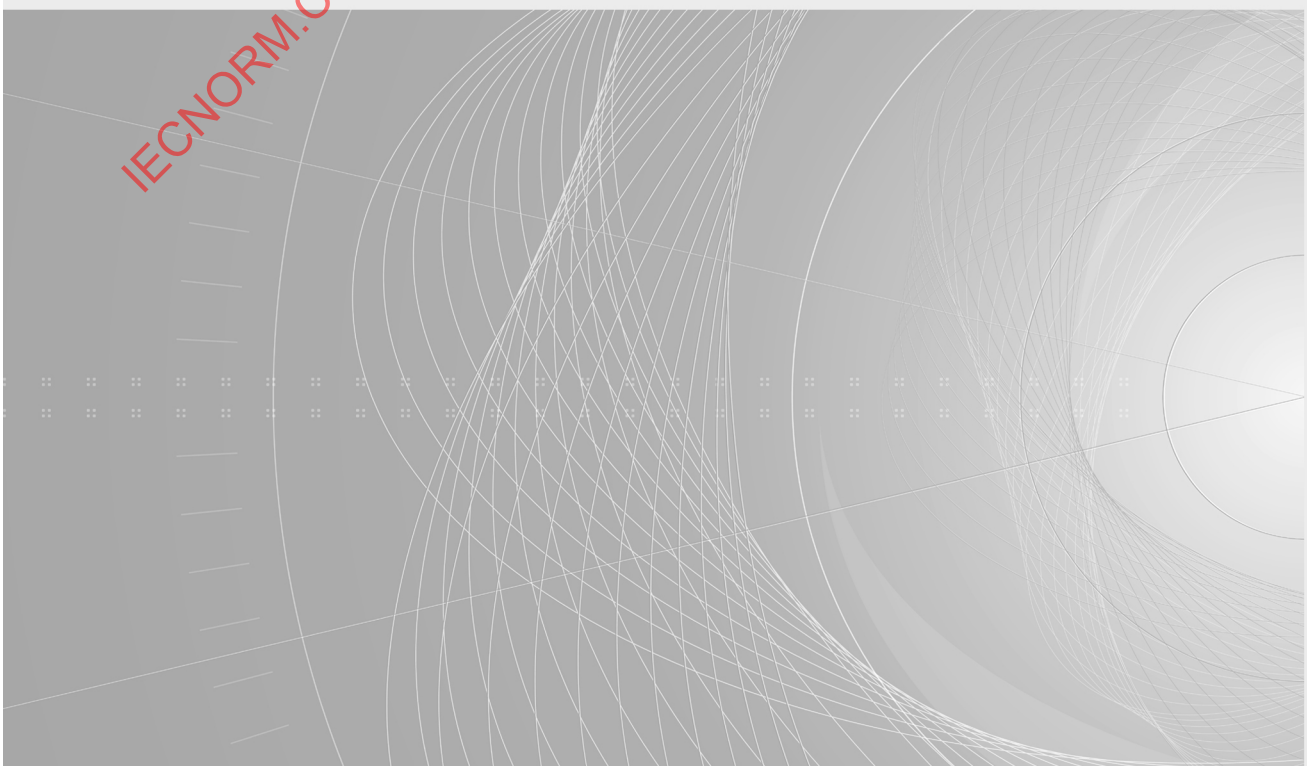
colour inside

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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



THIS PUBLICATION IS COPYRIGHT PROTECTED
Copyright © 2016 IEC, Geneva, Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

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

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

About the IEC
The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

About IEC publications
The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigenda or an amendment might have been published.

IEC Catalogue - webstore.iec.ch/catalogue
The stand-alone application for consulting the entire bibliographical information on IEC International Standards, Technical Specifications, Technical Reports and other documents. Available for PC, Mac OS, Android Tablets and iPad.

IEC publications search - webstore.iec.ch/advsearchform
The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee,…). It also gives information on projects, replaced and withdrawn publications.

IEC Just Published - webstore.iec.ch/justpublished
Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and also once a month by email.

Electropedia - www.electropedia.org
The world's leading online dictionary of electronic and electrical terms containing 21 000 terms and definitions in English and French, with equivalent terms in 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary
67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

IEC Customer Service Centre - webstore.iec.ch/csc
If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: sales@iec.ch.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

CISPR 16-2-3

Edition 4.0 2016-09
REDLINE VERSION

INTERNATIONAL STANDARD

colour inside

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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.100.10; 33.100.20

ISBN 978-2-8322-3644-4

Warning! Make sure that you obtained this publication from an authorized distributor.

® Registered trademark of the International Electrotechnical Commission

CONTENTS

FOREWORD....7
1 Scope....9
2 Normative references....9
3 Terms, definitions and abbreviations....10
3.1 Terms and definitions....10
3.2 Abbreviated terms....15
4 Types of disturbance to be measured....16
4.1 General....16
4.2 Types of disturbance....16
4.3 Detector functions....16
5 Connection of measuring equipment....17
6 General measurement requirements and conditions....17
6.1 General....17
6.2 Disturbance not produced by the equipment under test....17
6.2.1 General....17
6.2.2 Compliance (conformity assessment) testing....17
6.3 Measurement of continuous disturbance....18
6.3.1 Narrowband continuous disturbance....18
6.3.2 Broadband continuous disturbance....18
6.3.3 Use of spectrum analyzers and scanning receivers....18
6.4 ~~Operating conditions of the EUT~~ EUT arrangement and measurement conditions....18
6.4.1 ~~Normal load conditions~~ General arrangement of the EUT....18
6.4.2 Operation of the EUT....21
6.4.3 EUT time of operation....21
6.4.4 EUT running-in time....21
6.4.5 EUT supply....21
6.4.6 EUT mode of operation....21
6.4.7 Operation of multifunction equipment....21
6.4.8 Determination of arrangement(s) causing maximum emissions....21
6.4.9 Recording of measurements....22
6.5 Interpretation of measuring results....22
6.5.1 Continuous disturbance....22
6.5.2 Discontinuous disturbance....22
6.5.3 Measurement of the duration of disturbance....22
6.6 Measurement times and scan rates for continuous disturbance....23
6.6.1 General....23
6.6.2 Minimum measurement times....23
6.6.3 Scan rates for scanning receivers and spectrum analyzers....24
6.6.4 Scan times for stepping receivers....25
6.6.5 Strategies for obtaining a spectrum overview using the peak detector....25
6.6.6 Timing considerations using FFT-based instruments....29
7 Measurement of radiated disturbances....32
7.1 Introductory remarks....32
7.2 Loop-antenna system measurements (9 kHz to 30 MHz)....33

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

7.2.1 General 33
7.2.2 General measurement method 33
7.2.3 Test environment 34
7.2.4 Configuration of the equipment under test 35
7.2.5 Measurement uncertainty for LAS 35
7.3 Open-area test site or semi-anechoic chamber measurements (30 MHz to 1 GHz) 35
7.3.1 Measurand 35
7.3.2 Test site requirements 38
7.3.3 General measurement method 38
7.3.4 Measurement distance 39
7.3.5 Antenna height variation 40
7.3.6 Product specification details 40
7.3.7 Measurement instrumentation 43
7.3.8 Field-strength measurements on other outdoor sites 43
7.3.9 Measurement uncertainty for OATS and SAC 43
7.4 Fully-anechoic room measurements (30 MHz to 1 GHz) 43
7.4.1 Test set-up and site geometry 43
7.4.2 EUT position 46
7.4.3 Cable layout and termination 47
7.4.4 Measurement uncertainty for FAR 48
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 48
7.5.1 Applicability 48
7.5.2 EUT perimeter definition and antenna-to-EUT separation distance 48
7.5.3 Uniform test volume 49
7.5.4 Specifications for EUT set-up in common emissions/immunity test set-up 50
7.5.5 Measurement uncertainty for common emission/immunity set-up and method 56
7.6 Fully-anechoic room and absorber-lined OATS/SAC measurements (1 GHz to 18 GHz) 56
7.6.1 Quantity to measure 56
7.6.2 Measurement distance 56
7.6.3 Set-up and operating conditions of the equipment under test (EUT) 57
7.6.4 Measurement site 57
7.6.5 Measurement instrumentation 57
7.6.6 Measurement procedure 58
7.6.7 Measurement uncertainty for FAR 65
7.7 *In situ* measurements (9 kHz to 18 GHz) 65
7.7.1 Applicability of and preparation for *in situ* measurements 65
7.7.2 Field-strength measurements *in situ* in the frequency range 9 kHz to 30 MHz 66
7.7.3 Field-strength measurements *in situ* in the frequency range above 30 MHz 66
7.7.4 *In situ* measurement of the disturbance effective radiated power using the substitution method 67
7.7.5 Documentation of the measurement results 71
7.7.6 Measurement uncertainty for *in situ* method 71
7.8 Substitution measurements (30 MHz to 18 GHz) 72

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

7.8.1 General 72
7.8.2 Test site 72
7.8.3 Test antennas 72
7.8.4 EUT configuration 73
7.8.5 Test procedure 73
7.8.6 Measurement uncertainty for substitution method 73
7.9 Reverberation chamber measurements (80 MHz to 18 GHz) 74
7.10 TEM waveguide measurements (30 MHz to 18 GHz) 74
8 Automated measurement of emissions 74
8.1 Introduction – Precautions for automated measurements 74
8.2 Generic measurement procedure 74
8.3 Pre-scan measurements 75
8.3.1 General 75
8.3.2 Determination of the required measurement time 75
8.3.3 Pre-scan requirements for different types of measurements 76
8.4 Data reduction 77
8.5 Emission maximization and final measurement 77
8.6 Post-processing and reporting 78
8.7 Emission measurement strategies with FFT-based measuring instruments 78
Annex A (informative) Measurement of disturbances in the presence of ambient emissions 79
A.1 General 79
A.2 Terms and definitions 79
A.3 Problem description 79
A.4 Proposed solution 79
A.4.1 Overview 79
A.4.2 Pre-testing the EUT in a shielded room 82
A.4.3 Method of measurement of EUT disturbances in the presence of narrowband ambient emissions 83
A.4.4 Method of measurement of EUT disturbance in the presence of broadband ambient emissions 86
A.5 Determination of the EUT disturbance in case of superposition 88
Annex B (informative) Use of spectrum analyzers and scanning receivers 93
B.1 General 93
B.2 Overload 93
B.3 Linearity test 93
B.4 Selectivity 93
B.5 Normal response to pulses 93
B.6 Peak detection 93
B.7 Frequency scan rate 94
B.8 Signal interception 94
B.9 Average detection 94
B.10 Sensitivity 94
B.11 Amplitude accuracy 95
Annex C (informative) Scan rates and measurement times for use with the average detector 96
C.1 Purpose 96
C.2 Suppression of disturbances 96
C.2.1 Suppression of impulsive disturbance 96

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

C.2.2 Suppression of impulsive disturbance by digital averaging 97
C.2.3 Suppression of amplitude modulation 97
C.3 Measurement of slowly intermittent, unsteady or drifting narrowband disturbances 97
C.4 Recommended procedure for automated or semi-automated measurements 99
Annex D (informative) Explanation of the APD measurement method applying to the compliance test 100
Annex E (normative) Determination of suitability of spectrum analyzers for compliance tests 102
Bibliography 103

Figure 1 – Measurement of a combination of a CW signal (NB) and an impulsive signal (BB) using multiple sweeps with maximum hold 26
Figure 2 – Example of a timing analysis 27
Figure 3 – A broadband spectrum measured with a stepped receiver 28
Figure 4 – Intermittent narrowband disturbances measured using fast short repetitive sweeps with maximum hold function to obtain an overview of the emission spectrum 29
Figure 5 – FFT scan in segments 31
Figure 6 – Frequency resolution enhanced by FFT-based measuring instrument 32
Figure 7 – Concept of magnetic field induced current measurements made with the loop antenna system 34
Figure 8 – Measurement distance 36
Figure 9 – Separation distance relative to the phase centre of an LPDA antenna 38
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 39
Figure 11 – Position of CMAD for table-top equipment on OATS or in SAC 43
Figure 12 – Typical FAR site geometry, where a, b, c, e depend upon the room performance 44
Figure 13 – Typical test set-up for table-top equipment within the test volume of a FAR 45
Figure 14 – Typical test set-up for floor-standing equipment within the test volume of a FAR 46
Figure 15 – Positions of reference planes for uniform field calibration (top-view) 49
Figure 16 – Test set-up for table-top equipment 53
Figure 17 – Test set-up for table-top equipment – Top view 54
Figure 18 – Test set-up for floor-standing equipment 55
Figure 19 – Test set-up for floor-standing equipment – Top view 56
Figure 20 – Measurement method above 1 GHz, receive antenna in vertical polarization 58
Figure 21 – Illustration of height scan requirements for two different categories of EUTs 60
Figure 22 – Determination of the transition distance 70
Figure 23 – Substitution method set-up geometries for: a) measurement, b) calibration 73
Figure 24 – Process to give reduction of measurement time 75
Figure A.1 – Flow diagram for the selection of bandwidths and detectors and the estimated measurement errors due to that selection 81

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Figure A.2 – Relative difference in adjacent emission amplitudes during preliminary testing 83
Figure A.3 – Disturbance by an unmodulated signal (dotted line) 84
Figure A.4 – Disturbance by an amplitude-modulated signal (dotted line) 84
Figure A.5 – Indication of an amplitude-modulated signal as a function of modulation frequency with the QP detector in CISPR bands B, C and D 85
Figure A.6 – Indication of a pulse-modulated signal (pulse width 50 μs) as a function of pulse repetition frequency with peak, QP and average detectors 86
Figure A.7 – Disturbance by a broadband signal (dotted line) 86
Figure A.8 – Unmodulated EUT disturbance (dotted line) 87
Figure A.9 – Amplitude-modulated EUT disturbance (dotted line) 87
Figure A.10 – Increase of peak value with superposition of two unmodulated signals 89
Figure A.11 – Determination of the amplitude of the disturbance signal by means of the amplitude ratio d and the factor i (see Equation (A.3) and Equation (A.6)) 90
Figure A.12 – Increase of average indication measured with a real receiver and calculated from Equation (A.8) 91
Figure C.1 – Weighting function of a 10 ms pulse for peak (PK) and average detections with (CISPR AV) and without (AV) peak reading: meter time constant 160 ms 98
Figure C.2 – Weighting functions of a 10 ms pulse for peak (PK) and average detections with (CISPR AV) and without (AV) peak reading: meter time constant 100 ms 98
Figure C.3 – Example of weighting functions (of a 1 Hz pulse) for peak (PK) and average detections as a function of pulse width: meter time constant 160 ms 99
Figure C.4 – Example of weighting functions (of a 1 Hz pulse) for peak (PK) and average detections as a function of pulse width: meter time constant 100 ms 99
Figure D.1 – Example of APD measurement Method 1 for fluctuating disturbances 100
Figure D.2 – Example of APD measurement Method 2 for fluctuating disturbances 101

Table 1 – Minimum measurement times for the four CISPR bands 23
Table 2 – Minimum scan times for the three CISPR bands with peak and quasi-peak detectors 23
Table 3 – Applicable frequency ranges and document references for CISPR radiated emission test sites and test methods 33
Table 4 – Minimum dimension of w (w_{min}) 59
Table 5 – Example values of w for three antenna types 60
Table 6 – Horizontal polarization correction factors as a function of frequency 70
Table 7 – Recommended antenna heights to guarantee signal interception (for pre-scan) in the frequency range 30 MHz to 1 000 MHz 76
Table A.1 – Combinations of EUT disturbance and ambient emissions 80
Table A.2 – Measurement error depending on the detector type and on the combination of ambient and disturbing signal spectra 92
Table C.1 – Pulse suppression factors and scan rates for a 100 Hz video bandwidth 97
Table C.2 – Meter time constants and the corresponding video bandwidths and ~~maximum~~ minimum scan ~~rates~~ times 97
Table E.1 – Maximum amplitude difference between peak and quasi-peak detected signals 102

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

This redline version of the official IEC Standard allows the user to identify the changes made to the previous edition. A vertical bar appears in the margin wherever a change has been made. Additions are in green text, deletions are in strikethrough red text.

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

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

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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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]

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

2 Figures in square brackets refer to the Bibliography.

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.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

~~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.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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).

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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:

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

- 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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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:

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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

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

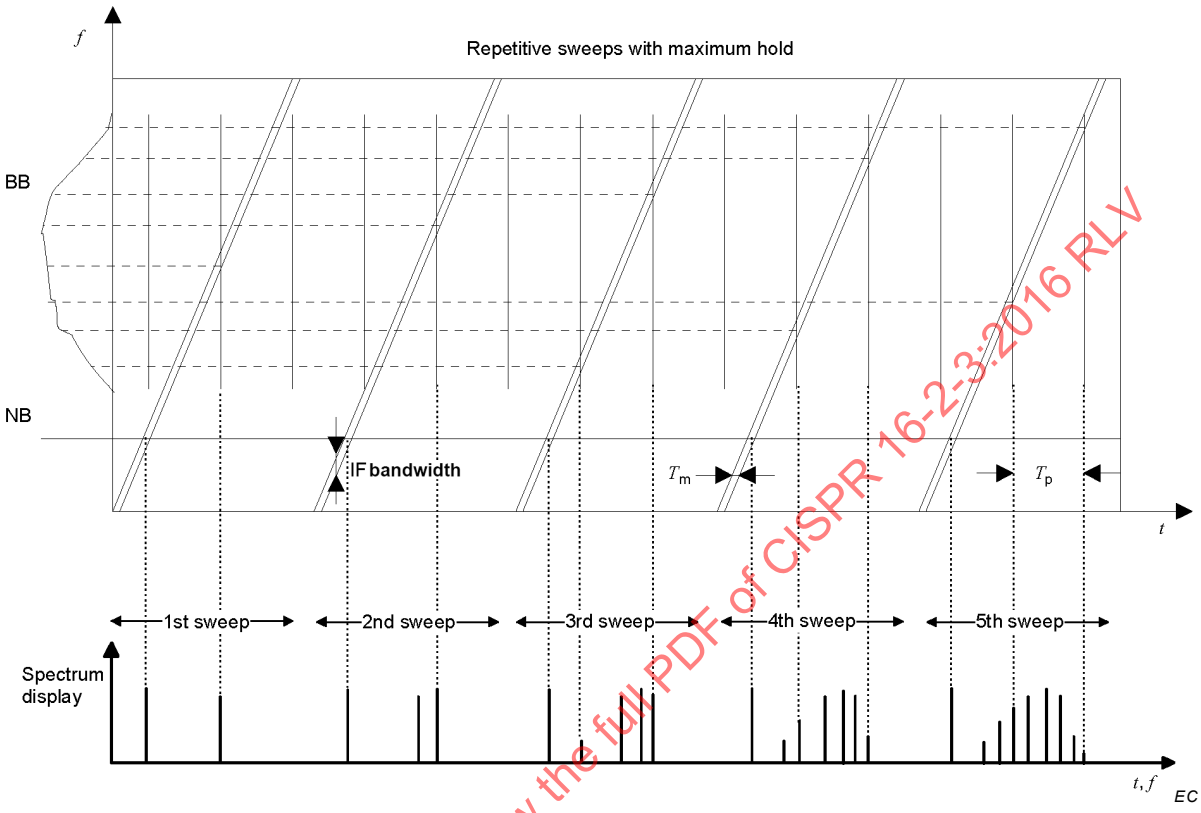
For each pre-scan measurement, the probability of intercepting all critical spectral components of the EUT spectrum shall be equal to 100 % or as close to 100 % as possible. Depending on the type of measuring receiver and the characteristics of the disturbance, that may contain narrowband and broadband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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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:

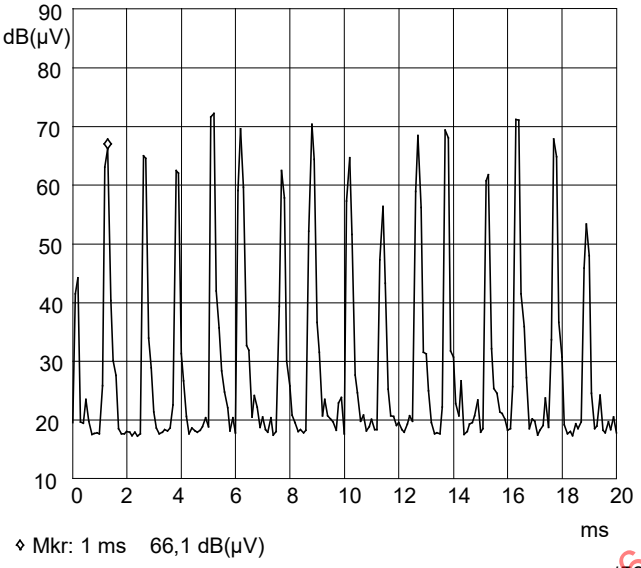
T_o is the pulse-repetition interval of the impulsive signal. A pulse occurs at each vertical line of the spectrum versus time display (upper part of the figure).

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.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



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:

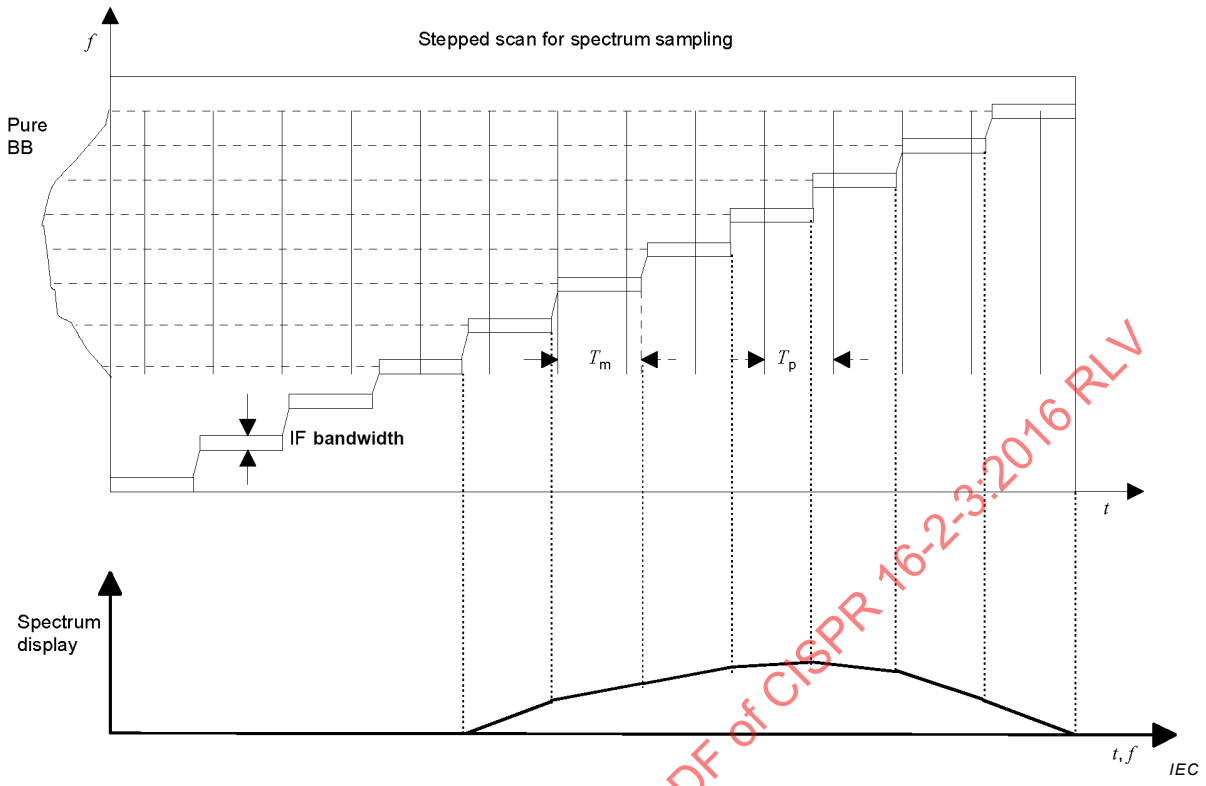
– for **continuous unmodulated narrowband** disturbances, the fastest scan time possible for the selected instrument settings may be used;

– 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.

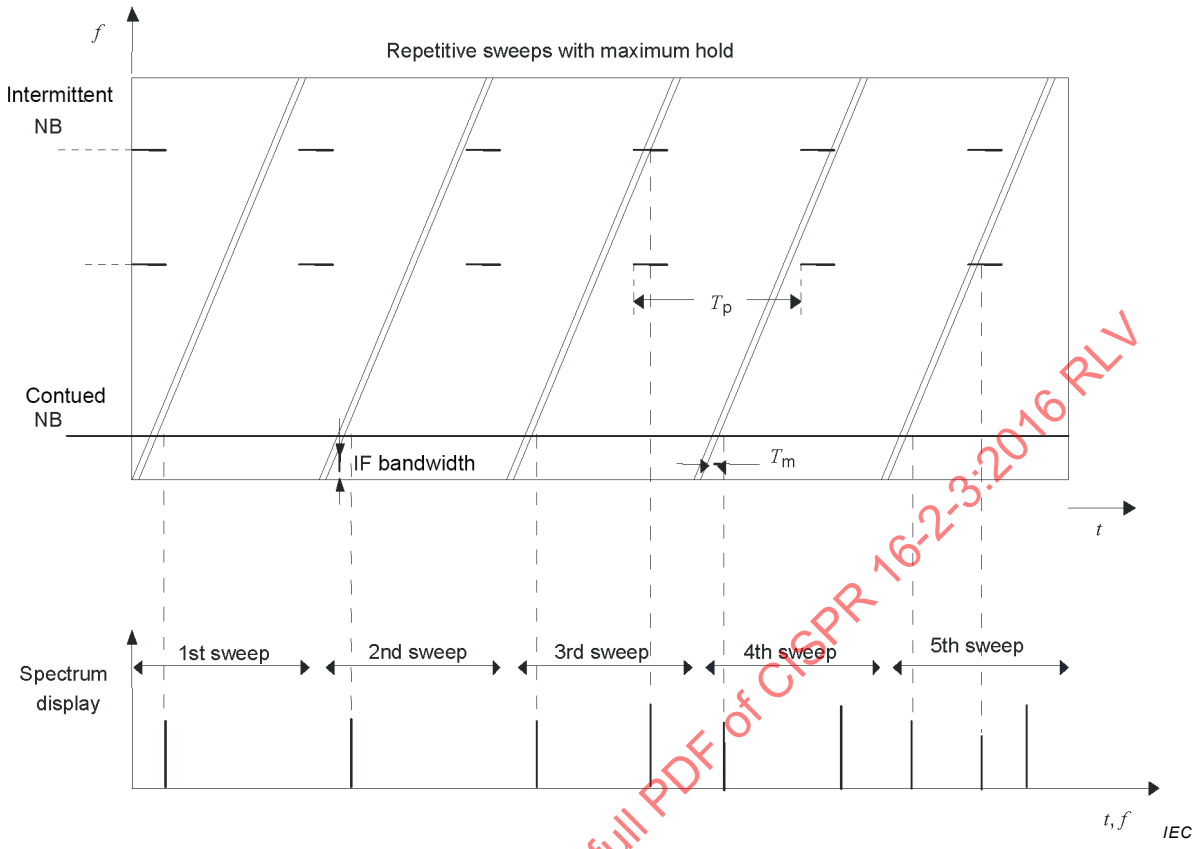
IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



~~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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



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, $f_{step\ final}$.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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].

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

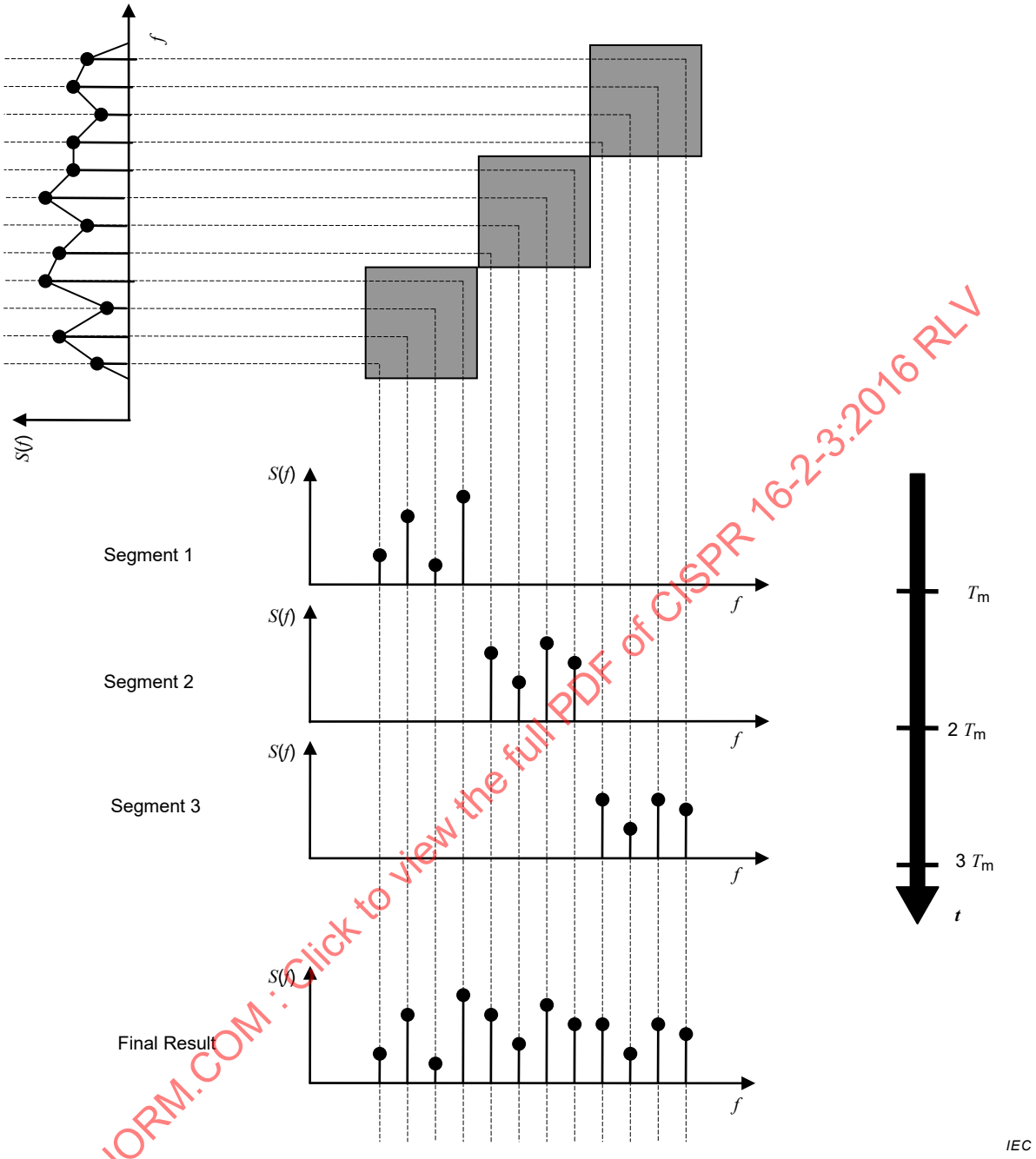
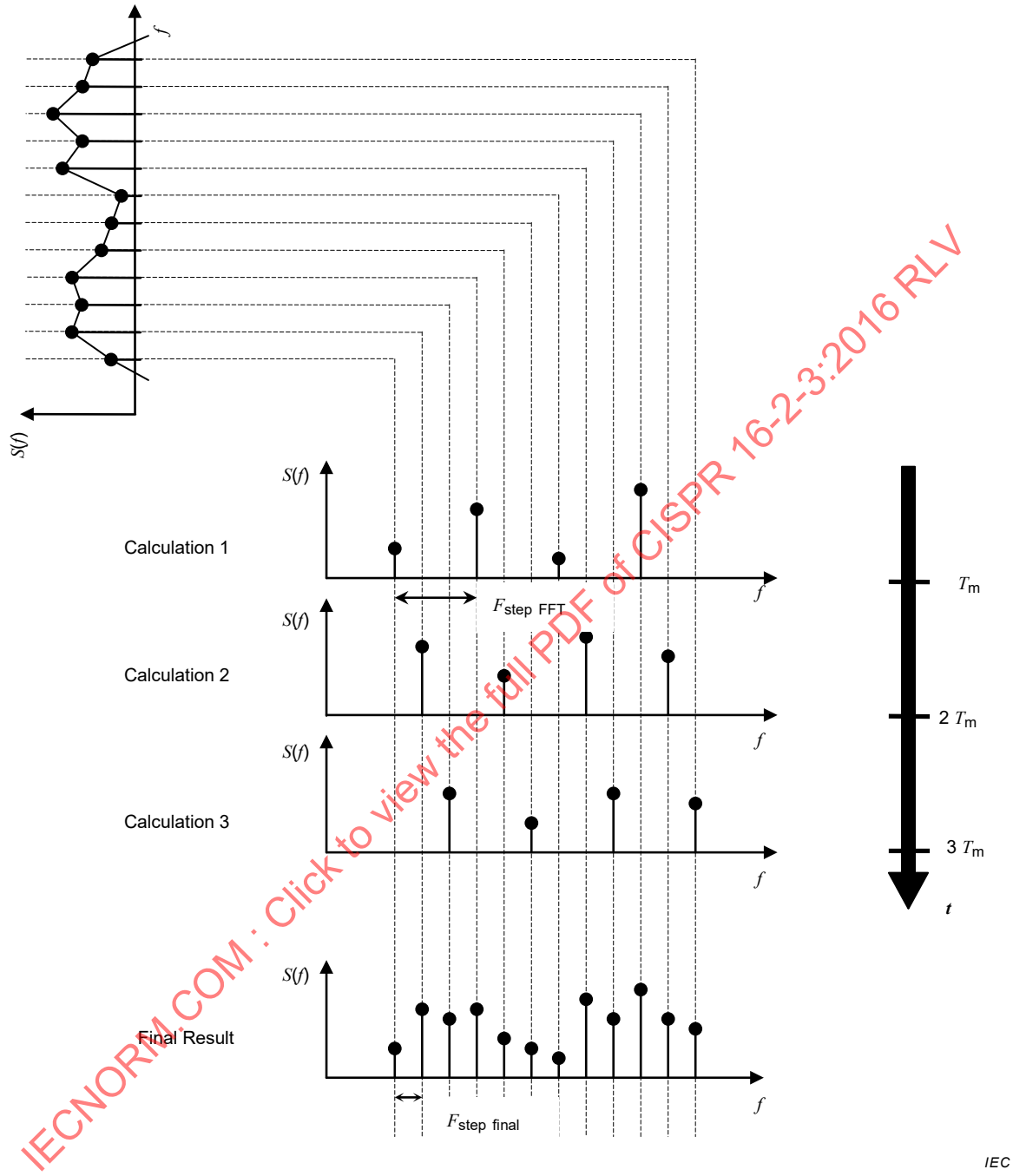


Figure 5 – FFT scan in segments

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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

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			

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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

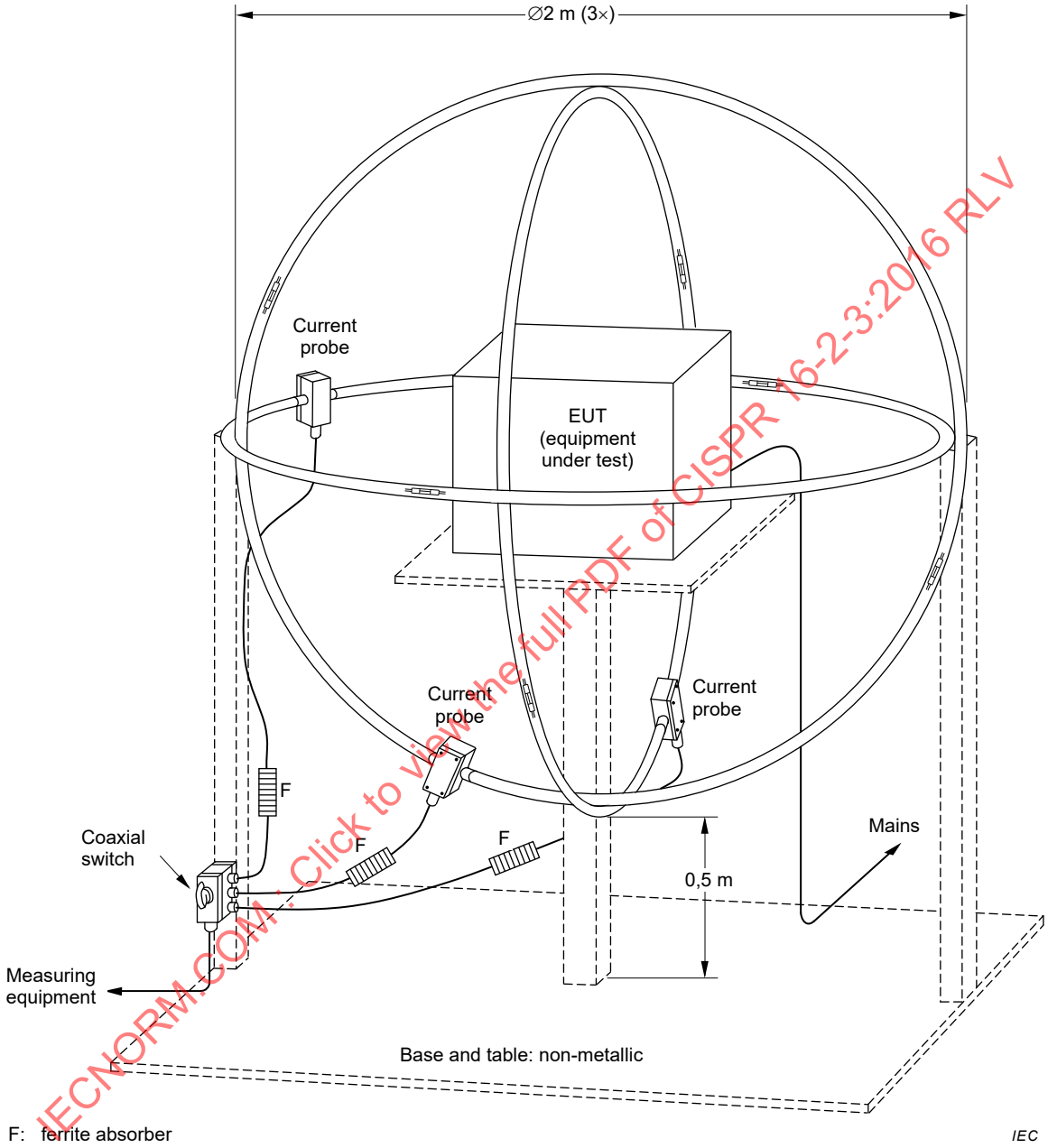
7.2.1 General

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.

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.



IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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.

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:

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

$$E = V_r + A_c + F_a \quad (7)$$

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.

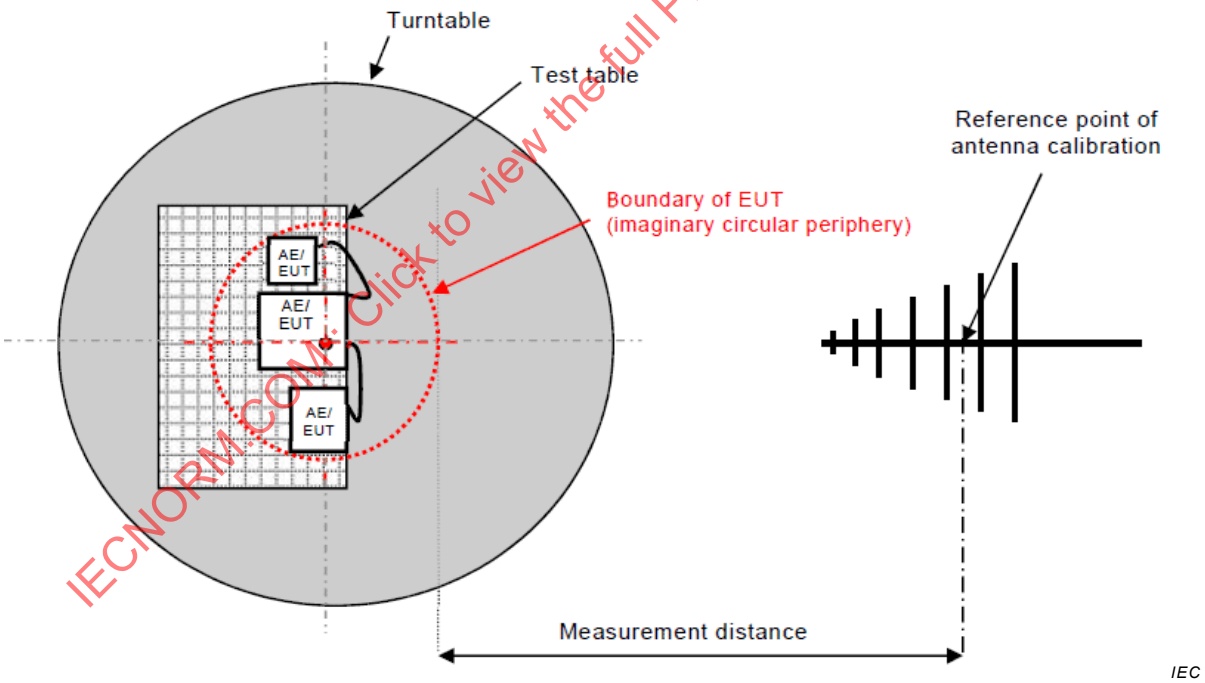


Figure 8 – Measurement distance

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.

IECNORM.COM: Click to view the full PDF of CISPR 16-2-3:2016 RLV

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 $0{,}9 \times 150/f$ 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.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

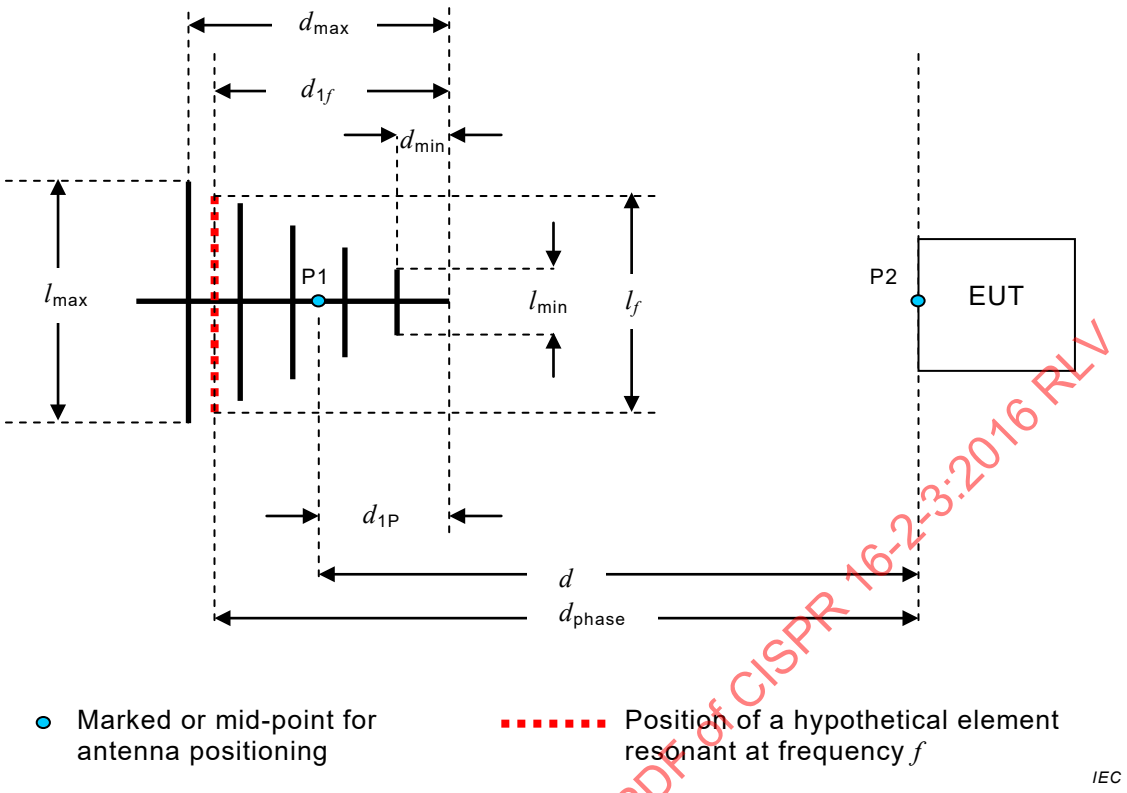


Figure 9 – Separation distance relative to the phase centre of an LPDA antenna

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.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

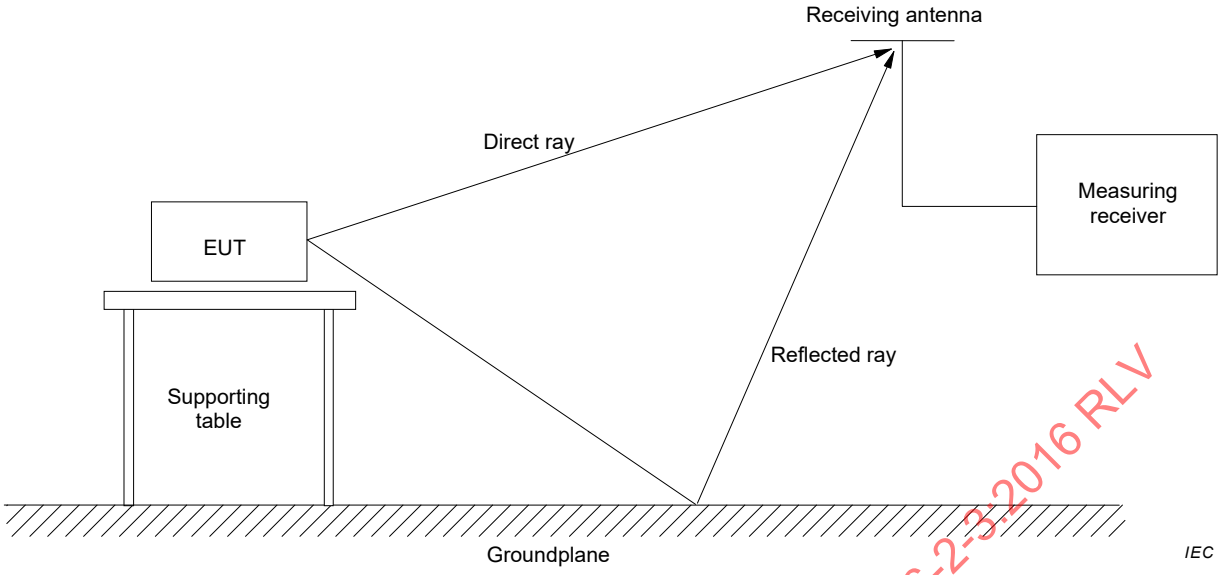


Figure 10 – Concept of electric field strength measurements made on an open-area test site (OATS) or semi-anechoic chamber (SAC) showing the direct and reflected rays arriving at the receiving antenna

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; $f_{centre} = 10^{\text{~~log~~ lg } (f\ centre)}$.

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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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.~~

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

~~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.

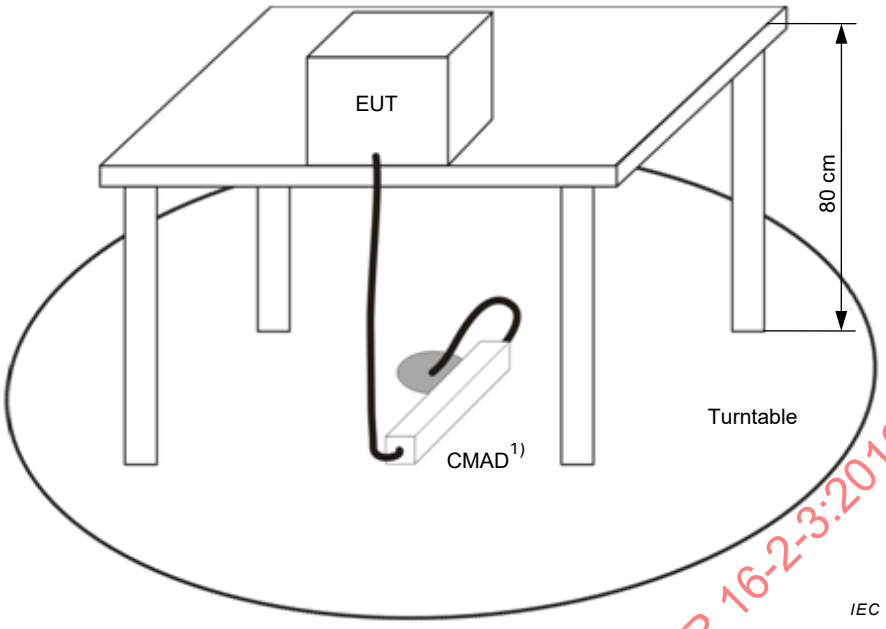
In order to avoid saturation, high common mode current power cables (e.g. the output port of inverters) should not be treated with CMADs unless the CMADs in use are specifically designed for high common mode currents.

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].

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



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)

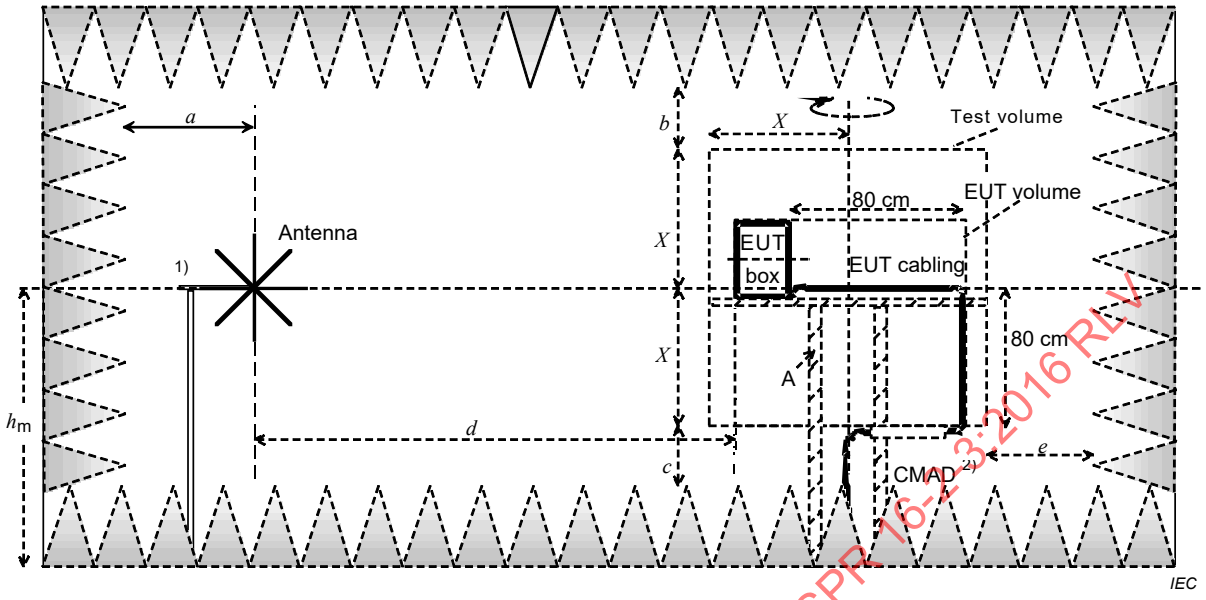
7.4.1 Test set-up and site geometry

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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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

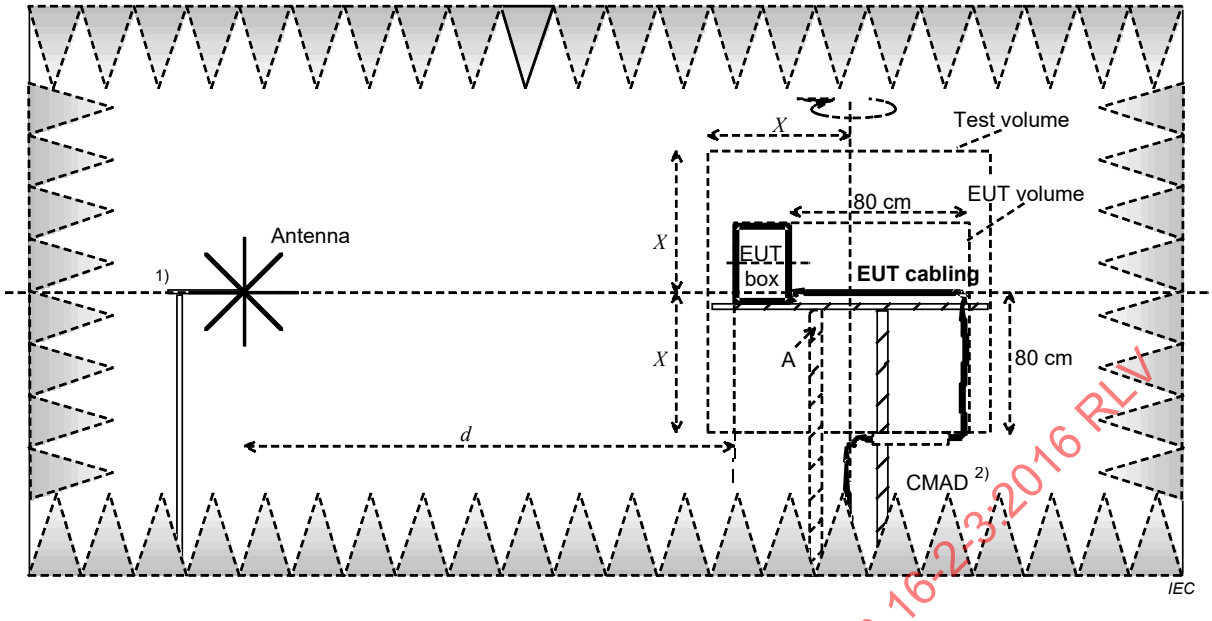
A	turntable and EUT support fixture
2X	1,5 m, 2,5 m, 5 m – corresponds to test distance used (3 m, 5 m, or 10 m respectively)
h_m	middle level of the test volume
a, b, c, e	≥0,5 m recommended (≥1 m is more convenient), the actual value is consistent with the FAR validation procedure of CISPR 16-1-4
d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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



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.

$$C_{dr} = 20 \log\left|\left(d + P_f - r\right)/d\right| \qquad (5)$$

~~The field strength is given by:~~

$$E_f = V_f + F_a + C_{dr} \qquad (6)$$

~~where~~

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

~~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);~~

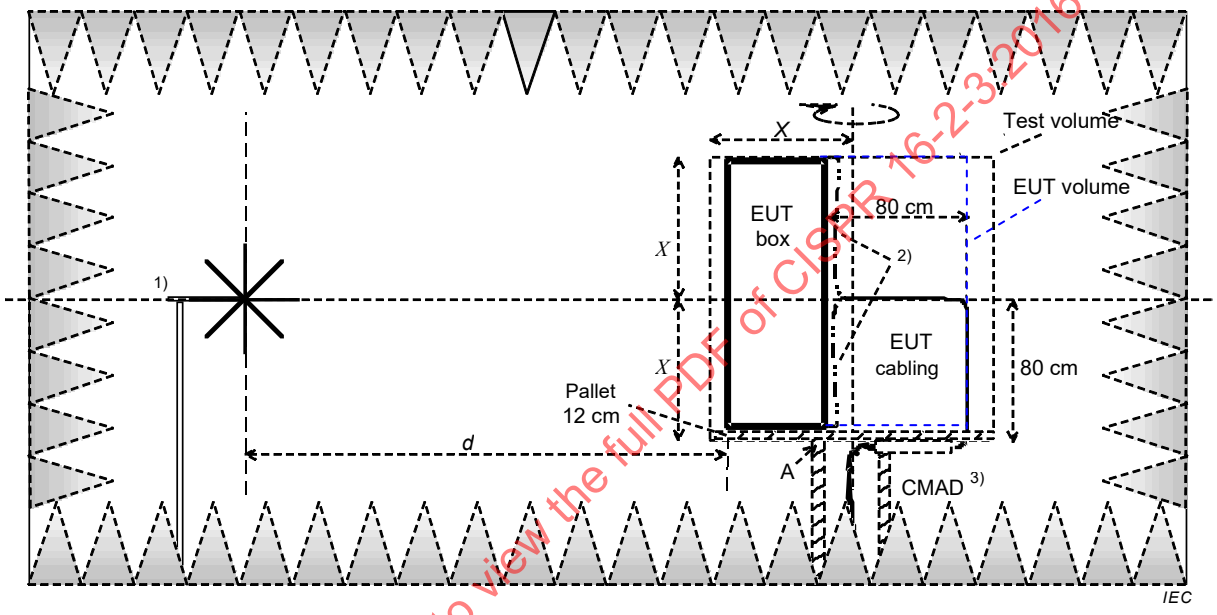
~~r is the distance of the reference point on the antenna from the antenna tip (m);~~

~~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 normal

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

determining its distance from the EUT is the identified reference point. However, if the reference point is not specified, the reference point is a point along the horizontal antenna boom midway between the dipole antenna elements that correspond to a half wavelength of the upper and lower frequency limits to be evaluated.

NOTE For a log-periodic antenna, the manufacturer may specify the reference point.

For a given frequency, the correction ΔE in dB in Equation (8) is 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. If a phase centre correction is not included, it shall be considered in the uncertainty budget. Refer to 7.3.1 for more details.

The EUT perimeter is defined by the smallest virtual (imaginary) rectangle encompassing the EUT. All intersystem cables shall be included within this perimeter (see Figure 15). Each edge of this perimeter shall lie in one of the four face planes of the EUT, co-planar with (and possibly residing within) the uniform field areas (UFAs) calibrated for immunity tests, depending upon the horizontal test distance.

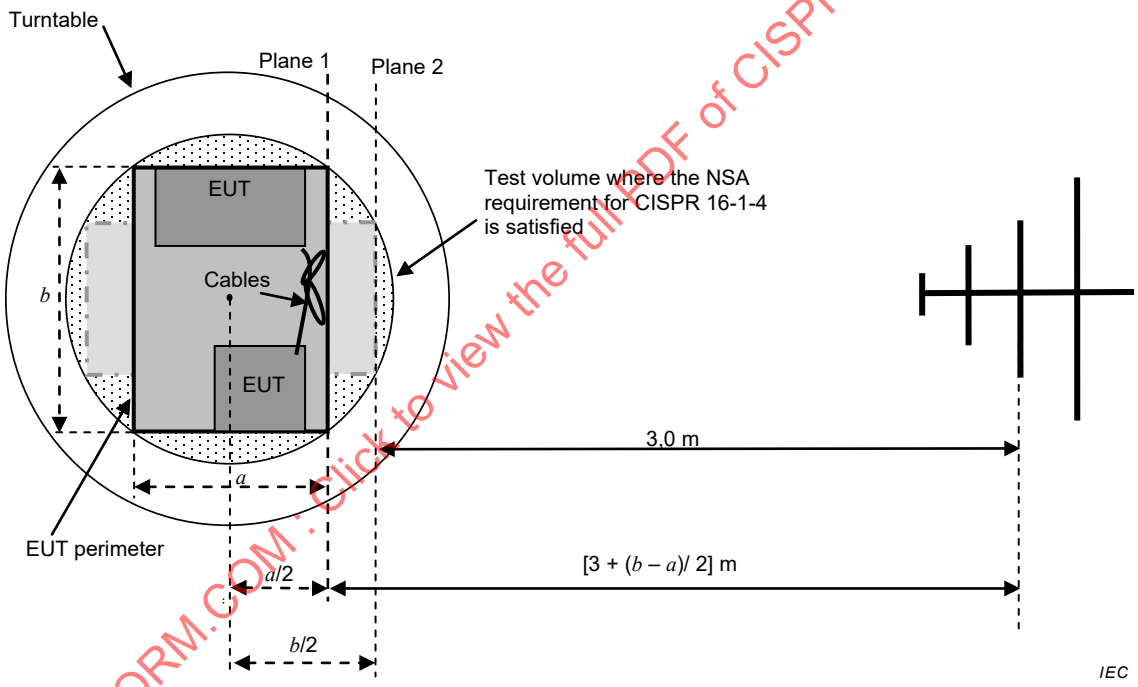


Figure 15 – Positions of reference planes for uniform field calibration (top-view)

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

7.5.3 Uniform test volume

The uniform test volume is defined by the following conditions.

- The EUT and its auxiliary equipment (AuxEq) (e.g. peripherals and cables) shall fit into a test volume where the site validation requirements of CISPR 16-1-4 are fulfilled. Refer to the site validation procedure for alternative test sites for use in emission measurements of CISPR 16-1-4;
- The EUT and its AuxEq shall fit into a test volume that allows each of the faces of the EUT and its AuxEq to be aligned with the uniform field area according to the requirements of IEC 61000-4-3 and as described in this subclause.

Evaluation of EUTs having unequal or non-symmetric boundaries at two antenna separation distances necessitate uniform field area calibrations according to the requirements of IEC 61000-4-3. In the example shown in Figure 15, this is at the plane with length b along the front face of the EUT (0° azimuth) and the plane with length a along the side face of the EUT (90° azimuth).

To accommodate EUTs with a maximum width of 1,5 m, the uniform field area may be calibrated for the two conditions:

- in a plane orthogonal to the axis of the antenna through the centre of the turntable;
- in a plane orthogonal to the axis of the antenna 0,75 m in front of the centre of the turntable, perpendicular to the measurement axis.

A linear interpolation can be performed to test any EUT whose exposed front is between the two calibrated UFAs. It is presumed that:

- the −0 dB to +6 dB criteria complies at the number of points defined by IEC 61000-4-3 for each of the two surfaces, and
- the average field strengths of the points satisfying the −0 dB to +6 dB criterion in the two UFAs are inversely proportional to the antenna-to-UFA distance when applying a constant forward power to the antenna.

Designate P_{c1} as the forward power (logarithmic scale) for the UFA at the centre of the turntable, evaluated by either the calibration with constant field strength or the calibration method with constant power, and P_{c2} as the corresponding forward power for the UFA at 0,75 m in front of the centre of the turntable. The required forward power to illuminate an EUT surface can be calculated by linear interpolation from P_{c1} and P_{c2} and the corresponding distances (also in logarithmic scale) to the antenna. For other measurement details and descriptions, refer to 6.2 of IEC 61000-4-3:2006 calibration of field.

For EUT perimeter dimensions that differ by 20 % or less of the 3 m separation distance (that is, 0,6 m or less), only a single uniform field area calibration is required at the separation distance corresponding to Plane 1 in Figure 15 (the widest face of the EUT).

NOTE When using the method described in the preceding paragraph, two faces of the EUT will be tested at a higher immunity field-strength level due to their closer distance to the transmitting antenna.

The EUT perimeter, including the connecting cables, shall fit within the test volume where the site validation requirement is satisfied. For the common emission/immunity set-up, the facility ~~must~~ shall be calibrated at two vertical planes corresponding to the minimum and maximum dimensions of the EUT perimeter at 0°, 90°, 180° and 270° to the EUT faces. The types of equipment to be tested in the facility may be considered for selection of the two plane locations.

If floor absorbers are used to achieve the field uniformity criterion, these absorbers shall be placed between the transmitting antenna and Plane 2. If only one plane is calibrated (that is, an EUT with a difference of the two boundary dimensions being less than 0,6 m), the floor absorbers, when used, shall be placed between the transmitting antenna and the calibrated plane.

7.5.4 Specifications for EUT set-up in common emissions/immunity test set-up

The tests shall be performed with the equipment configured as closely as possible to its typical, practical operation. Unless stated otherwise, cables and wiring shall be as specified by the manufacturer and the equipment shall be in its housing (or cabinet) with all covers and access panels in place. Any deviation from normal EUT operating conditions shall be included in the test report. The specifications of 7.3.6.3 apply. The EUT (on a non-conductive support structure, where applicable) shall be placed on a remotely operated turntable, as specified in 7.3.6.3, to allow the EUT to be rotated.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

The height of the EUT above the ground plane shall be in accordance with the following requirements.

- Tabletop equipment is placed on a non-conductive set-up table with height 0,8 m ± 0,01 m, see 7.3.6.3. CISPR 16-1-4 specifies the method to determine the impact of the non-conductive set-up table on test results.
- Floor-standing equipment is placed on a non-conductive support, as specified in the applicable product standard. If there are no EUT height placement requirements in the product standard, the EUT shall be placed on a non-conductive support at a height of 5 cm to 15 cm above the ground plane.

Equipment designed for wall-mounted operation shall be tested as table-top equipment. The orientation of the EUT shall be consistent with that of normal operation (that is, positioned as normally installed).

Interface cables, loads, and devices should be connected to at least one of each type of the interface ports of the EUT and, where practical, each cable shall be terminated in a device typical for its actual use. Where there are multiple interface ports of the same type, a typical number of these devices shall be connected to devices or loads. It is sufficient to connect only one of the loads, provided that it can be shown, for example by preliminary testing, that the connection of further ports would not significantly increase the level of disturbance (that is, more than 2 dB) or significantly degrade the immunity level. The rationale for the configuration and loading of ports shall be documented in the test report.

The number of additional cables should be limited to the condition where the addition of another cable does not decrease the margin by a significant amount (for example, 2 dB) with respect to the limit. In some cases the optimum arrangement of features, loads, interface types, and cables for emissions and immunity tests are different, which may result in the need for some reconfiguration of the EUT within the confines of the uniform EUT arrangement.

The cable layout and termination shall be according to the following requirements.

- The cables shall be oriented so that vertically- and horizontally-polarized radiation fields are not excluded. The cable layout rules and cable lengths defined in the applicable product emission and immunity standards shall be applied. However, in case of conflicting requirements, the layout and maximum cable lengths defined in the product emission standard ~~must take precedence~~ shall be used. Fulfilling the rules can be accomplished by applying the cable placement rules of the emissions standard and exposing a minimum length of 1 m of cable, with a mix of horizontal or vertical parts, to the electromagnetic field during immunity testing (unless the manufacturer's specifications require shorter cables). Excess cable lengths should be bundled in the approximate centre of the length of the cable to form a bundle 30 cm to 40 cm in length. If no information is provided about cable layout in the product emission standard, the following arrangement is applied.
  - For a table-top EUT (Figure 16 and Figure 17), the cables leaving the uniform test volume (that is, those that connect the EUT to the outside world) shall be exposed to the electromagnetic field according to Figure 16 and Figure 17 for a total length of 1 m (±0,1 m), and then extended vertically down towards the floor (with a minimum length of 0,8 m imposed by the EUT table height). Interconnecting cables that hang from the table shall be at a minimum distance of 0,4 m (±0,04 m) from the ground plane. If cables that hang closer than 40 cm to the ground plane cannot be shortened to the appropriate length, the excess cable shall be folded back and forth to form a bundle 30 cm to 40 cm long. If the maximum length declared by the manufacturer for certain cables does not allow a one meter horizontal cable layout, including a length to get to the ground plane for table-top products (placed on the 0,8 m height table), the horizontal layout shall depend on the length of cable in excess of 0,8 m. Bundling is not required.
  - For a floor-standing EUT (Figure 18 and Figure 19), cables leaving the uniform test volume shall be arranged with a length of at least 0,3 m run horizontally within the test volume and with a vertical run according to typical, normal use (depending on the

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

height above the floor of the I/O port). Horizontal cables shall be insulated from the ground planes by a minimum height of 10 cm for the entire length of the cable that is intended to be laid out along the floor.

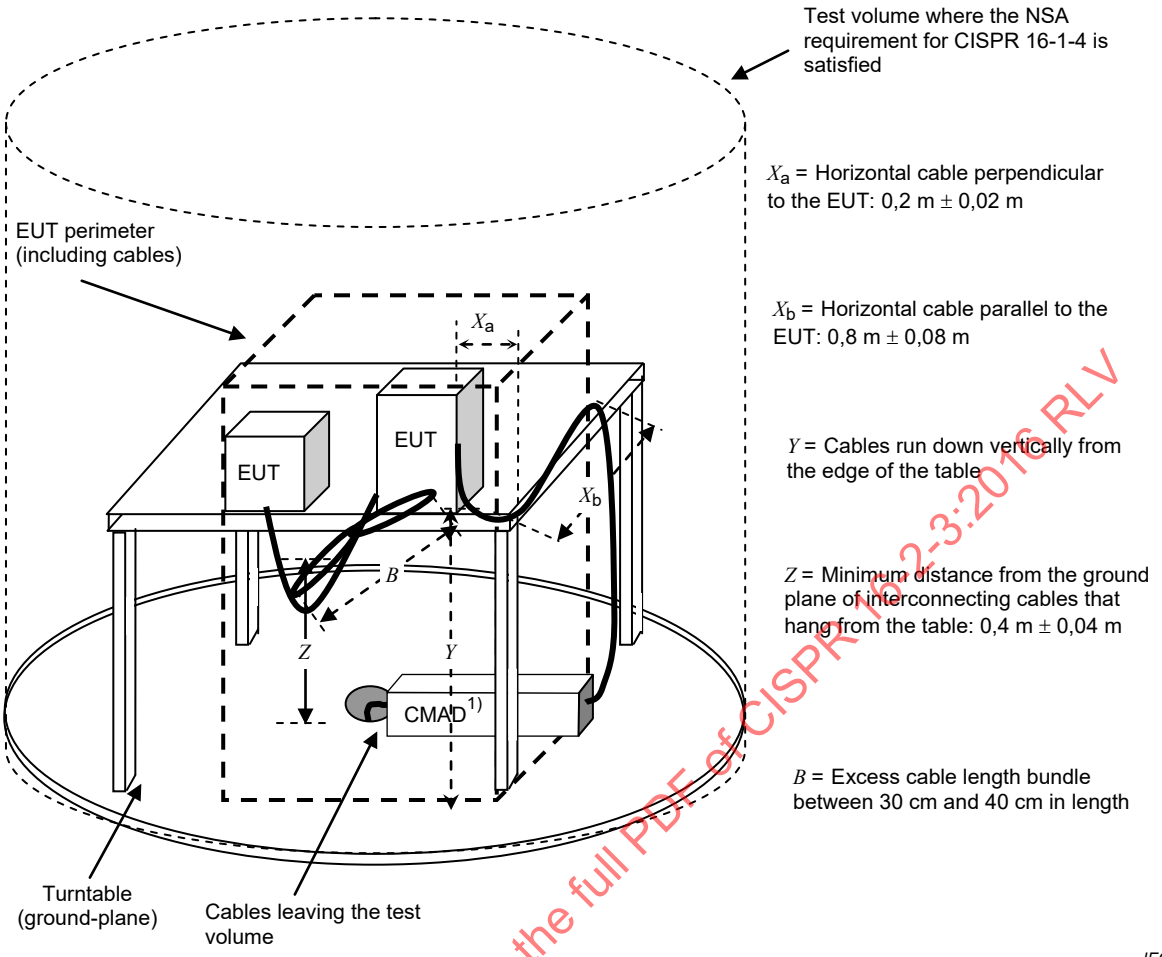
Cabling between enclosures of the EUT shall be treated as follows.

- The manufacturer's specified cabling types and connectors shall be used.
- If the manufacturer's specification requires a cable length of less than or equal to 3 m, then the specified length shall be used. The cables shall be exposed for a length of 1 m (±0,1 m) and the excess shall be folded back and forth, forming a bundle 30 cm to 40 cm long, for table-top equipment (see Figure 16 and Figure 17) and approximately 1 m for floor-standing equipment (see Figure 18 and Figure 19).
- If the specified length is greater than 3 m or is not specified, then the illuminated length shall be 1 m. The excess cables shall be extended outside the test volume.
- EUT combinations of table-top equipment and floor-standing equipment shall be arranged according to the set-up of each individual equipment configuration and the interconnecting cables between table-top equipment and floor-standing equipment shall be according to these rules.
- For the cables not terminated into auxiliary equipment, differential- and common-mode terminations should be simulated to represent the auxiliary equipment that would be connected to the cables and represent the required functional impedance.
- Cables not connected to another device may be terminated as follows (see also 7.3.6.3).
  - Coaxial shielded cables shall be terminated with a coaxial termination (usually 50 Ω or 75 Ω).
  - Shielded cables with more than one inner wire should have common- and differential-mode termination according to the EUT manufacturer's specifications. This common-mode termination is to be connected appropriately between the inner wires or their differential-mode termination and cable shield. If no information is available about the common-mode terminations, 150 Ω common-mode terminations should be used.
  - Unshielded cables ~~must~~ shall have differential-mode termination according to the manufacturer's specifications.
  - All cables that have been shortened in respect to their maximum lengths declared by the manufacturer and provided with artificial terminations for testing convenience, according to this paragraph, should also be provided with additional 150 Ω common-mode terminations to the test chamber wall or floor.

The following items should be considered with 7.3.6.3.

- If the EUT needs associated equipment (AE) to operate properly, special care ~~must~~ shall be taken to ensure that the AE does not affect the radiated emissions measurements or the radiated immunity tests. The AE may be located outside the anechoic chamber during testing if proper connecting interfaces are available on the chamber shielding. Measures to prevent RF-leakage into or out of the anechoic chamber through the interconnection cable may be necessary.
- Other methods or equipment used to suppress unwanted emissions from AE shall be located outside the test chamber or beneath the raised floor.
- The test set-up, including cable layout, specifications of attached cables and terminations, use of CMAD(s) on cables leaving the test volume, and other measures taken to suppress emissions from AE outside the test volume, shall be clearly described in the test report.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



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

Figure 16 – Test set-up for table-top equipment

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

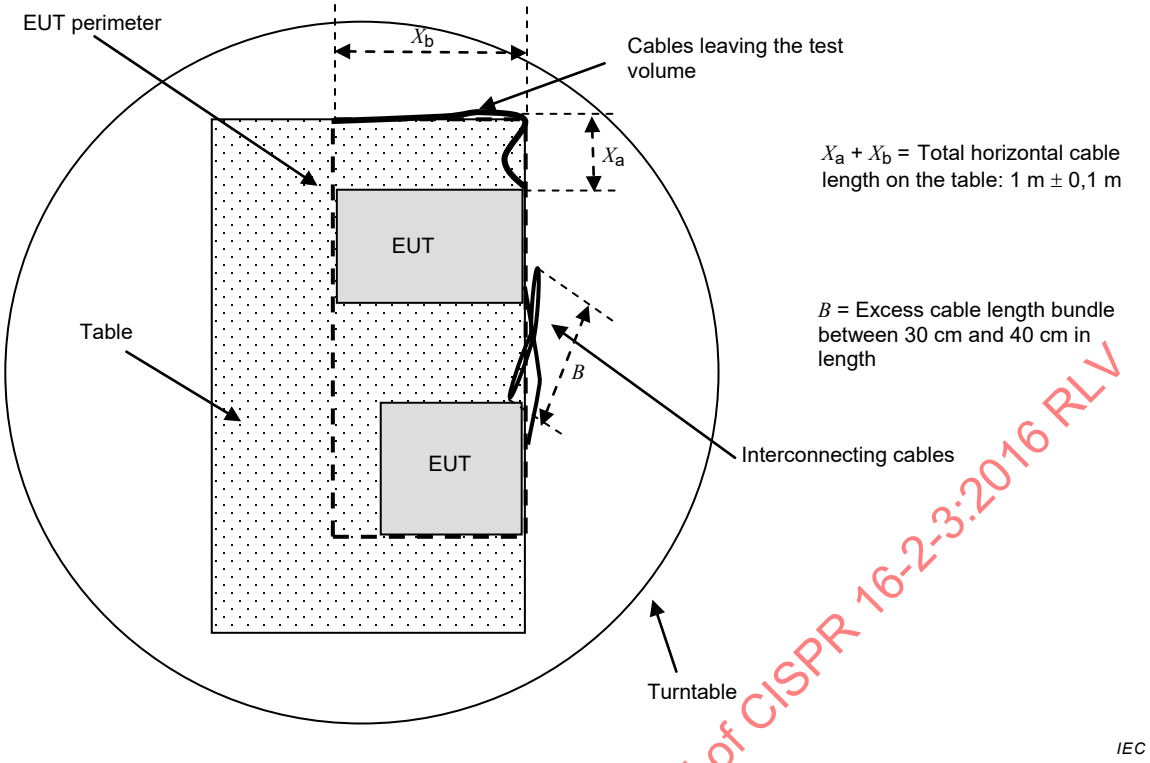
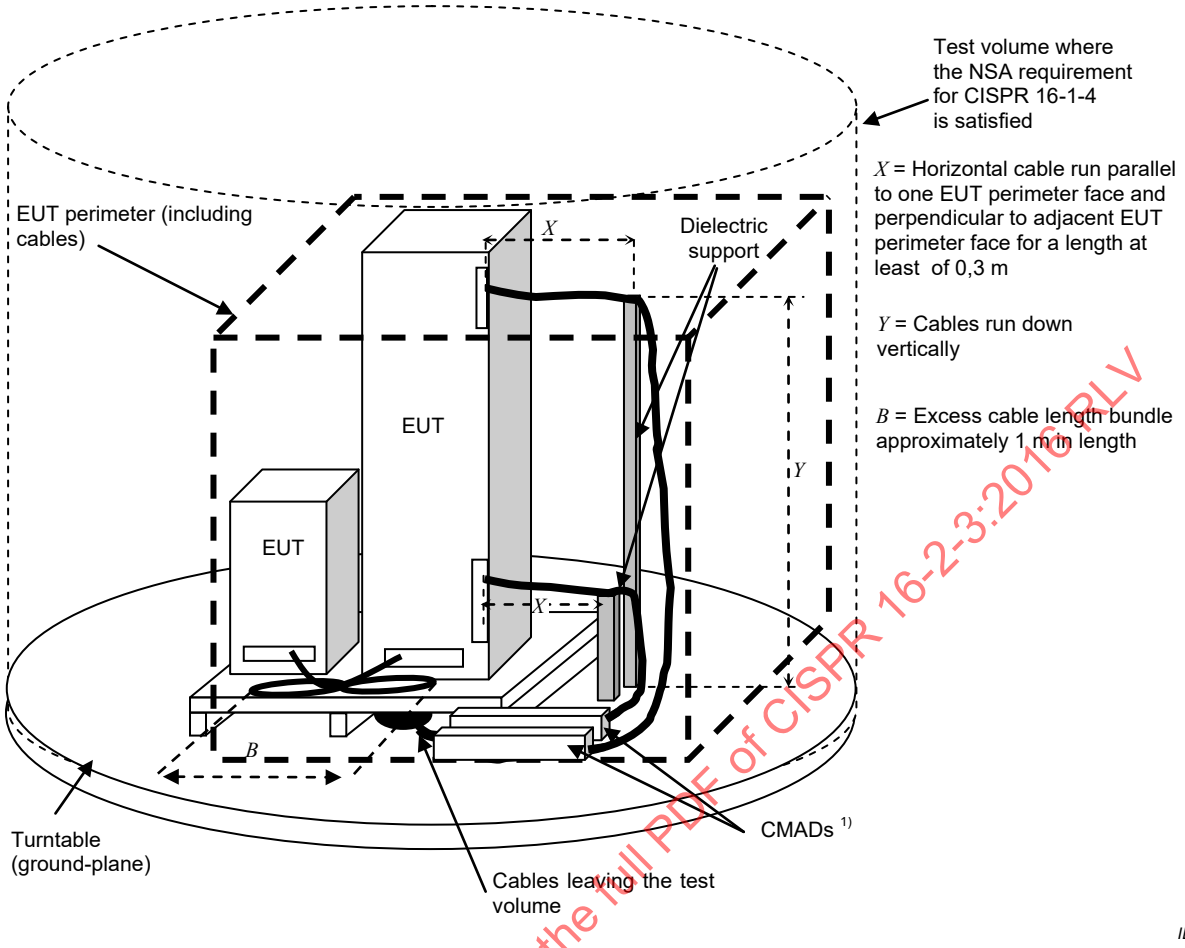


Figure 17 – Test set-up for table-top equipment – Top view

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

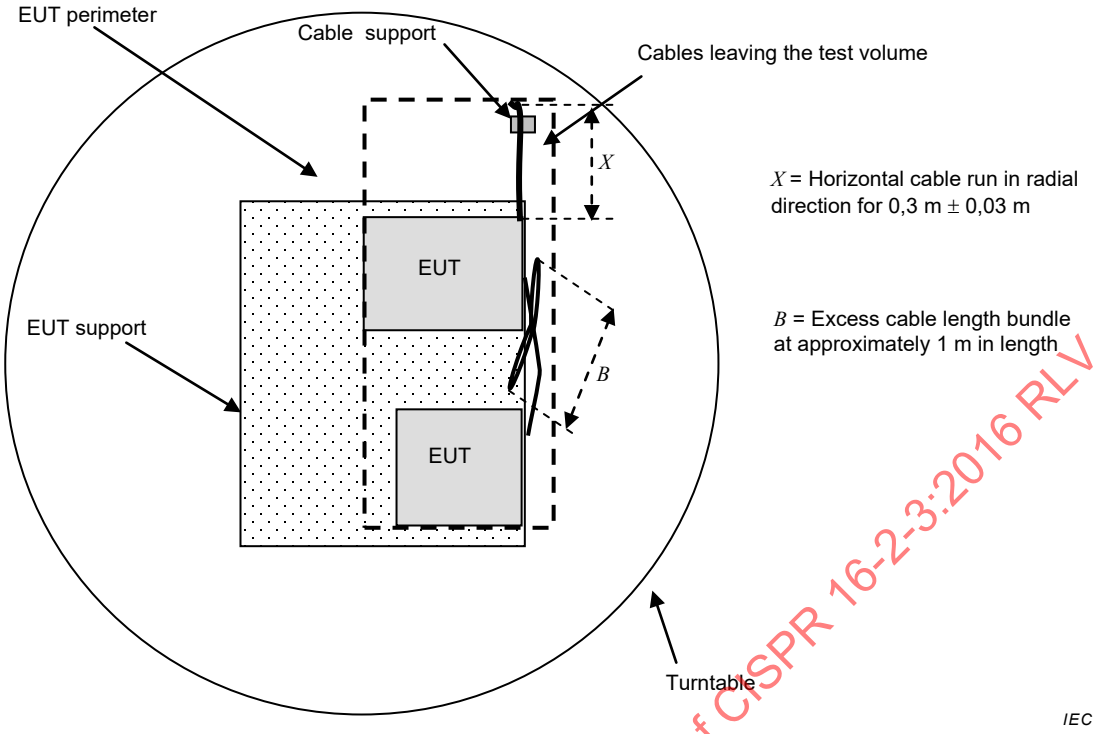


Note that the bend radius of cables shall not be exceeded to meet the bundled cable length.

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

Figure 18 – Test set-up for floor-standing equipment

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



Note that the bend radius of cables shall not be exceeded to meet the bundled cable length.

Figure 19 – Test set-up for floor-standing equipment – Top view

7.5.5 Measurement uncertainty for common emission/immunity set-up and method

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

7.6 Fully-anechoic room and absorber-lined OATS/SAC measurements (1 GHz to 18 GHz)

7.6.1 Quantity to measure

The electric field strength emitted by the EUT at the measuring distance is the quantity to be measured. The result shall be expressed in terms of field strength.

In some standards, emission limits above 1 GHz for equipment are expressed in terms of effective radiated power (P_{RE}) in dB(pW). Under free-space far-field conditions, the equation to convert P_{RE} into field strength, in dB(μV/m), at a 3 m distance is:

$$E_{3m} = P_{RE} + 7{,}4 \tag{11}$$

For distances d, in m, other than 3 m:

$$E_d = P_{RE} + 7{,}4 + 20\lg\left(\frac{3}{d}\right) \tag{12}$$

7.6.2 Measurement distance

The field strength emitted by the EUT is measured at a preferred distance of 3 m. The measurement distance, d, is the horizontal distance between the periphery of the EUT and the

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

receive antenna reference point (see Figure 20). The EUT encompasses all portions of the EUT, including cable racks and support equipment and a minimum cable length of 30 cm.

Other distances may be used in practical situations, i.e.:

– shorter distances in the case of high ambient noise, or to reduce the effect of unwanted reflections, but care should be taken to ensure the measurement distance is greater than or equal to D2/(2λ);
– greater distances for large EUTs to allow the antenna beam to encompass the EUT.

~~NOTE~~ Because dominant components of the EUT disturbance signals may be assumed to be incoherent and radiated from a point source, the minimum distance mentioned above, i.e. $D^2/(2\lambda)$, is to be established using the measuring antenna dimensions, and not the EUT dimensions.

If measurements are ~~made~~ carried out at a distance other than 3 m ~~(see note above)~~, the measurement distance shall be greater than or equal to 1 m and less than or equal to 10 m. In such a case, the measurement data is to be adjusted to a 3 m distance, assuming free-space propagation. Users are advised that comparison of measurements at different distances and extrapolation of results typically will not correlate as well as measurements made at the same distance. Standards or specifications that reference this test method should identify a preferred measurement distance.

7.6.3 Set-up and operating conditions of the equipment under test (EUT)

As a general guideline, test set-ups and operating conditions of the EUT shall be the same as those used below 1 GHz. Whenever possible, the test set-up should be representative of the most typical configuration of the EUT (table-top, floor-standing, rack-mounted, wall-mounted, etc.).

The test set-up should also consider that for measurements above 1 GHz absorbers are typically required on the floor between the antenna and EUT. Whenever practical, for emission measurements above 1 GHz the EUT should be raised above the height of the absorbers. If it is not possible to raise the entire EUT above the absorbers (i.e. for rack-mounted or floor-standing equipment), efforts should be made to configure the EUT (within a rack or chassis, for example) such that the radiating elements are located above the absorbers. The EUT shall be located in the test volume established during site validation, as described in CISPR 16-1-4. If it is not practical and safe to raise the EUT or its radiating elements above the absorber height, the maximum extent of the EUT that is permitted to be located below the highest point of the absorbers is 30 cm (see 7.6.6.1 and Figure 20).

The actual EUT configuration and set-up used shall be documented in the test report with photographs or diagrams clearly showing the location of the EUT with respect to the facility floor or turntable surface, absorber placement on the floor (height and location) and receive antenna location.

7.6.4 Measurement site

The measurement site shall comply with the requirements described in CISPR 16-1-4.

7.6.5 Measurement instrumentation

The measurement instrumentation shall comply with the requirements described in CISPR 16-1-1 and CISPR 16-1-4.

Measurements to verify compliance with a peak limit shall be conducted with the peak measuring spectrum analyzer or receiver using a measurement bandwidth of 1 MHz (impulse bandwidth) as defined CISPR 16-1-1.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Measurements to verify compliance with an average limit shall be conducted with a peak measuring spectrum analyzer using a measurement bandwidth of 1 MHz (impulse bandwidth) and a reduced video bandwidth, set as defined in CISPR 16-1-1. The value of video bandwidth required for an average measurement shall be less than the lowest spectral component of the input signals to be measured.

NOTE A spectrum analyzer can be used to perform average measurements by setting the display mode to linear and the video bandwidth to a value that is lower than the lowest spectrum component of the input signal to be measured. For example, if the input signal has a 1 kHz pulse repetition frequency (PRF), for a video bandwidth less than 1 kHz, only the d.c. component of the signal (i.e. the average value) will pass through the video filter.

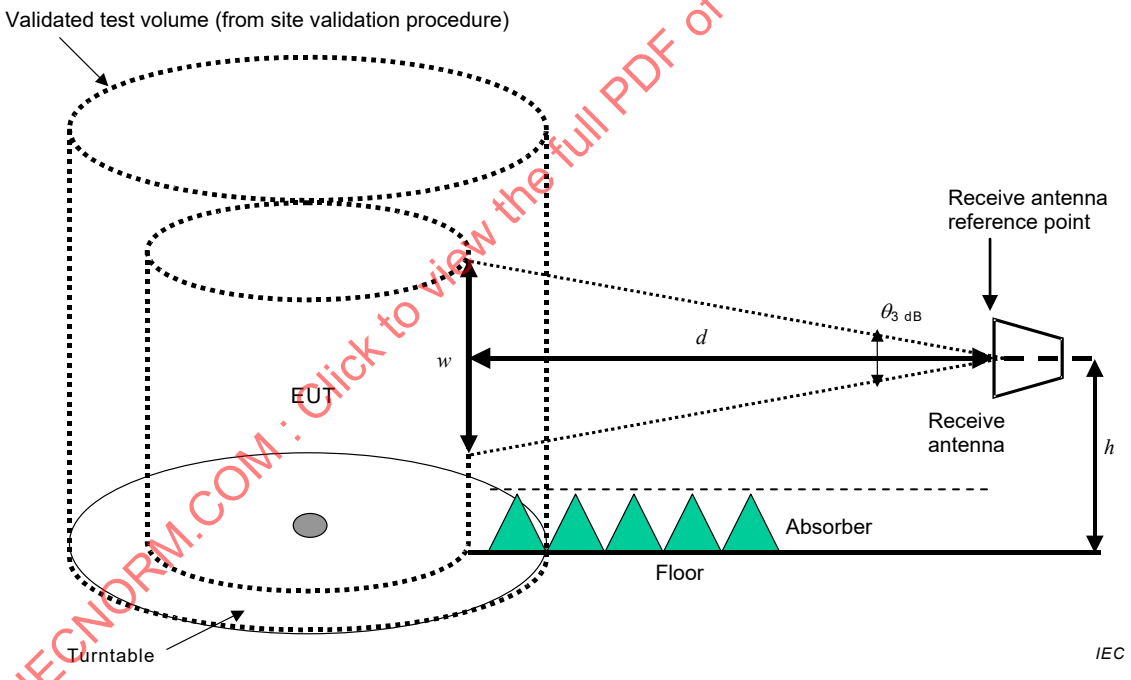
The use of other types of linear average detectors that comply with these requirements is allowed. In general, the spectrum analyzer shall be set to linear display mode when performing average measurements, not the logarithmic display mode. The sweep time of the spectrum analyzer shall be increased, due to the use of narrower video bandwidths, to ensure accurate measurement results. The logarithmic mode is permitted for average measurements when the specification limits assume a logarithmic detector will be used.

7.6.6 Measurement procedure

7.6.6.1 General description of the radiated field measurement method above 1 GHz

The radiated field measurement method above 1 GHz is based on measurement of the maximum electric field emitted from the EUT, with a set-up as shown in Figure 20.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



NOTE The anechoic material placed on the ground plane is for illustration purposes only. Consult CISPR 16-1-4 for more detailed guidance about placement of absorber to comply with the site validation requirements.

Figure 20 – Measurement method above 1 GHz, receive antenna in vertical polarization

The following descriptions apply to the parameters and terms given in Figure 20.

- Validated test volume: the volume evaluated during the site validation procedure (see CISPR 16-1-4). Typically, this determines the largest diameter EUT that can be tested in the facility.
- EUT (volume): the smallest diameter cylinder that will fully encompass all portions of the actual EUT, including cable racks and a minimum length of 30 cm of cables. The EUT that

is located within this cylinder ~~must~~ shall be capable of rotating about its centre (typically by a remotely controlled turntable). The EUT ~~must~~ shall be located within the validated test volume. A maximum of 30 cm of w (see definition of w below) may be below the height of absorbers on the floor only when the EUT is floor-standing and cannot be raised above the height of the absorbers (see 7.6.3).

- $\theta_{3\ \mathrm{dB}}$: Minimum 3 dB beamwidth of the receive antenna at each frequency of interest. $\theta_{3\ \mathrm{dB}}$ is the minimum of both the E-plane and H-plane values at each frequency. $\theta_{3\mathrm{dB}}$ may be obtained from manufacturer-provided data for the receive antenna.
- d: The measurement distance (in meters). This is measured as the horizontal distance between the periphery of the EUT and the reference point of the receive antenna.
- w: The dimension of the line tangent to the EUT formed by $\theta_{3\ \mathrm{dB}}$ at the measurement distance d. Equation (15) shall be used to calculate w for each actual antenna and measurement distance used. The values of w shall be included in the test report. This calculation may be based on the manufacturer-provided receive-antenna beamwidth specifications:

$$w = 2d \tan\left(0{,}5\,\theta_{3\,\mathrm{dB}}\right) \tag{13}$$

  w shall be of the minimum dimension as specified in Table 4.
- h: Height of the receive antenna, measured from its reference point to the floor.

Table 4 specifies the minimum acceptable dimension of w (w_{min}). The minimum requirements shown in Table 4 are calculated from Equation (13) based on testing at the minimum permitted measurement distance of 1 m specified in 7.6.2, and the values of $\theta_{3\ \mathrm{dB(min)}}$ shown. The selection of measurement distance d and antenna type shall be made such that w is equal to or greater than the values shown in Table 4 at any frequency where the field is measured. At frequencies not shown in Table 4, the limit of w_{min} shall be linearly interpolated between the nearest two frequencies listed. Table 5 gives example values of w calculated using Equation (13) for three antenna types at measurement distances of 1 m, 3 m, and 10 m.

The maximum emission is measured by moving the receive antenna in height along with rotation of the EUT in azimuth (0° to 360°). The required range of height investigation is specified below and illustrated in Figure 21 for two typical categories of EUTs.

Table 4 – Minimum dimension of w (w_{min})

Frequency GHz	$\theta_{3\ \mathrm{dB,\ min}}$	w_{min} m
1,00	60	1,15
2,00	35	0,63
4,00	35	0,63
6,00	27	0,48
8,00	25	0,44
10,00	25	0,44
12,00	25	0,44
14,00	25	0,44
16,00	5	0,09
18,00	5	0,09

~~NOTE 1~~ a) The dimension, w, is permitted to be larger than the minimum shown, and other antennas and distances may be used to satisfy the minimum required value of $w = w_{\mathrm{min}}$ shown, provided that Equation (13) is met.

~~NOTE 2~~ b) Because both polarizations are required to be measured for each height of the receive antenna, w forms a minimum square observation area equal to w^2 (m^2).

~~NOTE 3~~ c) In some cases, w may encompass multiple physical components of the EUT that are physically separated. For example, multiple separate cabinets of a multi-cabinet system that are tested simultaneously.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

~~NOTE 4~~ d) The height scan requirement depends on w such that it may be advantageous to maximize w by selection of a wider beamwidth antenna and a larger measurement distance than the minimum requirements shown.

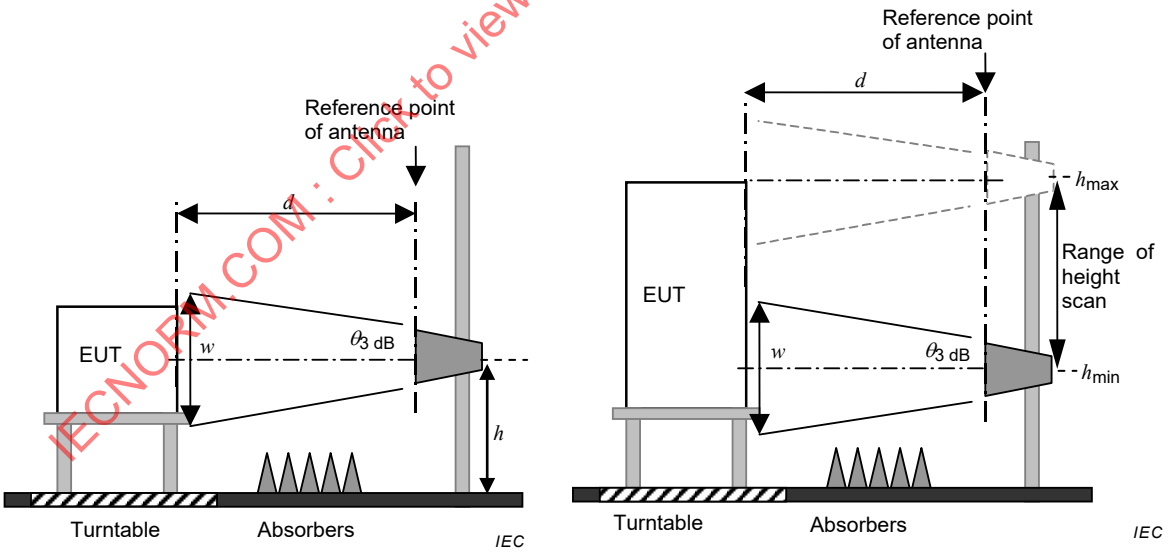
~~NOTE 5~~ e) The pattern and beamwidth of the antenna used can affect the measurement result. The antenna has at least two influence factors in addition to uncertainty in the antenna factor: 1) ripple or other anomalies in the antenna pattern, and 2) beamwidth differences between antennas, which may give different results depending on how many (constructive) emissions emanating from separate physical locations on the EUT fall within the antenna beamwidth.

Table 5 – Example values of w for three antenna types

Frequency	DRG horn				LPDA or LPDA-V [a]			
GHz	$\theta_{3\ dB}$ °	d = 1 m	d = 3 m	d = 10 m	$\theta_{3\ dB}$ °	d = 1 m	d = 3 m	d = 10 m
		w m	w m	w m		w m	w m	w m
1,00	60	1,15	3,46	11,55	60	1,15	3,46	11,55
2,00	35	0,63	1,89	6,31	55	1,04	3,12	10,41
4,00	35	0,63	1,89	6,31	55	1,04	3,12	10,41
6,00	27	0,48	1,44	4,80	55	1,04	3,12	10,41
8,00	25	0,44	1,33	4,43	50	0,93	2,80	9,33
10,00	25	0,44	1,33	4,43	50	0,93	2,80	9,33
12,00	25	0,44	1,33	4,43	50	0,93	2,80	9,33
14,00	25	0,44	1,33	4,43	45	0,83	2,49	8,28
16,00	5	0,09	0,26	0,87	40	0,73	2,18	7,28
18,00	5	0,09	0,26	0,87	40	0,73	2,18	7,28

[a] LPDA-V: V-type log periodic dipole array. The values shown for $\theta_{3\ dB}$ and w are typical of both the LPDA and LPDA-V. However, these antennas typically have different gains.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



a) w encompasses EUT height (fixed-height measurement)

b) w does not encompass EUT height (height scan required)

Figure 21 – Illustration of height scan requirements for two different categories of EUTs

For any EUT with maximum dimensions equal to or smaller than w, the centre of the receive antenna shall be fixed at the height of the centre of the EUT (Figure 21 a)). For any EUT with a maximum vertical dimension larger than w, the centre of the antenna shall be scanned vertically along the line parallel to w, as shown in Figure 21 b). The required scanning range

for h is 1 m to 4 m. If the EUT height is less than 4 m, scanning the centre of the receive antenna to heights above the top of the EUT is not required. In both cases the fixed height, h, or the range of heights investigated shall be recorded in the test report.

~~NOTE~~ When a height scan is required per the above paragraph, a continuous height scan within the required height range is recommended, to obtain the final, maximum emission. If stepped height increments are used, caution is advised to ensure that the height increments are sufficiently small in order to capture the maximum emission.

Regarding the horizontal extent of w, the EUT is not required to be fully within w. In cases where the EUT width is larger than w, the EUT shall be centred horizontally on the measurement axis, and rotation of the EUT provides the necessary horizontal scan for the determination of the maximum field strength. Horizontal-line (sideways, transverse) scanning by moving the receive antenna horizontally off the measurement axis is not required, but may be used if specified in a product standard.

7.6.6.2 Measurements using conventional (non-statistical) detectors

7.6.6.2.1 General measurement procedure

For any EUT, the frequencies of emission should first be detected by a preliminary emission maximization procedure (see 7.6.6.2.3). Then the final emission test is performed (see 7.6.6.2.4). Both of these measurements are to be made preferably at the specific limit distance. If, for any justified reason, the final measurement is performed at a distance ~~different from~~ other than the limit distance, a measurement at the limit distance should be made first, to help in interpreting the resulting data ~~in case of dispute~~.

In performing these measurements, the sensitivity of the measurement equipment relative to the limit shall be determined before the test. If the overall measurement sensitivity is inadequate, low-noise amplifiers, closer measurement distances or higher-gain antennas may be used. If closer measurement distances or higher gain antennas are used, the beam width versus size of the EUT shall be accounted for. Also, measurement system overload levels shall be determined to be adequate when preamplifiers are used.

Burn-out and saturation protection for the measuring instrumentation is required when low-level emissions are to be measured in the presence of a high level signal. A combination of band-pass, band-stop, low-pass and high-pass filters may be used. However, the insertion loss of these or any other devices at the frequencies of measurement shall be known and included in any calculations in the report of measurements.

NOTE A simple method of determining whether non-linear effects (overload, saturation, etc.) occur, consists of inserting a 10 dB attenuator at the input of the measurement instrument (ahead of any pre-amplifier if one is used) and verifying that the amplitude of all the harmonics of the high-amplitude signal (that may cause non-linear effects) is reduced by 10 dB.

7.6.6.2.2 Conditional testing procedure

If the highest internal frequency of the EUT (see 3.1.27) is less than 108 MHz, emissions shall be measured at least up to 1 GHz.

If the highest internal frequency of the EUT is between 108 MHz and 500 MHz, emissions shall be measured at least up to 2 GHz.

If the highest internal frequency of the EUT is between 500 MHz and 1 GHz, emissions shall be measured at least up to 5 GHz.

If the highest internal frequency of the EUT is above 1 GHz, emissions shall be measured up to the lower of 5 times the highest internal frequency or the highest frequency at which the limits are defined.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

7.6.6.2.3 Preliminary measurement procedure

The procedures of this subclause are for informative purposes – normative measurement requirements are listed in 7.6.6.2.4. The maximum radiated ~~emission~~ disturbance for a given mode of operation may be found during a preliminary test. To minimize measurement time, it is suggested to first perform measurements using peak detection, and then compare the test results to the average limit. Subsequent measurements with the average detector and comparison of results to the average limit will only be performed in those frequency ranges where the average limit was exceeded by data collected with peak detection.

Guidelines for a preliminary procedure to identify the radiated ~~emissions~~ disturbance are as follows.

a) Use scan or sweep mode over the complete frequency range of the antenna using peak detection and maximum-hold mode.

b) Determine the proper sweep or scan time ~~should be determined~~ to ensure adequate signal interception.

c) If necessary, during preliminary tests, reduce the resolution bandwidth ~~may be reduced~~ in sweep mode to reduce the displayed noise level of the ~~spectrum analyzer or~~ measuring receiver. Note that this may reduce the amplitude of broadband ~~emissions~~ disturbance, so additional investigations to determine whether the ~~emissions are~~ disturbance is broadband or narrowband may be necessary.

d) Rotate the EUT continuously or in increments of 15° or less, then repeat for the other polarization. The EUT should be rotated 360° in azimuth for both polarizations to determine the maximum ~~emissions~~ disturbance at each frequency of interest.

e) For continuous turntable rotation mode, ~~spectrum analyzer~~ set the measuring receiver sweep time ~~should be set~~ such that the selected frequency span can be swept within a time that is equal to or less than the time needed for the turntable to rotate 15°. If the rotational speed of the turntable is such that an angle larger than 15° is covered during a complete sweep or scan of the ~~spectrum analyzer~~ measuring receiver, a smaller frequency range should be used to reduce ~~spectrum analyzer~~ measuring receiver sweep time and to achieve the maximum 15° turntable rotation per sweep.

f) As needed to identify the frequencies ~~of~~ corresponding to the maximum ~~emissions~~ disturbance, apply the method described above ~~may be applied~~ for all the height levels required by 7.6.6.1 (and Figure 21), and for the various operating modes of the EUT.

g) To further evaluate the frequencies found in steps a) to d), use a small frequency span (typically 5 MHz or less) and investigate around frequencies near the limit using additional smaller turntable increments and height steps. Typically, all frequencies within approximately 10 dB of the specification limit warrant further investigation with a narrow frequency span and additional finer rotation/height increments.

7.6.6.2.4 Final measurement procedure

The field strength emitted by the EUT at the given measurement distance is measured using the configuration (antenna height, EUT azimuth, etc.) producing the maximum ~~emission~~ disturbance, as identified during the preliminary ~~emission~~ disturbance maximization ~~(the receiving antenna being aligned with this maximum emission)~~. Final measurements shall be done using the EUT operational mode identified by preliminary measurements to have the highest ~~emissions~~ disturbance.

This final measurement shall be the result of a maximum hold on the ~~spectrum analyzer~~ measuring receiver during a given time proportional to the frequency span used. This given time should be defined for each product or product family, taking into account the duration of the operating modes and the time constants associated with each specific product to be tested. Final measurements shall be performed using all required detectors. Alternatively, peak measurement results may be used to demonstrate compliance with all specified limits.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

If the configuration of the EUT (antenna height, EUT azimuth, operation mode, etc.) producing the maximum ~~emission~~ disturbance was not conclusively determined by a preliminary measurement the following additional measurements shall be done:

a) for any EUT with maximum dimension equal to or smaller than w, the centre of the receiving antenna shall be fixed at the height of the centre of the EUT (see Figure 21a));

b) for any EUT with maximum vertical dimension larger than w, height scanning shall be performed in accordance with the height scan requirements (upper and lower bounds) specified in 7.6.6.1;

c) in all cases, in order to find the maximum ~~emissions~~ disturbance, the EUT shall be rotated in azimuth through all angles in the range of 0° to 360°, and the measurements shall be performed for both horizontal and vertical polarizations.

In summary, the requirements for final measurements above 1 GHz are as follows.

The maximum ~~emissions~~ disturbance shall be recorded from the following required investigations, some of which may be performed during the preliminary measurement procedure:

1) the EUT shall be rotated in azimuth through all angles from 0° to 360° either by a turntable or movement of the receive antenna around the volume;

   If a preliminary measurement was performed with azimuth steps of $1° < a \leq 15°$, the final measurement shall include an azimuth search continuous through all angles of at least $\pm a$ around the azimuth angle found in the preliminary measurement, where a is the azimuth angle.

2) the receive antenna shall be height-scanned if the EUT height is larger than w in the vertical direction;

3) both horizontal and vertical polarizations shall be investigated.

7.6.6.3 Measurements using APD (statistical) function

7.6.6.3.1 General

The measurement of the amplitude probability distribution (APD) of a disturbance signal provides a statistical characterization of the disturbance signal in question. Background material on the application of the APD-measuring function is provided in 4.7 of CISPR TR 16-3:2014 [2]. A product committee may choose the APD measurement as the method to be used for final emission testing. The APD measurement shall be made at those frequencies where the EUT generates high disturbance field strengths. The number and selection method of frequencies shall be established by a product committee.

The APD measurement shall be made using one of the following two methods. The first method is for measurement of the disturbance level E_{meas} in dB(μV/m) related to the specified probability of time p_{limit}, designated as Method 1 (see 7.6.6.3.2). The second method is the measurement of the probability of time p_{meas} during which the disturbance envelope exceeds a specified level E_{limit} in dB(μV/m), designated as Method 2 (see 7.6.6.3.3). Additional information and figures are given in Annex D to show the specifics of the two APD measurement methods.

If a product committee decides to use the APD approach, either Method 1 or Method 2 shall be selected. If the APD measuring instrument does not include an A/D converter, only Method 2 shall be used. If the APD measuring instrument includes an A/D converter, either Method 1 or Method 2 may be used.

The number of pairs of limits (E_{limit}, p_{limit}) and their values shall be specified by the product committee. The product committee shall also decide whether to also use a peak limit together with the APD limits.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

7.6.6.3.2 Method 1 – Measurement of the level of disturbance

The measurement shall be performed using the following procedure.

1) Set the resolution bandwidth (RBW) and the video bandwidth (VBW) of the spectrum analyzer according to CISPR 16-1-1 (for measurements above 1 GHz).
2) Find the frequencies at which high disturbances are observed. This can be accomplished by using the maximum hold function in the frequency span of interest. Peak detection shall be used when applying this procedure.

   NOTE In cases where narrowband emissions are hidden by broadband emissions, the maximum hold mode in combination with the peak detector may overlook narrowband emissions. Therefore, an additional measurement may be needed to find the frequencies of the narrowband emissions to be measured. The product committee may require additional sweeps using the average detector or digital video averaging. Furthermore, the number of frequencies for the APD measurement may also be specified by the product committee.
3) Determine the frequencies for the APD measurement. The number of the frequencies shall be specified by the product committee.
4) Set the centre frequency of the spectrum analyzer to the frequency at which the highest level is observed during the application of step 2) of this procedure.
5) Set the reference level of the spectrum analyzer to minimum 5 dB above the maximum level of disturbance that is obtained in step 2).
6) Set the spectrum analyzer to the zero frequency span mode and measure the APD of disturbance during the measurement time that is specified by the product committee. The measurement time shall be longer than the period of the disturbance.

   In case of fluctuating disturbance frequencies, the product committee shall specify the frequency range XX (in MHz) in which the APDs of the disturbance shall be measured. APDs within the range XX MHz shall be measured with a 1 MHz frequency step size. However, for frequency ranges with APD measurement values that are greater than -6 dB from the APD limit, additional measurements may be needed with a smaller frequency step size (e.g. 0,5 MHz). The product committee shall define the smaller frequency step size.
7) Change the centre frequency of the spectrum analyzer to the next frequency determined in step 2), then repeat the procedures of steps 4) to 6) until the APD measurements for all frequencies are carried out.
8) Read the disturbance level E_{meas} in dB(μV/m) related to the specified probability p_{limit} from the results of step 6).
9) Compare E_{meas} dB(μV/m) against the limit E_{limit} dB(μV/m). The EUT complies if E_{meas} is less than or equal to E_{limit} at all frequencies.

7.6.6.3.3 Method 2 – Measurement of the probability of time

The measurement shall be performed using the following procedure.

Steps 1), 2), 3), 4), 5) and 7) of Method 2 are the same as the corresponding steps of Method 1 (7.6.6.3.2).

For Method 2, modify step 6), step 8), and step 9) of Method 1 as follows:

6) Set the spectrum analyzer to the zero frequency span mode and measure the APD (or measure the probability p_{meas} related to the specified levels directly) of the disturbance during the measurement time that is to be specified by the product committee.
8) Read the probabilities p_{meas} during which the disturbance envelope exceeds a specified level E_{limit} in dB(μV/m) from the results of step 6).
9) Compare p_{meas} against the limits p_{limit}. The EUT complies if p_{meas} is less than or equal to p_{limit} at all frequencies.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

7.6.7 Measurement uncertainty for FAR

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

7.7 *In situ* measurements (9 kHz to 18 GHz)

7.7.1 Applicability of and preparation for *in situ* measurements

In situ measurements may be necessary for the investigation of an interference problem at a particular location, i.e. where electrical equipment is suspected of causing interference to radio reception in its vicinity. Where allowed by the relevant product standard, *in situ* measurements may be made for the evaluation of compliance, if it is not possible for technical reasons to make radiated emission measurements on a standard test site. Technical reasons for *in situ* measurements are excessive size and/or weight of the EUT or situations where the interconnection to the infrastructure for the EUT is too expensive for the measurement on standard test sites. *In situ* measurement results of an EUT type will normally deviate from site-to-site or from results obtained on a standard test site and can therefore not be used for type testing.

NOTE ~~1~~ In general, however, due to imperfections such as mutual coupling between the conductive structures present in the *in situ* environment, which may also be more or less corrupted by ambient electromagnetic fields, and the measuring antenna/equipment under test, *in situ* measurements cannot fully replace measurements on a suitable test site (open-area test site or alternative test site, for example (semi-) anechoic chamber) as specified in CISPR 16-1-4.

The EUT usually consists of one or more devices and/or systems, is part of an installation, or is interconnected with an installation. A perimeter connecting the outer parts of the EUT is usually taken as the reference point to determine the measurement distance. In some product standards, the exterior walls or boundaries of business parks or industrial areas are taken as the reference points.

Preliminary measurements shall be made to identify the frequency and amplitude of the disturbance field strengths amongst the ambient signals taking into account the potential sources of interference (for example, oscillators) in the EUT. For these measurements the use of a spectrum analyzer is recommended in place of a receiver because a large frequency spectrum can be analysed. For the identification of the frequency and amplitude of the disturbance signals the use of a current probe on the connected cables, or near-field probes or the measurement antennas placed closer to the EUT, is recommended.

Measurements shall also be made on selected frequencies to determine, where possible, the modes of operation in which the EUT generates the highest disturbance field strengths. The subsequent measurements shall be made with the EUT in these modes of operation.

~~NOTE 2~~ Where the EUT is a piece of equipment for which the operating mode cannot be switched independently of the operation of other equipment, the selection of conditions producing the highest disturbances may be infeasible. For some equipment and operating modes, these conditions may be dependent on time, particularly if operations are cyclic. In such cases, the period of observation should be chosen to approach the conditions producing the highest disturbances.

Measurements shall be made around the EUT at approximately the same measurement distance on each of the selected frequencies to determine the direction of the highest disturbance field strength. The EUT should be tested in at least three different directions. The final disturbance field-strength measurements on each frequency shall be made in the directions of the highest disturbance field strengths, which may vary from frequency to frequency, taking into account the local (ambient) conditions. The highest disturbance field strengths shall be measured with the antenna in vertical and horizontal polarization. If the ratio of the measured disturbance field strength to any ambient emission is lower than 6 dB, the measurement methods described in Annex A can be used.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

7.7.2 Field-strength measurements *in situ* in the frequency range 9 kHz to 30 MHz

7.7.2.1 Measurement method

The magnetic disturbance field strength shall be measured in the direction of maximum radiation with the EUT in the mode of operation generating the highest disturbance field strength.

The horizontally-polarized disturbance field strength shall be measured at the standard measurement distance d_{limit} using a loop antenna as described in 4.3.2 of CISPR 16-1-4:2010 at a height of 1 m (between the ground and lowest part of the antenna). The maximum disturbance field strength shall be determined by rotating the antenna.

~~NOTE~~ For the measurement of the maximum disturbance field strength along radial lines arranged in any direction, the antenna should be oriented in three orthogonal directions, and the measured field strength is calculated by

$$E_{\text{sum}} = \sqrt{E_x^2 + E_y^2 + E_z^2}$$

In cases where limits are given for the E-field equivalent but the measured field strengths are the magnetic components, the H field strength can be converted to the corresponding E field strength using the free space impedance of 377 Ω by multiplying the H field reading by 377. The H field in this case is given by

$$H_{\text{sum}} = \sqrt{H_x^2 + H_y^2 + H_z^2}$$

This H field value can be used directly in cases where limits are directly given for the magnetic field strength.

If the antenna cannot be oriented in three orthogonal directions, it can be turned by hand in the direction of maximum reading for the measurement of the maximum disturbance field strength.

7.7.2.2 Measurement distances other than the standard distance

If it is not possible to adhere to the standard distance d_{limit}, as specified in the product or generic standard, the measurements should be made at distances either less or greater than the standard measuring distance in the direction of the maximum radiation. At least three measurements at different measuring distances less or greater than the standard measuring distance shall be used, if it is not possible to use the standard distance.

The measurement results (in decibels) shall be plotted as a function of the measurement distance on a logarithmic scale. One line shall be drawn to join up the measurement results. This line represents the decrease in the field strength and can be used to determine the disturbance field strength at distances other than the measurement distance, for example, at the standard distance.

7.7.3 Field-strength measurements *in situ* in the frequency range above 30 MHz

7.7.3.1 Measurement method

The disturbance electric field strength shall be measured in the direction of maximum radiation at the standard distance with the EUT in the mode of operation generating the highest disturbance field strength. The maximum horizontally- and vertically-polarized disturbance field strengths shall be measured using broadband antennas with, as far as

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

practicable, a variable height of 1 m to 4 m. The highest value shall be taken as the measured value.

It is recommended that biconical antennas be used for measurements in the frequency range up to 200 MHz, and log-periodic antennas for measurements in the frequency range above 200 MHz. The distance between the measuring antenna and any nearby metallic elements (including cables) should be greater than 2 m.

7.7.3.2 Measurement distances other than the standard distance

The standard measurement distance d_{std} is specified in the product or generic standard. If it is not possible to adhere to the standard measurement distance, the disturbance field strength shall be measured in different measuring distances as described in 7.7.2.2. A height scan of the antenna shall be used for each measurement The disturbance field strength at the standard distance d_{std} shall be determined according to 7.7.2.2 by plotting the measured field strength as a function of the measurement distance on a logarithmic scale.

If it is not possible to measure at varying distances, and the measurement distance refers to the outer wall of a building or the border of the premises, the measurement results shall be converted to the standard distance using Equation (14).

$$E_{std} = E_{meas} + 20\, n \lg \frac{d_{meas}}{d_{std}} \quad (14)$$

where

E_{std} is the field strength at the standard distance in dB(μV/m) for comparison with the emission limit;

E_{meas} is the field strength at the measurement distance in dB(μV/m);

d_{meas} is the measurement distance in metres;

d_{std} is the standard distance in metres.

The factor n depends on the distance d_{meas} as follows:

if $30\ m \leq d_{meas}$, $n = 1$;

if $10\ m \leq d_{meas} < 30\ m$, $n = 0{,}8$;

if $3\ m \leq d_{meas} < 10\ m$, $n = 0{,}6$.

NOTE $n < 1$ accommodates the difference between the measuring distance and the distance to the EUT.

Measurement distances closer than 3 m shall not be used.

If it is not possible to measure at varying distances, and Equation (14) is not used because the measurement distance does not refer to the outer wall of a building or boundary of premises, the field strength should be determined by measurement of the radiated disturbance power (see 7.7.4).

7.7.4 *In situ* measurement of the disturbance effective radiated power using the substitution method

7.7.4.1 General measurement condition

The substitution method can be used without additional conditions if, and only if, the EUT can be switched off and if the EUT can be removed for the substitution.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

If the EUT cannot be removed, and if its front face is a large plane surface, the effect of this face on the substitution shall be accounted for (see Equation (14)). If the front surface of the EUT does not fit into a two-dimensional plane in the measurement direction, the additional measurement uncertainty is not considered.

If the EUT cannot be switched off, it is still possible to use the substitution method to measure the radiated power of a disturbance from the EUT at a particular frequency, by using a nearby frequency at which the field strength of the disturbance from the EUT is at least 20 dB below that of the frequency of interest ("nearby" means within one or two receiver IF-bandwidths). The frequency selected should, where possible, be chosen with regard to possible interference to radio services.

7.7.4.2 Frequency range of 30 MHz to 1 000 MHz

7.7.4.2.1 Measurement distance

The measurement distance chosen shall be such that the measurement is made in the far field. This requirement is generally met, if:

- d is greater than $\lambda/(2\pi)$ and
- $d \geq 2D^2/\lambda$ (15)

where

d is the measurement distance in m;
D is the maximum dimension of the EUT with cabling in m;
λ is the wavelength in m;

or if measurement distance d is equal to or greater than 30 m. In the far field, the exponent n in Equation (14) may be assumed to be one (1). If a shorter measurement distance is chosen, this assumption can be validated by using the procedure of 7.7.3.2 to verify that the field strength falls off inversely with distance. If the local conditions require that a shorter measurement distance be chosen, this shall be indicated.

7.7.4.2.2 Measurement method

The effective radiated disturbance power shall be measured in the direction of maximum radiation with the EUT in the mode of operation generating the highest disturbance field strength. The measurement distance shall be chosen according to 7.7.4.2.1 and the highest disturbance field strength on the selected frequency determined by varying the antenna height at least in the range of 1 m to 4 m as far as practicable.

For measurement of the effective radiated disturbance power, the following steps a) to g) shall be used.

a) The EUT shall be disconnected and removed. A half-wave dipole or antenna with similar radiation characteristics and known gain G, relative to a half-wave dipole is substituted in its place. If it is impractical to remove the EUT, a half-wave or broadband dipole (in the frequency range lower than about 150 MHz to minimize mutual coupling to the EUT) is positioned in the vicinity of the EUT. The vicinity is a range up to 3 m.

b) The half-wave (or broadband) dipole shall then be fed by a signal generator operating on the same frequency.

c) The position and polarization of the half-wave dipole (or broadband antenna) shall be such that the measuring receiver receives the highest field strength. If the EUT is not removed, then, if possible, it shall be switched off and the dipole is moved in a range up to 3 m around the EUT.

d) The power of the signal generated shall be varied until the measuring receiver shows the same reading as when the highest disturbance field strength from the EUT was measured.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

e) If the EUT constitutes the front of a large plane surface (e.g. a building with a cable-TV network), the substitution antenna (half-wave dipole) is positioned about 1 m in front of the large plane surface (e.g. the front wall of a building). The location of the substitution measurement shall be selected such that an imaginary line between the substitution antenna and the measuring antenna is perpendicular to the direction of the face of the building.

f) The height, polarization and distance between the half-wave dipole (or broadband antenna) and the plane surface shall be varied such that the receiver displays the highest field-strength reading.

g) The power of the signal generator shall be varied as in d).

For removed EUTs, and EUTs that cannot be removed (see steps a) and c), respectively), the power at the signal generator, P_g, plus the gain of the transmit antenna relative to a half-wave dipole, G, yields the effective radiated disturbance power, P_r, to be measured:

$$P_r = P_g + G \tag{16}$$

For EUTs having a large plane surface (e.g. buildings with telecommunication networks), the increase in gain of the dipole positioned in front of this surface is given by:

$$P_r = P_g + G + 4 \text{ dB} \tag{17}$$

where

P_r is in dB(pW);
P_g is in dB(pW); and
G is in dB.

The effective radiated disturbance power can be used to calculate the disturbance field strength at the standard measurement distance d_{std}. The free-space field strength E_{free} shall be calculated using the following equation:

$$E_{free} = \frac{7\sqrt{P_r}}{d_{std}} \tag{18}$$

where

E_{free} is in μV/m;
P_r is in pW and
d_{std} is in m.

If the calculated free-space field strength of Equation (21) is compared with limits of disturbance field strength measured at a standard test site, it ~~must~~ shall be considered that the amplitude field strength measured at a standard test site is approximately 6 dB higher than the free-space field strength of Equation (21), due to the reflections from the ground plane. Equation (21) can be modified to take into account this difference. The disturbance field strength at the standard distance E_{std} can therefore be calculated, for the vertical polarization case, using the following equation:

$$E_{std} = P_r - 20 \lg d_{std} + 22{,}9 \tag{19}$$

For horizontal polarization below 160 MHz the maximum field strength is not measured at standard test sites. Therefore the 6 dB factor ~~must~~ shall be corrected using the following equation, for which Table 6 shows several calculated values:

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

$$E_{std} = P_r - 20 \lg d_{std} + 16{,}9 + (6 - c_c) \quad (20)$$

where

E_{std} is in dB(μV/m);

f is the measuring frequency;

d_{std} is in m; and

c_c is the correction factor for horizontal polarization. This was determined assuming a radiation source at 1 m in height.

This method for determining the disturbance field strength can be used mainly when there are obstacles between the measuring antenna and the EUT.

Table 6 – Horizontal polarization correction factors as a function of frequency

f MHz	30	40	50	60	70	90	100	120	140	160	180	200	750	1 000
c_c dB	11	10,2	9,3	8,5	7,6	5,9	5,1	3,4	1,7	0	0	0	0	0

7.7.4.3 Frequency range of 1 GHz to 18 GHz

7.7.4.3.1 Measurement distance

The measurement distance chosen shall be such that the measurement is made in the far field. The far-field condition shall be verified by measuring the radiated disturbance power with a double-ridged waveguide horn or log-periodic antenna as a function of distance. The requirement is met if the measurement distance is equal to, or greater than, the transition distance. The transition distance is marked by the transition point that shall be determined as shown in Figure 22. The measurement results shall be plotted and two parallel lines separated by 5 dB drawn to enclose as many of the measurement results; the transition point is the point where the lines intersect and after which the radiated power decreases by 20 dB/decade.

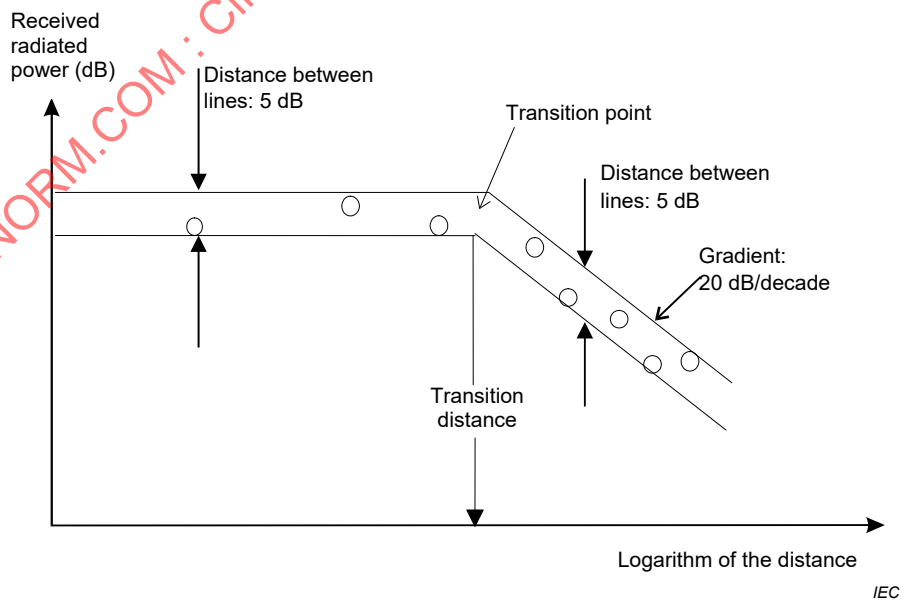


Figure 22 – Determination of the transition distance

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

7.7.4.3.2 Measurement method

The radiated disturbance power shall be measured in the direction of maximum radiation with the EUT in the mode of operation generating the highest disturbance field strength. A double-ridged waveguide horn or log-periodic antenna shall be used to determine the direction of maximum radiation. The measurement distance shall then be chosen according to 7.7.4.2.1 and the disturbance field strength on the selected frequency is measured. The antenna position shall be varied slightly to ensure that the measured field strength is not at a local minimum (for example, due to reflections).

For measurement of the radiated disturbance power, the EUT shall be disconnected and a double-ridged horn or log-periodic antenna positioned either in the immediate vicinity of the EUT or in its place. The antenna shall then be fed by a signal generator operating at the same frequency. The orientation of the antenna shall be such that the test receiver receives the highest field strength. This antenna position shall be fixed. The power of the signal generated shall be varied until the test receiver receives the same power as that generated by the EUT. The power at the signal generator P_g plus the gain G of the transmitting antenna relative to a half-wave dipole yields the required radiated disturbance power P_r:

$$P_r = P_g + G \tag{21}$$

where

P_r is in dB(pW);
P_g is in dB(pW) and
G is in dB.

7.7.5 Documentation of the measurement results

The particular circumstances and conditions of the *in situ* measurements should be documented to enable the operational conditions to be reproduced if the measurements are repeated. The documentation should include

– reasons for the *in situ* measurement instead of using a standard test site,
– description of the EUT,
– technical documentation,
– scale drawings of the measurement site, showing the points at which measurements were made,
– description of the measured installation,
– details of all connections between the measured installation and the EUT: technical data and details of their location/configuration,
– description of the operating conditions,
– details of the measuring equipment;
– measurement results:
  - antenna polarization;
  - measured values: frequency, measured level and disturbance level;

    NOTE The disturbance level is the level referred to the standard measuring distance.

  - assessment of the degree of interference (if applicable).

7.7.6 Measurement uncertainty for *in situ* method

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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

7.8 Substitution measurements (30 MHz to 18 GHz)

7.8.1 General

The substitution method is intended for measuring radio disturbance radiated from the cabinet, including wiring and circuitry inside the cabinet, of an equipment under test. The EUT may be either a self-contained unit with no port for any connection or have one or several ports for power and other external connections. For future product standards, product committees are invited to use the field-strength measurement method described in 7.6 for 1 GHz to 18 GHz.

7.8.2 Test site

The test site shall be a level area. Indoor sites may be used, but may need special arrangements, especially in the upper part of the frequency range, in order to meet the requirements of stable and non-critical reflections from the surroundings, for example, a corner reflector added to the measuring antenna and an absorbing wall behind the EUT. The suitability of the site shall be determined as follows.

Two horizontal half-wavelength dipoles, designated A and B (see also 7.8.3), shall be placed parallel to each other, at the same height h, with height not less than 1 m above the floor and spaced at the measurement distance d. Dipole B shall be connected to a signal generator and dipole A connected to the input of the measuring receiver. The signal generator shall be tuned to give maximum indication on the measuring receiver and its output adjusted to a convenient level. The site shall be considered suitable for the purpose of measurement at the test frequency if the indication on the measuring receiver does not vary more than ±1,5 dB when dipole B is moved 100 mm in any direction. The test shall be repeated throughout the frequency range at frequency intervals small enough to ensure that the site is satisfactory for all measurements intended. If an EUT requires that measurements also be made with vertical polarization (see 7.8.4), the suitability test of the site shall be repeated with the two dipoles positioned for vertical polarization.

7.8.3 Test antennas

The test antennas A and B of Figure 23 have been described above as half-wave dipoles. For the frequency range below 1 GHz, this requirement applies primarily to the transmitting antenna B for which the radiated power in the direction of maximum radiation ~~must~~ shall be relatable to the power at the terminals of antenna B. The measuring antenna A should also be a half-wave dipole. Its actual sensitivity will be included in the substitution calibration of the test configuration. In the frequency range of 1 GHz to 18 GHz linearly-polarized horn antennas are recommended.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

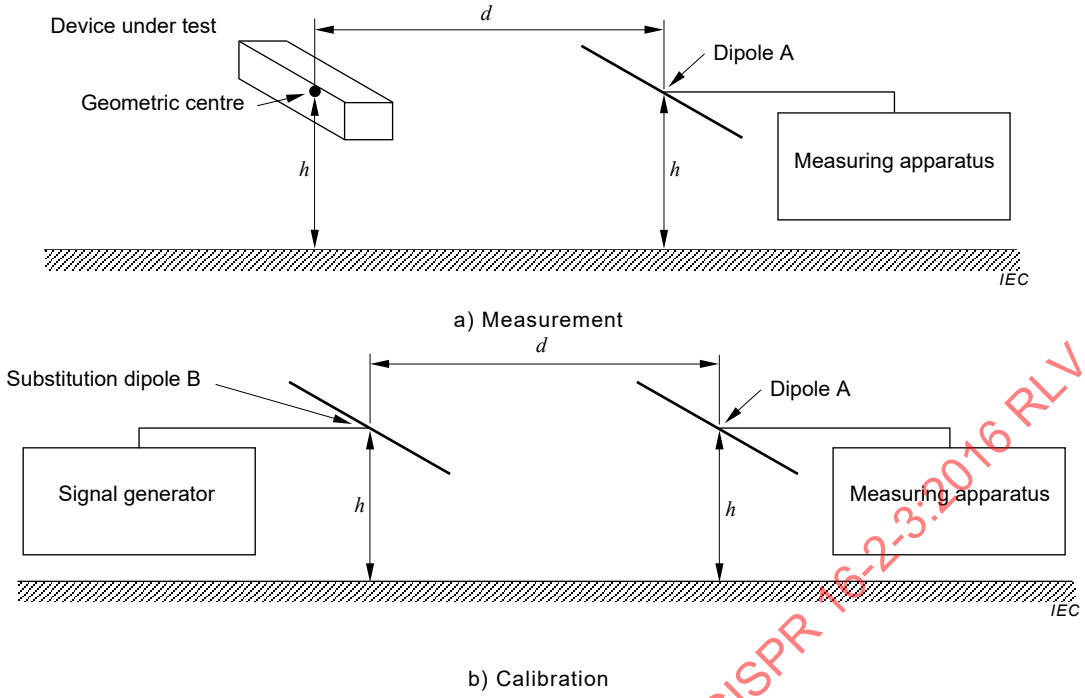


Figure 23 – Substitution method set-up geometries for: a) measurement, b) calibration

7.8.4 EUT configuration

The EUT shall be placed on a non-conducting table with provision to rotate in the horizontal plane (azimuth). The EUT shall be configured so that the geometric centre of the EUT coincides with the point earlier used as the centre point for dipole B (see Figure 23). If the EUT consists of more than one unit, each unit shall be measured separately. Detachable leads to the EUT should be removed if operation is not affected adversely. Required leads shall be provided with absorbing ferrite rings and be so positioned that they will not influence the measurements. For shielded EUTs, all connectors not used shall be terminated by shielded terminations.

7.8.5 Test procedure

With the EUT arranged as described in 7.8.4, the horizontally polarized measuring dipole A shall be placed in the same position as when checking the test site. The dipole shall be normal to a vertical plane through its centre and that of the EUT. The EUT is first measured in its normal table-standing position and secondly when tilted 90° to stand on a normally vertical side. In each position it shall be rotated 360° in the horizontal plane. The highest reading shall be the characteristic value for the EUT.

The measuring system is calibrated by replacing the EUT with a half-wave dipole B. The centre of this calibrating dipole B shall be placed in the same spot as the geometric centre of the previously measured EUT and parallel with the measurement antenna A, and be connected to a signal generator. The radiated power from the cabinet of the EUT is defined as the power at the terminals of the half-wave dipole B when the signal generator is adjusted to give the same reading on the measuring receiver as the maximum reading recorded earlier (Y), at each frequency of measurement.

When measurements are made with both horizontally and vertically polarized measuring dipoles, separate calibrations ~~must~~ shall be made for the two modes.

7.8.6 Measurement uncertainty for substitution method

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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

7.9 Reverberation chamber measurements (80 MHz to 18 GHz)

Radiated emission measurements may be performed in reverberation chambers using the methods specified in IEC 61000-4-21 [8]. Conditions for the use of alternative test methods are given in CISPR 16-4-5. General and basic considerations about uncertainties of emission measurements are given in CISPR 16-4-1.

7.10 TEM waveguide measurements (30 MHz to 18 GHz)

Radiated emission measurements may be performed in TEM waveguides using the methods specified in IEC 61000-4-20. Conditions for the use of alternative test methods are given in CISPR 16-4-5. General and basic considerations about uncertainties of emission measurements are given in CISPR 16-4-1.

8 Automated measurement of emissions

8.1 Introduction – Precautions for automated measurements

Much of the tedium of making repeated EMI measurements can be removed by automation. Operator errors in reading and recording measurement values are minimized. By using a computer to collect data, however, new forms of error can be introduced that may have been detected by an operator. Automated testing can lead, in some situations, to greater measurement uncertainty in the collected data than manual measurements performed by a skilled operator. Fundamentally, there is no difference in the accuracy with which an emission value is measured whether manually or under software control. In both cases, the measurement uncertainty is based on the accuracy specifications of the equipment used in the test set-up. Difficulties may arise, however, when the present measurement situation is different from the scenarios the software was configured for.

For example, an EUT emission adjacent in frequency to a high level ambient signal may not be measured accurately, if the ambient signal is present during the time of the automated test. A knowledgeable tester, however, is more likely to distinguish between the actual interference and the ambient signal; therefore the method for measuring the EUT emission can be adapted as required. However, valuable test time can be saved by performing ambient scans prior to the actual emission measurement with the EUT turned off to record ambient signals present on the OATS. In this case the software may be able to warn the operator of the potential presence of ambient signals at certain frequencies by applying appropriate signal identification algorithms. Operator interaction is recommended if the EUT emission is slowly varying, if the EUT emission has a low on-off cycle or when transient ambient signals (e.g. arc welding transients) may occur.

8.2 Generic measurement procedure

Signals need to be intercepted by the EMI receiver before they can be maximized and measured. The use of the quasi-peak detector during the emission maximization process for all frequencies in the spectrum of interest leads to excessive test times (see 6.6.2). Time-consuming processes like antenna height scans are not required for each emission frequency. These should be limited to frequencies at which the measured peak amplitude of the emission is above or near the emission limit. Therefore, only the emissions at critical frequencies whose amplitudes are close to or exceed the limit will be maximized and measured. The generic process depicted in Figure 24 will yield a reduction in measurement time.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

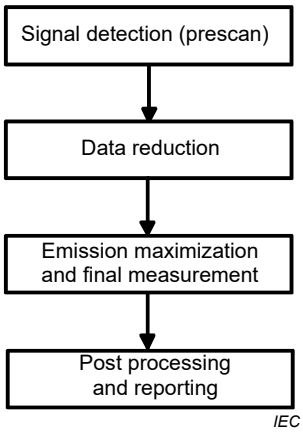


Figure 24 – Process to give reduction of measurement time

8.3 Pre-scan measurements

8.3.1 General

This initial step in the overall measurement procedure serves multiple purposes. Pre-scan places the least number of restrictions and requirements upon the test system since its main purpose is to gather a minimal amount of information upon which the parameters of additional testing or scanning will be based. This measurement mode can be used to test a new product, where the familiarity with its emission spectrum is very low. In general, pre-scan is a data acquisition procedure used to determine where in the frequency range of interest, significant signals are located. Depending on the goal of this measurement, antenna tower and turntable movement may be necessary (for the radiated emission test) as well as improved frequency accuracy (e.g. for further processing on an OATS) and data reduction through amplitude comparison. These factors define the measurement sequence during the execution of pre-scan. In any case, the results will be stored in a signal list for further processing. When a pre-scan measurement is made to quickly obtain information on the unknown emission spectrum of an EUT, frequency scanning can be performed by applying the considerations of 6.6.

8.3.2 Determination of the required measurement time

If the emission spectrum and especially the maximum pulse repetition interval T_p of the EUT are not known, they shall be investigated to assure the measurement time T_m is not shorter than T_p. The intermittent character of the emission of an EUT is especially relevant for critical peaks of the emission spectrum. First it should be determined at which frequencies the amplitude of the emission is not steady. This can be done by comparing the maximum-hold with a minimum-hold or clear/write function of the measuring equipment or software, and observing the emission for a period of 15 s. During this period no change in the set-up should be made (no change of lead in case of conducted emission, no movement of absorbing clamp, no movement of turntable or antenna in case of radiated emission). Signals with e.g. more than 2 dB difference between the maximum-hold result and minimum-hold result are marked as intermittent signals. (Care should be taken not to mark noise as intermittent signals.)

In case of radiated emission, the polarization of the antenna is changed and the measurement is repeated, to reduce the risk that certain intermittent peaks are not found because they remain below noise level. From each intermittent signal the pulse repetition period T_p can be measured, by applying zero-span or using an oscilloscope connected to the IF-output of the measurement receiver. The correct measurement time can also be determined by increasing it until the difference between maximum-hold and clear/write displays is below e.g. 2 dB. During further measurements (maximization and final measurement), it shall be assured for each part of the frequency range that the measuring time T_m is not smaller than the applicable pulse repetition period T_p.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

8.3.3 Pre-scan requirements for different types of measurements

The type of measurement determines the definition of a pre-scan measurement in the following way.

- For radiated emissions in the frequency range from 9 kHz to 30 MHz, e.g. per CISPR 11 [1], both the loop antenna and the EUT need to be rotated to find the maximum field strength while the receiver is scanning the emission spectrum.
- In the frequency range from 30 MHz to 1 000 MHz, the antenna height may be preset to fixed heights given in Table 7, based on measurement distance, frequency range and polarization. The necessary pre-scan measurements ~~must~~ shall be made for a sufficient number of EUT azimuths. For quick overview measurements this will yield an indication of the radiated emission amplitudes as a starting point for final maximization. If a more detailed determination of the worst-case antenna height, polarization and EUT azimuth is desired, the applicable standard should be used to determine the appropriate maximization procedure.
- In the frequency range above 1 GHz, the antenna needs to be positioned in horizontal and vertical polarization and the EUT rotated to find the maximum field strength while the emission spectrum is scanned. For details of the test procedure, see 7.6.6.1.

Table 7 – Recommended antenna heights to guarantee signal interception (for pre-scan) in the frequency range 30 MHz to 1 000 MHz

Measurement distance m	Polarization h – horizontal v – vertical	Frequency range MHz	Recommended antenna heights for each frequency range (minimum / maximum) m
3	h	30 to 100 100 to 250 250 to 1 000	2,5 1 / 2 1 / 1,5
	v	30 to 100 100 to 250 250 to 1 000	1 1 / 2 1 / 1,5 / 2
10	h	30 to 100 100 to 200 200 to 400 400 to 1 000	4 2,5 / 4 1,5 / 2,5 /4 1 /1,5 /2,5
	v	30 to 200 200 to 300 300 to 600 600 to 1 000	1 1 / 3,5 1 / 2 / 3,5 1 / 1,5 / 2 / 3,5
30	h	30 to 300 300 to 500 500 to 1 000	4 2,5 / 4 1,5 / 2,5 / 4
	v	30 to 500 500 to 800 800 to 1 000	1 1 / 3,5 1 / 2,5 / 3,5

~~NOTE 1~~ a) The recommended antenna heights were derived for source phase-centre heights of between 0,8 m and 2,0 m for maximum errors of 3 dB (which is good for a pre-scan only). If the range of phase centre heights is reduced, the number of receive antenna heights may be reduced. If radiation pattern lobes exist (distinct peaks and nulls), e.g. in the upper frequency ranges, more antenna heights may be needed.

~~NOTE 2~~ b) For very large EUTs, e.g. telecom systems, the receiving antenna may need to be positioned in several vertical and horizontal positions, depending on the antenna beam width.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

8.4 Data reduction

The second step in the overall measurement procedure is used to reduce the number of signals collected during pre-scan and is thus aimed at further reduction of the overall measurement time. These processes can accomplish various tasks, e.g. determination of significant signals in the spectrum, discrimination between ambient or auxiliary equipment signals and EUT emissions, comparison of signals to limit lines, and data reduction based on user-definable rules. Another example of data-reduction methods involving the sequential use of different detectors and amplitude versus limit comparisons is given by the decision tree in Annex C of CISPR 16-2-1:2014. Data reduction may be performed fully automated or interactively, involving software tools or manual operator interaction. It need not be a separate section of the automated test, i.e. it may be part of a pre-scan.

In certain frequency ranges, especially the FM band, an acoustic ambient discrimination is very effective. This requires signals to be demodulated to be able to listen to their modulation content. If an output list of pre-scan contains a large number of signals and acoustic discrimination is needed, it can be a rather lengthy process. However, if the frequency ranges for tuning and listening can be specified, only signals within these ranges will be demodulated. The results of the data reduction process are stored in a separate signal list for further processing.

8.5 Emission maximization and final measurement

During the final test the emissions are maximized to determine their highest level. After the maximization of the signals, the emission amplitude is measured using quasi-peak detection and/or average detection, allowing for the appropriate measurement time (at least 15 s if the reading shows fluctuations close to the limit).

The type of the radiated emission measurement defines the maximization process yielding the highest signal amplitudes:

- in the frequency range from 9 kHz to 30 MHz – maximization of the indicated level by variation of the EUT azimuth angle and the azimuth angle of the (vertical) plane of the loop antenna (e.g. tests for CISPR 11 [1]);
- in the frequency range from 30 MHz to 1 000 MHz – maximization of the indicated level by variation of height and polarization of the measurement antenna as well as variation of the EUT azimuth;
- in the frequency range above 1 GHz – maximization of the indicated level by variation of the antenna polarization and variation of the EUT azimuth and, if the EUT surface is wider than the antenna beam, by moving the antenna along the EUT surface.

Before the actual maximization sequence can be executed, the worst-case EUT set-up shall be determined to ensure the detection of maximum emission amplitudes. The process of finding the EUT and cable configuration that yields the worst case emissions is primarily a manual operation. This can be done using a scanning receiver with a graphical display of the emission spectrum and signal maximum-hold capability for observing the changes in amplitudes as cable and equipment layouts are manipulated. The automated final measurement of emissions should begin after the worst case EUT operating mode and layout has been configured.

The measurement of a particular radiated emission includes a maximization process involving the rotation of the EUT, scanning the receive antenna over a height range, and changing antenna polarization. This time-consuming search process can be effectively automated, but it ~~must~~ shall be recognized that a variety of search strategies may be used that can lead to different results. In case of previous knowledge of the radiation characteristics of an EUT, a maximization sequence should be chosen that allows the determination of the worst-case amplitude within the search ranges of the antenna mast and the turntable. For instance, if the EUT emits highly directive signals in the horizontal plane, e.g. due to slots in the case, the turntable should be rotated continuously while taking data with the receiver. A table

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

movement in discrete steps, on the other hand, may not allow the detection of the maximum amplitude or may cause the signal to be missed completely if the chosen angular increments of the positions are too far apart. The scan time of the spectrum analyzer should be less than the time for 15º of rotation of the turntable to produce effective maximization data.

One search strategy might be to rotate the turntable 360° while leaving the antenna at a fixed height to find the angle for maximum emission amplitude. Next, the turntable is rotated back over the full range after the antenna polarization was changed (e.g. from horizontal to vertical). During this process test data is taken continuously with the receiver and at the end of the second table scan the highest amplitudes, based on turntable angle and antenna polarization, are determined. Then, the worst case positions of the antenna and turntable are selected and the antenna is scanned over the required height range to find the position yielding the maximum amplitude. At this point the emission level is either recorded using the receiver's quasi-peak detector after returning to the maximum emission height, or finer search continues with incremental rotation of the turntable and following incremental height search, to find the maximum emission amplitude at the given frequency with greater precision. Again, it is important to have some understanding of the radiation pattern of the EUT in order to configure the software for an optimum search strategy that finds the maximum of the EUT emission in the shortest time. Variability is introduced into the test result when the final measurement is performed on the slope of the radiation pattern rather than on its peak.

NOTE The final measurement may be performed at several frequencies in parallel using FFT-based measurement instrumentation.

8.6 Post-processing and reporting

The last part of the test procedure addresses documentation requirements. The functionality for defining sorting and comparison routines that then can be automatically or interactively applied to signal lists supports a user in compiling the necessary reports and documentation. The corrected peak, quasi-peak or average signal amplitudes should be available as sorting or selection criteria. The results of these processes are stored in separate output lists or can be combined in a single list and are available for documentation or further processing.

Results shall be available in tabular and graphics format for use in a test report. Furthermore, information about the test system itself, e.g. transducers used, measuring instrumentation, and documentation of the EUT set-up as required by the product standard should also be part of the test report.

8.7 Emission measurement strategies with FFT-based measuring instruments

Depending on the implementation, FFT-based measuring instruments may perform weighted measurements significantly faster than the tunable selective voltmeters. A weighted measurement over the frequency range of interest may then be faster than a measurement consisting of a prescan and final scan performed with a superheterodyne receiver as described in 8.2.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Annex A
(informative)

Measurement of disturbances in the presence of ambient emissions

A.1 General

High ambient emissions have to be accounted for during *in situ* tests (conducted and radiated) and type tests on an open-area test site (OATS). It is the purpose of this annex to describe measurement procedures for a number of different situations.

In some circumstances, the procedures will not provide a solution to the problems caused by ambient signals. In particular, the procedures cannot be expected to overcome the problems of 5.2.4 of CISPR 16-1-4:2010. But aside from this caveat, the following procedures can be used.

A.2 Terms and definitions

A.2.1
EUT disturbance
EUT emission spectrum to be measured

A.2.2
ambient emission
emission spectrum superimposed on the EUT disturbance spectrum that influences the accuracy of the EUT disturbance measurement

~~NOTE This method does not consider the procedures of 10.8 of CISPR 22 [3].~~

A.3 Problem description

During *in situ* tests and type tests on an OATS the ambient emissions frequently do not correspond to the ambient radio frequency environment of the test site recommendations of CISPR 16-1-4.

The radio disturbance of the EUT is often located within the frequency bands of ambient emissions and cannot be measured with a radio disturbance measuring receiver as specified in CISPR 16-1-1 due to insufficient frequency spacing between the EUT disturbance and the ambient emission or due to superposition.

The CISPR standard measuring receiver is suitable to provide uniform test results for all types of radio-frequency emissions, where the EUT disturbance alone is to be measured. It is, however, not optimized to discriminate between EUT disturbance and ambient emissions or to measure the EUT disturbance in the aforementioned situation.

Because in actual interference investigation situations there are no alternatives to an *in situ* test, a solution is described below for cases when a differentiation between EUT disturbance and ambient emission is possible.

A.4 Proposed solution

A.4.1 Overview

EUT disturbance emissions a-nd ambient emissions can be categorized as in Table A.1.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Table A.1 – Combinations of EUT disturbance and ambient emissions

EUT disturbance	Ambient emission
Narrowband	Narrowband
	Broadband
Broadband	Narrowband
	Broadband

Narrowband ambient emissions may be, for example, AM- or FM-modulated; broadband ambient emissions may be, for example, TV or digitally-modulated signals. Here the terms “narrowband” and “broadband” are always relative to the bandwidth of the measuring receiver, as specified in CISPR 16-1-1. Narrowband signals are defined as signals that have a bandwidth less than the measuring receiver bandwidth. In this case, all the signal’s spectral components are contained in the receiver bandwidth. A CW signal will always be narrowband; a narrow FM signal can be either narrow or broadband, depending on the actual receiver bandwidth. On the contrary, an impulsive signal will usually be broadband because a few of its spectral components will be within and many of its spectral components outside the receiver bandwidth.

The measurement of the EUT disturbance is a manifold problem: first, to identify EUT disturbance and ambient emission and, second, to distinguish between narrowband and broadband emission. Modern measuring receivers and spectrum analyzers provide various resolution bandwidths and detector types. These can be used to analyse the combined spectrum, to distinguish between EUT disturbance and ambient emission spectra, to distinguish between narrowband and broadband emissions and to measure (or in difficult situations to estimate) the EUT disturbance.

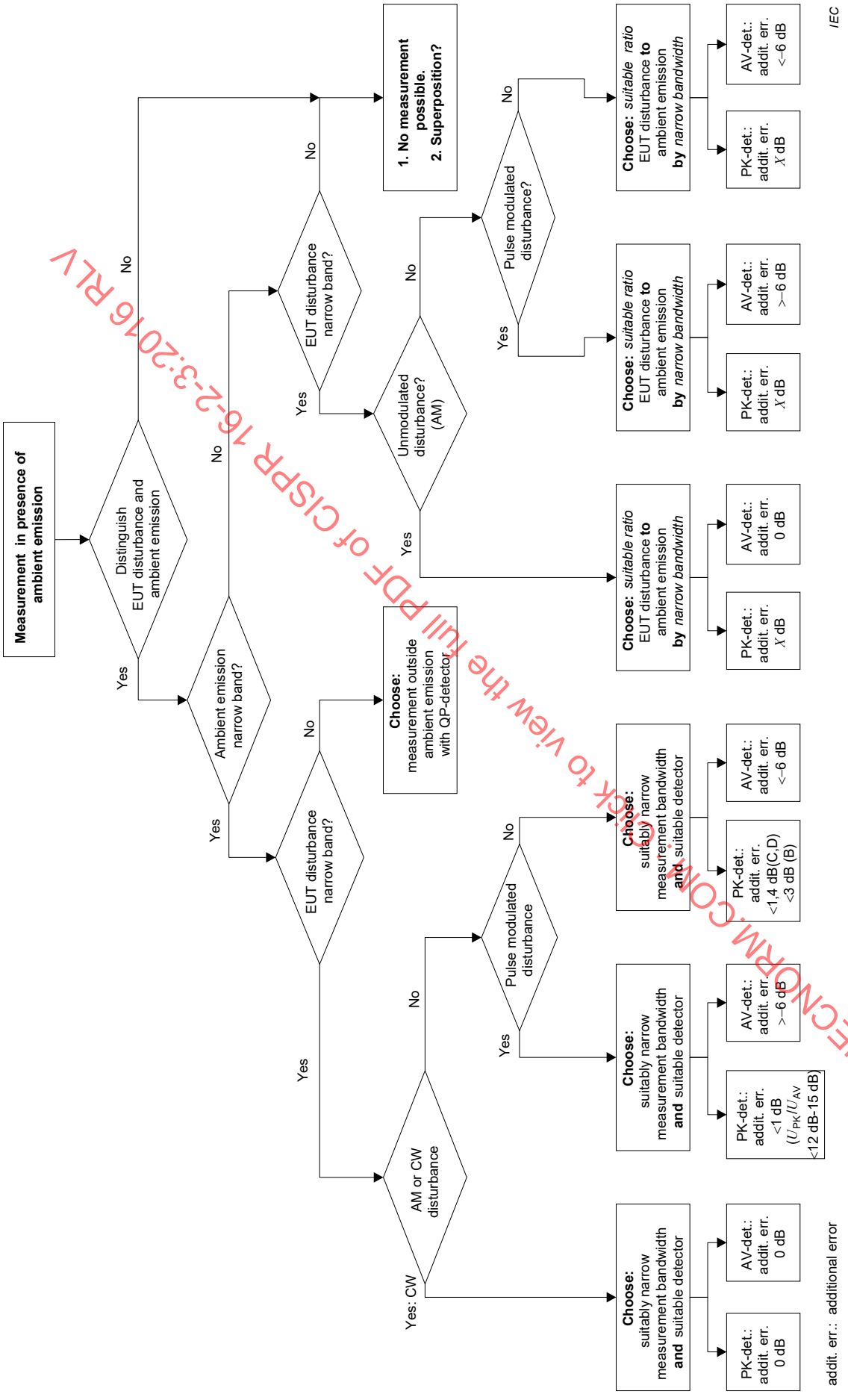
In case of type testing on an OATS, identification and pre-measurement of the EUT disturbance may also be carried out by pre-testing the EUT in a non-compliant (for example, partially) absorber-lined shielded room, and final testing on an OATS, whereby levels of emissions hidden by ambients may be determined by comparison with emissions in the vicinity.

Superposition of the emissions shall be accounted for when EUT disturbance and ambient emissions cannot be separated. The separation needs an EUT disturbance-and-ambient-emission to ambient-emission ratio of about 20 dB.

In cases where IF-bandwidths and detectors are different from the specified bandwidth and the quasi-peak (QP) detector, the QP value in the specified bandwidth is the reference for the measurement-error determination.

Figure A.1 shows a flow diagram for the selection of bandwidths and detectors and the estimated measurement errors due to that selection.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Figure A.1 – Flow diagram for the selection of bandwidths and detectors and the estimated measurement errors due to that selection

A.4.2 Pre-testing the EUT in a shielded room

Emission frequency and amplitude data acquired from preliminary testing in a shielded room may be used under certain restrictive conditions (a simple shielded room is not an absorber-lined shielded room – semi-anechoic or anechoic – and thus does not meet present NSA values in Annex E of CISPR 16-1-4:2010, (Annex A of [4])). This will give the emission spectrum that has significant amplitudes. In cases of narrowband emission the product emission spectrum contains harmonics and subharmonics of any clock frequency used in the product.

These pre-test results may be used to determine product emission amplitudes in certain restrictive situations. In particular, when the final compliance test is performed at an OATS and one (or more) of the frequencies are masked (hidden) by an RF ambient, chances are that an adjacent frequency to these masked frequencies will not coincide precisely with an RF ambient. Hence, the unmasked emission can be recorded in the usual manner using the required receiver or spectrum analyzer bandwidth. Then the amplitude of the EUT emission that is masked by the high RF ambient can be judged using the preliminary quiet-chamber measurements in the following way.

Assume that during the shielded room preliminary measurements ~~that~~ two adjacent frequency emissions differ in amplitude by X dB (see Figure A.2). Next one of these frequencies that are not masked by the RF ambient is measured at the OATS. The difference in amplitude (X dB) of the masked frequency from the measurable adjacent frequency can be added to (or subtracted from, depending on the sign of the difference) the amplitude found in the shielded room to determine the amplitude of the adjacent frequencies. This is shown in Figure A.2, where (assuming that the frequency f_1 is the masked frequency and f_0 is not masked), the amplitude for f_1 is shown as X dB greater than the amplitude at f_0. Then to find the amplitude of f_1 at the OATS, X dB is added to the value of the measurable amplitude of f_0. Similarly, if the amplitude of f_6 were Y dB less than that for f_7 found during the quiet-chamber testing, the amplitude of f_6 (if masked by an ambient) would be Y dB less than that of f_7, which is assumed to be measurable at the OATS.

NOTE The above procedure emphasizes what is contained in point d) of 7.3.6.2 (Test environment).

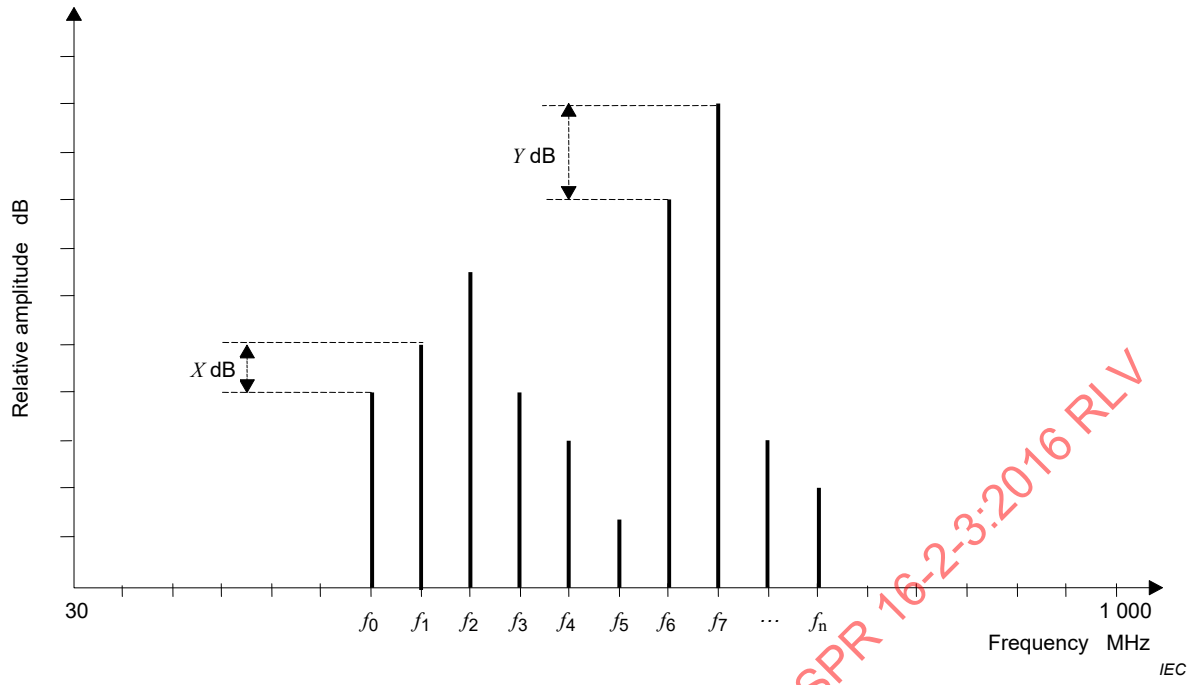
Several precautions should be taken in using this restricted procedure.

a) The adjacent frequency found in preliminary testing should not be more than one or two adjacent frequencies away (usually a sub-harmonic or harmonic of the basic clock frequency), so that the effect of the shielded room irregularities will not unnecessarily enhance or depress frequencies adjacent to the frequency to be estimated on the OATS. In this case, the value of X (or Y in Figure A.2) may not be suitable.

b) The amplitudes of adjacent frequencies need to be measured very carefully by height scan of the receive antenna in the quiet chamber (as would be the case for the final compliance measurement). If full height scan cannot be made, alternate correlations between the quiet-chamber measurements and the corresponding OATS measurements may have to be made before applying this OATS amplitude estimation technique (for emissions masked by the RF ambient).

c) For those quiet chambers that are fully absorber-lined on all six sides of the chamber, alternate height-scan techniques might be available, such as measurements at two or three fixed heights (since the ground plane reflections are suppressed and that contribution to the received signal diminished) and using the maximum of these readings. Such techniques may need the same correlation measurements as stated in item b) above.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



NOTE Generally f_n is n times f_0, the EUT fundamental emission frequency (basic clock frequency).

Figure A.2 – Relative difference in adjacent emission amplitudes during preliminary testing

A.4.3 Method of measurement of EUT disturbances in the presence of narrowband ambient emissions

A.4.3.1 General

Depending on the type of EUT disturbance, its measurement is based on

– the analysis of the combined spectrum with a bandwidth narrower than that of the CISPR measuring receiver,

– the determination of a suitable measurement bandwidth for the selection of narrowband disturbance close to ambient emissions,

– the use of the peak detector (if the disturbance is AM or pulse modulated) or the average detector,

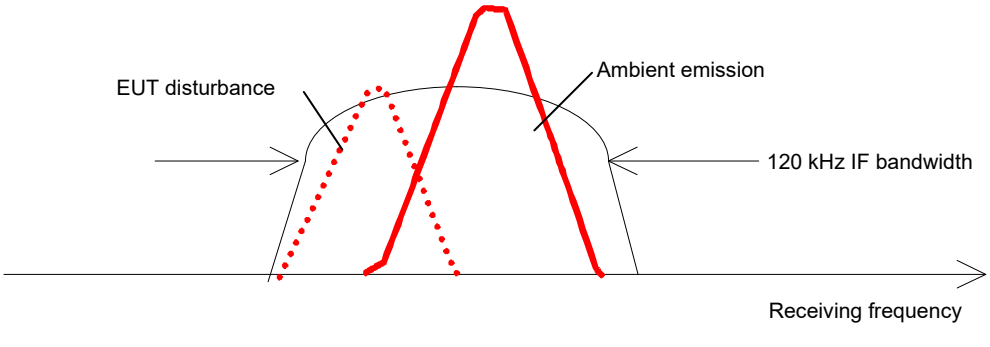
– the increase of the EUT disturbance to ambient emission ratio in case of a narrowband disturbance within a relatively broadband ambient emission when a narrower measurement bandwidth is used, and

– accounting for superposition of EUT disturbance and ambient emission, if separation is not possible.

A.4.3.2 Unmodulated EUT disturbance

The unmodulated EUT disturbance (see Figure A.3) can be separated from the ambient signal carrier by choosing a suitably narrow measurement bandwidth. Either the peak or the average detector may be used. There is no additional measurement error compared with the quasi-peak detector. If the difference in level between peak and average values is very small (for example, lower than 1 dB), the measured average value is equivalent to the quasi-peak value.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



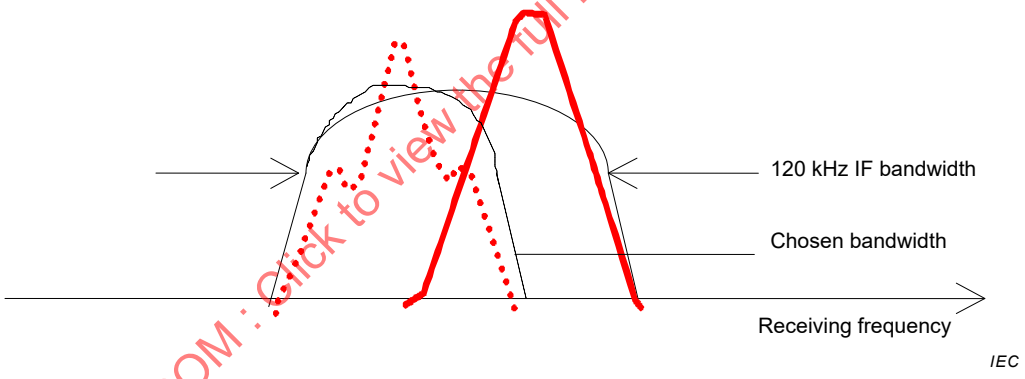
Key

dotted line	EUT disturbance
solid bold line	ambient emission
thin line	120 kHz IF bandwidth

Figure A.3 – Disturbance by an unmodulated signal (dotted line)

A.4.3.3 Amplitude-modulated EUT disturbance

The amplitude-modulated EUT disturbance (see Figure A.4) can be separated from the ambient signal carrier by choosing a suitably narrow measurement bandwidth. Care should be taken to ensure that the narrow measurement bandwidth chosen does not suppress the modulation spectra of the EUT disturbance. Suppression of the modulation spectra is recognised by a decrease in the peak amplitude of the EUT disturbance as a result of the increase of selectivity.



Key

dotted line	EUT disturbance
solid bold line	ambient emission
thin line	120 kHz IF bandwidth

Figure A.4 – Disturbance by an amplitude-modulated signal (dotted line)

Only the peak detector with a measurement time greater than the reciprocal of the modulation frequency can be used. An additional measurement error shall be accounted for at modulation frequencies below 10 Hz (0,4 dB at 10 Hz; 1,4 dB at 2 Hz for bands C and D and 0,9 dB at 10 Hz; 3 dB at 2 Hz for band B), where the peak value is above the quasi-peak value. The QP-value as a function of the modulation frequency is shown in Figure A.5.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

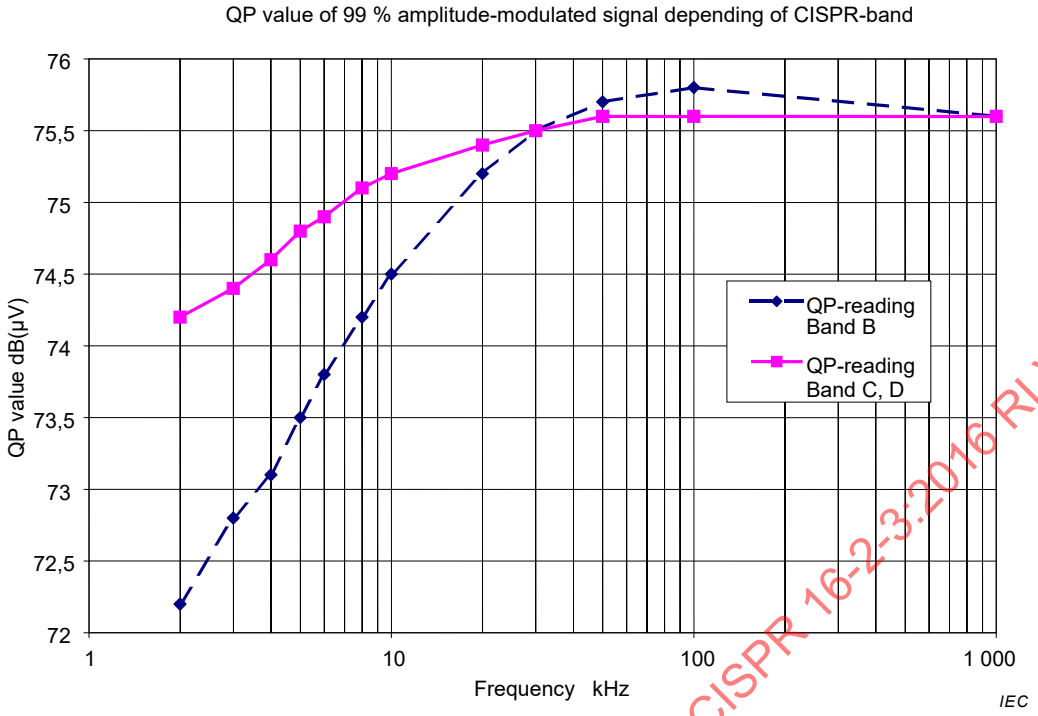


Figure A.5 – Indication of an amplitude-modulated signal as a function of modulation frequency with the QP detector in CISPR bands B, C and D

A.4.3.4 Pulse-modulated EUT disturbance

The narrowband pulse-modulated disturbance from the EUT is classified as a special case of amplitude modulation and can also be separated from the ambient signal carrier by a suitably narrow measurement bandwidth. The selectivity ~~must~~ shall not lead to a suppression of the modulation spectra. Only the peak detector can be used.

In cases of low repetition frequency, an additional error is possible, but as long as the difference between peak- and average detector reading is in the order of 12 dB to 14 dB, additional measurement errors compared with the quasi-peak value need not be accounted for.

For a pulse width τ = 50 µs, Figure A.6 shows that as long as the difference between peak and average levels is less than or equal to 14 dB, the deviation between peak and QP levels is negligible. So, the comparison between peak and average levels may be used to verify the usability of the peak detector.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

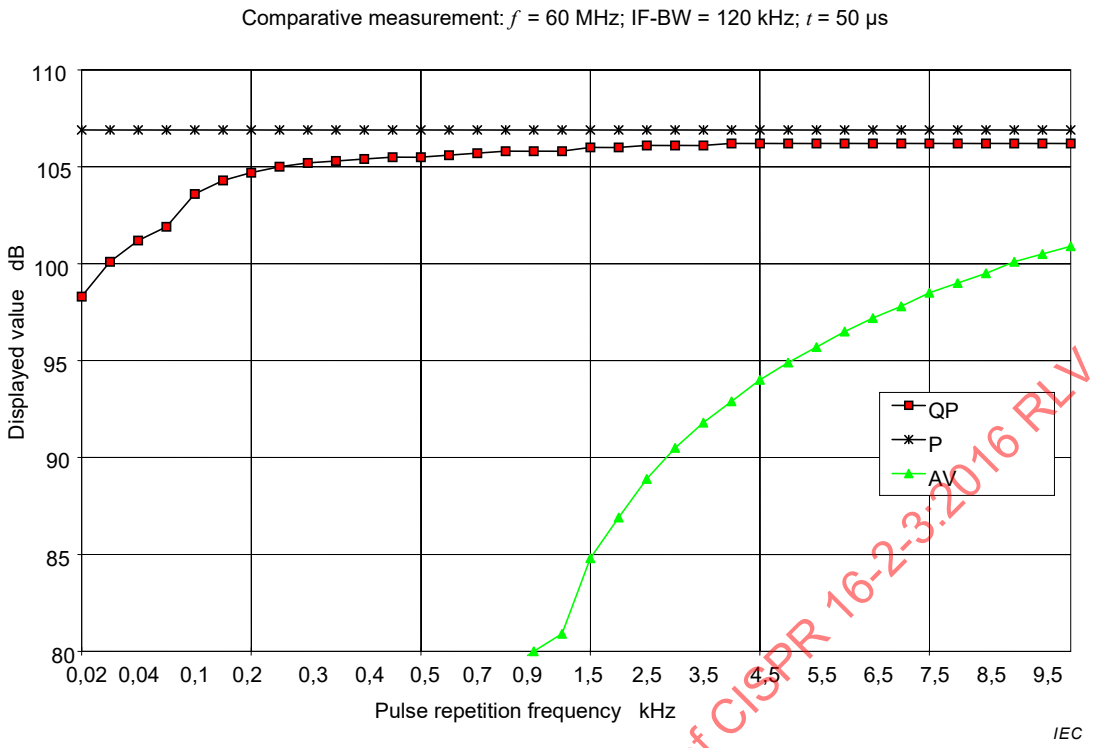
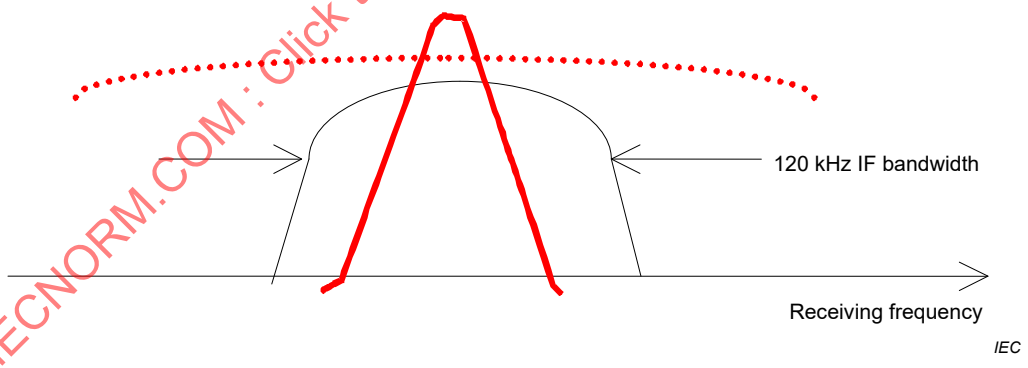


Figure A.6 – Indication of a pulse-modulated signal (pulse width 50 µs) as a function of pulse repetition frequency with peak, QP and average detectors

A.4.3.5 Broadband EUT disturbance

For the measurement of broadband disturbance (see Figure A.7) the quasi-peak detector shall be used. In fact it is not possible to carry out a measurement within the ambient signal bandwidth. Because of the finite bandwidth, the disturbance can generally be measured outside the ambient signal spectrum using the quasi-peak detector.



Key

dotted line	EUT disturbance
solid bold line	ambient emission
thin line	120 kHz IF bandwidth

Figure A.7 – Disturbance by a broadband signal (dotted line)

A.4.4 Method of measurement of EUT disturbance in the presence of broadband ambient emissions

A.4.4.1 General

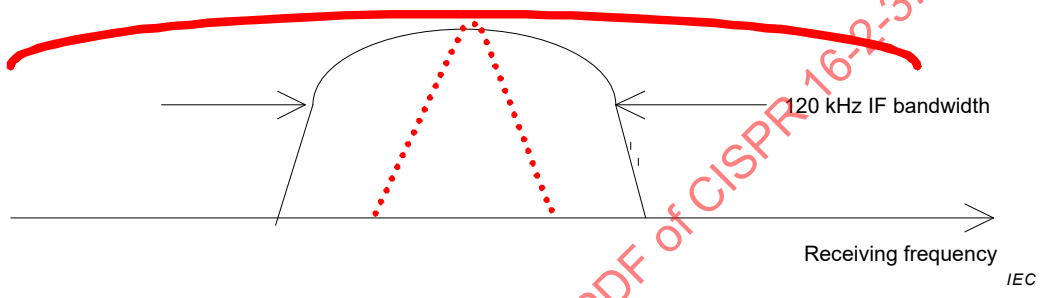
For this case the measurement method is based on

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

– the analysis of the combined spectrum with a bandwidth equal to the CISPR measuring receiver,
– measurement with a narrow bandwidth (in case of narrowband EUT disturbance; the use of a narrow bandwidth will increase the EUT disturbance to ambient emission ratio),
– the use of the average detector for narrowband EUT disturbance, and
– accounting for superposition of EUT disturbance and ambient emission, if separation is not possible.

A.4.4.2 Unmodulated EUT disturbance

The amplitude of the EUT disturbance (see Figure A.8) should be measured with the average detector (specified in CISPR 16-1-1). The measurement error depends on the average value of the broadband signal spectrum within the selected bandwidth. This measurement error can be minimized by choosing a measurement bandwidth that maximizes the EUT disturbance to ambient emission ratio (selectivity method).



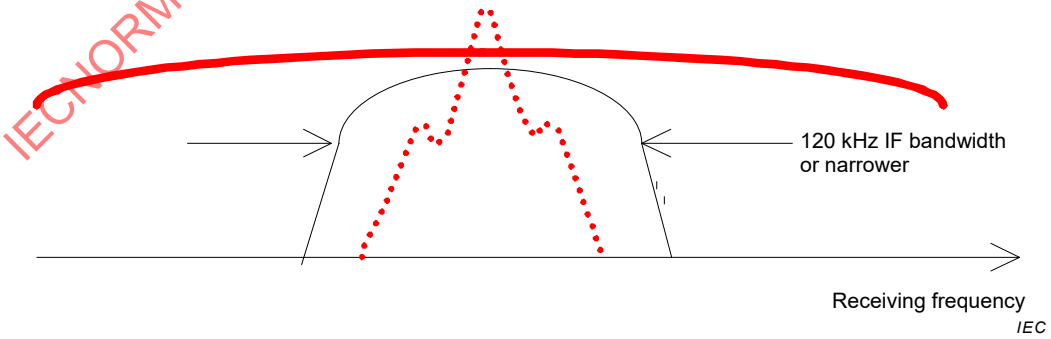
Key

dotted line	EUT disturbance
solid bold line	ambient emission
thin line	120 kHz IF bandwidth

Figure A.8 – Unmodulated EUT disturbance (dotted line)

A.4.4.3 Amplitude-modulated EUT disturbance

The amplitude of the EUT disturbance (see Figure A.9) is measured with the average detector, although an additional measurement error of up to 6 dB (at 100 % modulation) compared with a quasi-peak detector shall be accounted for. The measurement bandwidths chosen should maximize the EUT disturbance to ambient emission ratio (selectivity method).



Key

dotted line	EUT disturbance
solid bold line	ambient emission
thin line	120 kHz IF bandwidth

Figure A.9 – Amplitude-modulated EUT disturbance (dotted line)

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

A.4.4.4 Pulse-modulated EUT disturbance

It is not easy to detect and recognise a pulse-modulated EUT disturbance in a broadband ambient signal spectrum with a high level of reliability, because the 100 % amplitude modulation of the disturbance may mask the EUT disturbance within the spectrum.

The amplitude of the EUT disturbance can be measured with the average detector in case of high duty cycles. Due to the 100 % amplitude modulation depth with smaller duty cycles, the use of the average detector will cause an increasing measurement error compared with the quasi-peak detector. In the case of a duty cycle of 1:1 and use of the linear average detector, the measurement error is 6 dB. The measurement bandwidth should be such that the relationship between the measured average value of the EUT disturbance and the average value of the broadband ambient signal is maximized.

In case of low duty cycles, the average value will substantially deviate from the QP value. In this case the peak detector should be used together with a measurement bandwidth as narrow as possible but still wide enough to capture the complete disturbance bandwidth. Superposition with the ambient emission may have to be accounted for.

A.4.4.5 Broadband EUT disturbance

As a rule, broadband disturbance cannot be detected or measured in a broadband ambient signal spectrum. It may be possible to measure such a disturbance outside the ambient signal spectrum or by accounting for superposition.

The combinations of EUT disturbance with the ambient emission, and the error involved in the measurement, are displayed in Table A.2.

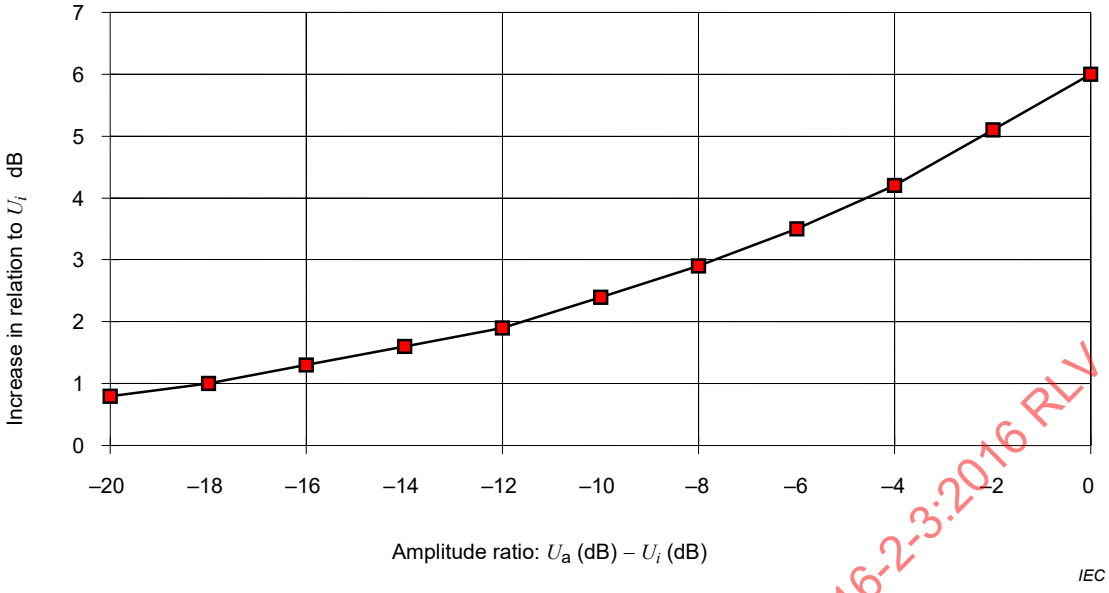
NOTE A scanning receiver or spectrum analyzer will show the spectra of two different broadband signals, unless the signal frequencies or pulse rates are harmonically related with each other, or the sweep rate of the measuring instrument is harmonically related with the measured pulse rates.

A.5 Determination of the EUT disturbance in case of superposition

If, as a result of the selection of the EUT disturbance and the ambient emission, the measured level to ambient emission ratio is lower than 20 dB, the superposition of ambient emission and EUT disturbance needs to be accounted for. For impulsive broadband voltage, the following calculation can be made.

The received signal U_{r} is the sum of the EUT disturbance U_i and the ambient emission U_{a}. U_{a} can be measured only when the EUT is switched off. The superposition is linear for the peak detector (see Figure A.10).

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



Key:

U_a is level of ambient emission

U_i is level of EUT disturbance

Figure A.10 – Increase of peak value with superposition of two unmodulated signals

The following equation applies when using the peak detector:

$$U_r = U_i + U_a \tag{A.1}$$

The EUT disturbance can thus be calculated from

$$U_i = U_r - U_a \tag{A.2}$$

The amplitude ratio d of the received signal to the ambient emission can be measured easily.

$$D = \frac{U_r}{U_a}, \quad d = 20 \lg D \tag{A.3}$$

The ambient emission U_a can be substituted in Equation (A.2):

$$U_i = U_r - \frac{U_r}{D} = U_r \left(1 - \frac{1}{D}\right) \tag{A.4}$$

or

$$U_{i,dB} = U_{r,dB} + 20 \lg \left(1 - \frac{1}{D}\right) \tag{A.5}$$

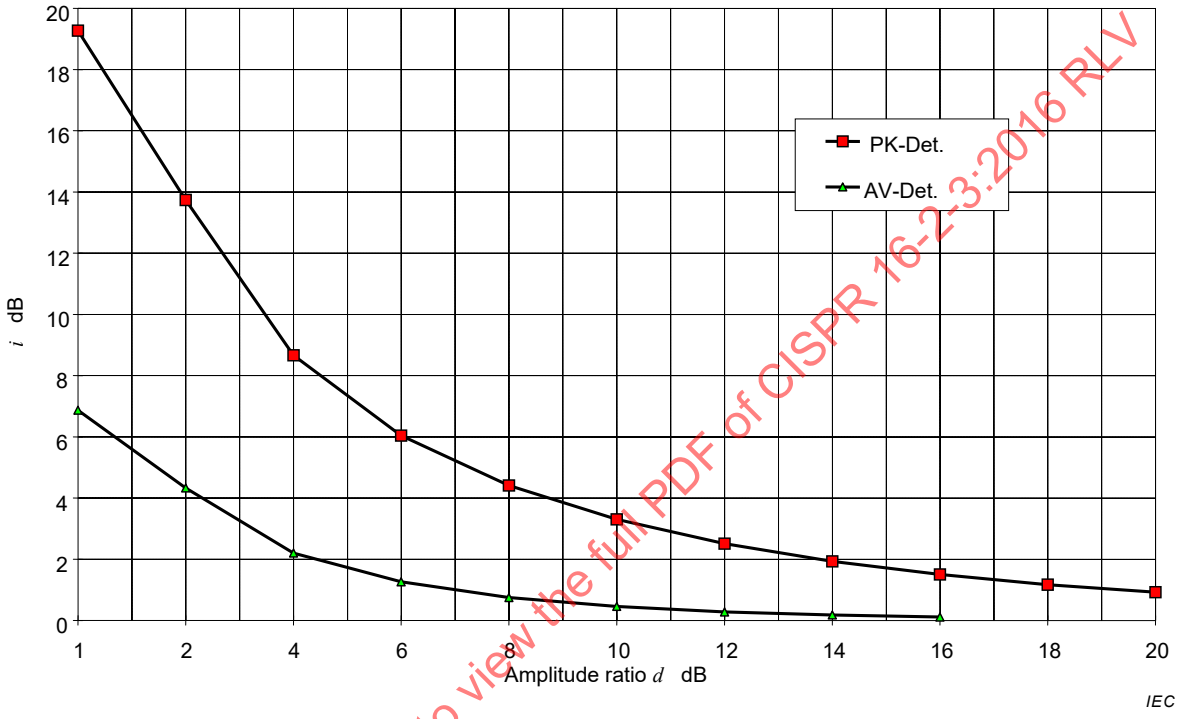
Defining i by Equation (A.6) as

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

$$i = -20 \lg\left(1 - \frac{1}{D}\right) \quad \text{(A.6)}$$

serves to determine the amplitude of the EUT disturbance. The factor i is illustrated in Figure A.11. Using i from Figure A.11, the amplitude of the EUT disturbance can be calculated as follows:

$$U_{i,\mathrm{dB}} = U_{\mathrm{r,dB}} - i \quad \text{(A.7)}$$



Key:

U_a is the ambient signal in dB

U_r is the resulting indication of received signal (by superposition) in dB

U_i is the disturbance signal in dB

$d = U_r - U_a$

$U_i = U_r - i$

$i = -20 \lg(1 - 1/D)$

Figure A.11 – Determination of the amplitude of the disturbance signal by means of the amplitude ratio d and the factor i (see Equation (A.3) and Equation (A.6))

Figure A.11 can be used as follows:

a) measure the ambient field strength U_a in dB(μV/m) (EUT off);

b) measure the resultant field strength U_r in dB(μV/m) (EUT on);

c) determine $d = U_r - U_a$;

d) find the value of i from Figure A.11;

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

e) determine U_i in dB(μV/m) using $U_i = U_r - i$.

If the received signal is measured with the average detector, Figure A.12 can be applied. Figure A.12 shows that in the case of unmodulated signals the following equation

$$U_r = \sqrt{U_i^2 + U_a^2} \tag{A.8}$$

can be used with an additional measurement error of up to about 1,5 dB. In case of modulation, the error decreases (see Figure A.12) but the errors in Table A.2 shall be accounted for.

By means of the average detector, the in-band disturbance can be estimated by applying Equation (A.7) if the curve of the average detector (Figure A.11) is used. In this case the factor i is defined as

$$i = -10 \lg\left(1 - \frac{1}{D^2}\right) \tag{A.9}$$

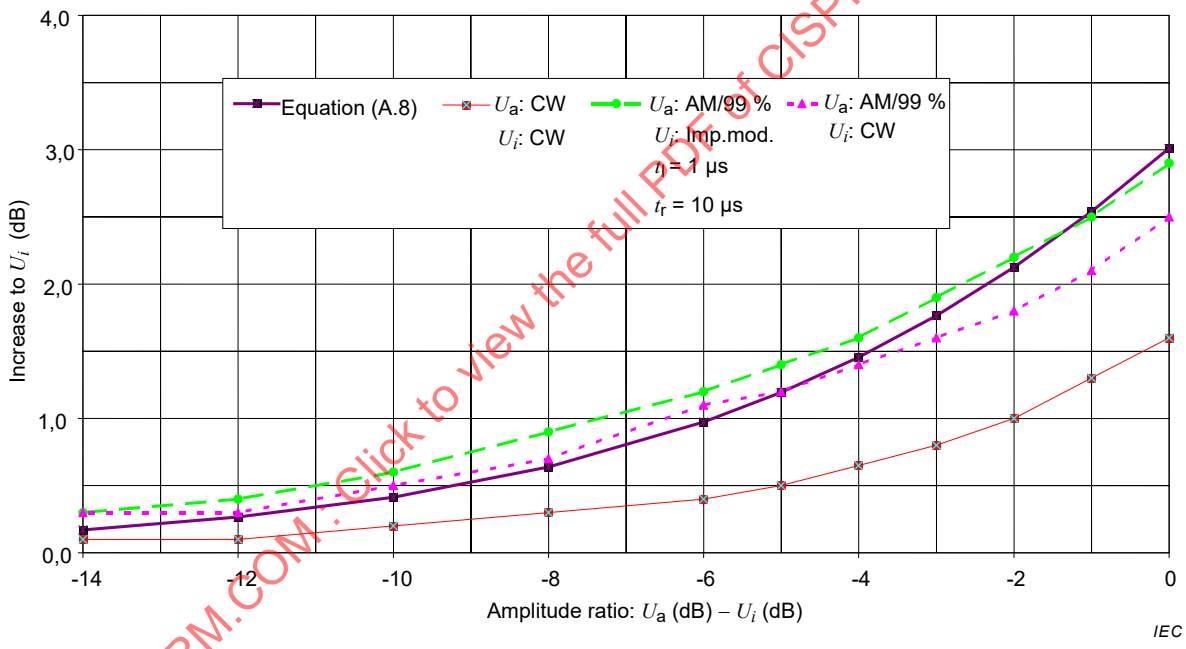


Figure A.12 – Increase of average indication measured with a real receiver and calculated from Equation (A.8)

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Table A.2 – Measurement error depending on the detector type and on the combination of ambient and disturbing signal spectra

Ambient emission	EUT disturbance			
	Unmodulated	**Amplitude-modulated**	**Pulse-modulated**	**Broadband disturbance**
Narrowband				
Steps taken to increase signal-to-noise ratio	Increased selectivity	Increased selectivity	Increased selectivity	Measurement outside ambient emission
Error of peak value $\left(\frac{PK}{QP}\right)$	0 dB	Less than or equal to +1,4 dB for bands C, D +3 dB for band B	Less than or equal to +1 dB $\left(\frac{U_{PK}}{U_{AV}} \leq 12...15 \text{ dB}\right)$	–
Error of average value $\left(\frac{AV}{QP}\right)$	0 dB	Less than or equal to –6 dB [a]	Greater than or equal to –6 dB [a]	–
Broadband				
Steps taken to increase signal-to-noise ratio	Selectivity	Selectivity	Selectivity	No measurement possible (superposition only)
Error of peak value $\left(\frac{PK}{QP}\right)$	$+X$ dB [a]	Less than or equal to $+X$ dB [a]	Greater than or equal to $+X$ dB [a]	–
Error of average value $\left(\frac{AV}{QP}\right)$	0 dB	Less than or equal to –6 dB [a]	Greater than or equal to –6 dB [a]	–

Key:

~~NOTE 1~~ X is the error depending on the pulse character of the ambient emission.

~~NOTE 2~~ PK is the peak value; QP is the quasi-peak value; AV is the average value.

~~NOTE 3~~ Bands B, C, D are defined as in CISPR 16-1-1.

[a] Measurement procedure not recommended – not allowed for compliance measurements.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Annex B
(informative)

Use of spectrum analyzers and scanning receivers

B.1 General

When using spectrum analyzers and scanning receivers, the following characteristics should be addressed. See also Clause 6 of this standard for additional information.

B.2 Overload

Most spectrum analyzers have no RF preselection in the frequency range up to 2 000 MHz; that is, the input signal is directly fed to a broadband mixer. To avoid overload, to prevent damage and to operate a spectrum analyzer linearly, the signal amplitude at the mixer should typically be less than 150 mV peak. RF attenuation or additional RF preselection may be required to reduce the input signal to this level.

B.3 Linearity test

Linearity can be evaluated by measuring the level of the specific signal under investigation and repeating this measurement after an X dB attenuator has been inserted at the input of the receiver or, if used, the preamplifier ($X \geq 6$ dB). The new reading of the receiver display should differ by X dB up to ±0,5 dB from the first reading, if the measuring system is linear.

B.4 Selectivity

The spectrum analyzer and scanning receiver ~~must~~ shall have the bandwidths specified in CISPR 16-1-1 to correctly measure broadband and impulsive signals, and narrowband disturbances with several spectrum components within the standardized bandwidth.

B.5 Normal response to pulses

The response of a spectrum analyzer and a scanning receiver with quasi-peak detection can be verified with the calibration test pulses specified in CISPR 16-1-1. The large peak voltage of the calibration test pulses typically requires insertion of an RF attenuation of 40 dB or more to satisfy the linearity requirements. This decreases the sensitivity and makes the measurement of low repetition rate and isolated calibration test pulses impossible for bands B, C and D. If a preselecting filter is used ahead of the receiver, then the RF attenuation can be decreased. The filter limits the spectrum width of the calibration test pulse as seen by the mixer.

B.6 Peak detection

The normal (peak) detection mode of spectrum analyzers provides a display indication that, in principal, is never less than the quasi-peak indication. It is convenient to measure emissions using peak-detection because it allows faster frequency scans than quasi-peak detection. Those signals that are close to the emission limits then need to be re-measured using quasi-peak detection to record quasi-peak amplitudes.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

B.7 Frequency scan rate

The scan rate of a spectrum analyzer or a scanning receiver should be adjusted for the CISPR frequency band and the detection mode used. The minimum sweep time/frequency ~~or the fastest scan rate~~ is listed in the following table:

Band	Peak-detection	Quasi-peak detection
A	100 ms/kHz	20 s/kHz
B	100 ms/MHz	200 s/MHz
C and D	1 ms/MHz	20 s/MHz

For a spectrum analyzer or scanning receiver used in a fixed tuned non-scanning mode, the display sweep time may be adjusted independently of the detection mode and according to the needs for observing the behaviour of the emission. If the level of disturbance is not steady, the reading on the receiver must be observed for at least 15 s to determine the maximum (see 6.5.1).

B.8 Signal interception

The spectrum of intermittent emissions may be captured with peak-detection and digital display storage if provided. Multiple, fast frequency scans reduce the time to intercept an emission compared to a single, slow frequency scan. The starting time of the scans should be varied to avoid any synchronism with the emission and thereby hiding it. The total observation time for a given frequency range ~~must~~ shall be longer than the time between the emissions. Depending upon the kind of disturbance being measured, the peak detection measurements can replace all or part of the measurements needed using quasi-peak detection. Re-tests using a quasi-peak detector should then be made at frequencies where emission maxima have been found.

B.9 Average detection

Average detection with a spectrum analyzer is obtained by reducing the video bandwidth until no further smoothing of the displayed signal is observed. The sweep time ~~must~~ shall be increased with reductions in video bandwidth to maintain amplitude calibration. For such measurements, the receiver shall be used in the linear mode of the detector. After linear detection is made, the signal may be processed logarithmically for display, in which case the value is corrected even though it is the logarithm of the linearly detected signal.

A logarithmic amplitude display mode may be used, for example, to distinguish more easily between narrowband and broadband signals. The displayed value is the average of the logarithmically distorted IF signal envelope. It results in a larger attenuation of broadband signals than in the linear detection mode without affecting the display of narrowband signals. Video filtering in log-mode is, therefore, especially useful for estimating the narrowband component in a spectrum containing both.

B.10 Sensitivity

Sensitivity can be increased with low noise RF pre-amplification ahead of the spectrum analyzer. The input signal level to the amplifier should be adjustable with an attenuator to test the linearity of the overall system for the signal under examination.

The sensitivity to extremely broadband emissions that require large RF attenuation for system linearity is increased with RF preselecting filters ahead of the spectrum analyzer. The filters reduce the peak amplitude of the broadband emissions and less RF attenuation can be used.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Such filters may also be necessary to reject or attenuate strong out-of-band signals and the intermodulation products they cause. If such filters are used, they ~~must~~ shall be calibrated with broadband signals.

B.11 Amplitude accuracy

The amplitude accuracy of a spectrum analyzer or a scanning receiver may be verified by using a signal generator, power meter and precision attenuator. The characteristics of these instruments, cable and mismatch losses have to be analysed to estimate the errors in the verification test.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Annex C
(informative)

Scan rates and measurement times for use with the average detector

C.1 Purpose

This annex is intended to give guidance on the selection of scan rates and measurement times when measuring impulsive disturbance with the average detector.

The average detector serves the following purposes:

a) to suppress impulsive noise and thus to enhance the measurement of CW components in disturbance signals to be measured;

b) to suppress amplitude modulation (AM) in order to measure the carrier level of amplitude modulated signals;

c) to show the weighted peak reading for intermittent, unsteady or drifting narrowband disturbances using a standardized meter time constant.

Clause 6 of this standard defines the average measuring receiver for the frequency range 9 kHz to 1 GHz.

In order to select the proper video bandwidth and the corresponding scan rate or measurement time, the following considerations apply.

C.2 Suppression of disturbances

C.2.1 Suppression of impulsive disturbance

The pulse duration T_p of an impulsive disturbance is often determined by the IF bandwidth, B_{res}, i.e. $T_p = 1/B_{res}$. For the suppression of such noise, the suppression factor a is then determined by the video bandwidth B_{video} relative to the IF bandwidth, i.e. $a = 20 \log \lg (B_{res}/B_{video})$. The bandwidth B_{video} is determined by the bandwidth of the low-pass filter following the envelope detector. For longer pulses, the suppression factor will be lower than a. The minimum scan time $T_{s\,min}$ (and maximum scan rate $R_{s\,max}$) is determined using:

$$T_{s\,min} = \frac{k\,\Delta f}{B_{res}\,B_{video}} \tag{C.1}$$

$$R_{s\,max} = \frac{\Delta f}{T_{s\,min}} = \frac{B_{res}\,B_{video}}{k} \tag{C.2}$$

where

Δf is the frequency span and

k is a proportionality factor that depends on the speed of the measuring receiver or spectrum analyzer.

For the longer scan times, k is very close to a factor of one (1). If a video bandwidth of 100 Hz is selected, the maximum scan rates and pulse suppression factors in Table C.1 are obtained.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Table C.1 – Pulse suppression factors and scan rates for a 100 Hz video bandwidth

	Band A	Band B	Bands C and D
Frequency range	9 kHz to 150 kHz	150 kHz to 30 MHz	30 MHz to 1 000 MHz
IF bandwidth B_{res}	200 Hz	9 kHz	120 kHz
Video bandwidth B_{video}	100 Hz	100 Hz	100 Hz
Maximum scan rate	17,4 kHz/s	0,9 MHz/s	12 MHz/s
Maximum suppression factor	6 dB	39 dB	61,5 dB

This can be applied for product standards calling out quasi-peak and average limits in bands B (and C) if short pulses are expected in the disturbance signal. Compliance of the EUT with both limits shall be demonstrated. If the pulse repetition frequency is greater than 100 Hz and the quasi-peak limit is not exceeded by the impulsive disturbance, then the short pulses are sufficiently suppressed for average detection with a video bandwidth of 100 Hz.

C.2.2 Suppression of impulsive disturbance by digital averaging

Average detection may be done by digital averaging of the signal amplitude. An equivalent suppression effect can be achieved if the averaging time is equal to the inverse of the video filter bandwidth. In this case, the suppression factor a = 20 ~~log~~ lg ($T_{av}B_{res}$), where T_{av} is the averaging (or measuring) time at a certain frequency. Consequently a measurement time of 10 ms will produce the same suppression factor as a video bandwidth of 100 Hz. Digital averaging has the advantage of zero delay time, when switching from one frequency to another. On the other hand, for averaging of a certain pulse repetition frequency f_p, the result may vary depending on whether n or $(n + 1)$ pulses are averaged. This has an effect of less than 1 dB, for $(T_{av}f_p) > 10$.

C.2.3 Suppression of amplitude modulation

In order to measure the carrier of a modulated signal, the modulation has to be suppressed by signal averaging over a sufficiently long time, or by using a video filter of sufficient attenuation at the lowest frequency. If f_m is the lowest modulation frequency, and assuming that the maximum measurement error due to a 100 % modulation is limited to 1 dB, then the measurement time T_m should be $T_m = 10/f_m$.

C.3 Measurement of slowly intermittent, unsteady or drifting narrowband disturbances

In CISPR 16-1-1, the response to intermittent, unsteady or drifting narrowband disturbances is defined using the peak reading with meter time constants of 160 ms (for Bands A and B) and 100 ms (for Bands C and D). These time constants correspond to second order video filter bandwidths of 0,64 Hz or 1 Hz respectively. For correct measurements, these bandwidths would require very long measurement times (see Table C.2).

Table C.2 – Meter time constants and the corresponding video bandwidths and ~~maximum~~ minimum scan ~~rates~~ times

	Band A	Band B	Bands C and D
Frequency range	9 kHz to 150 kHz	150 kHz to 30 MHz	30 MHz to 1 000 MHz
IF bandwidth B_{res}	200 Hz	9 kHz	120 kHz
Meter time constant	160 ms	160 ms	100 ms
Video bandwidth B_{video}	0,64 Hz	0,64 Hz	1 Hz
~~Maximum~~ Minimum scan ~~rate~~ time	8,9 s/kHz	172 s/MHz	8,3 s/MHz

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

This applies, however, only for pulse repetition frequencies of 5 Hz or less. For all higher pulse widths and modulation frequencies, higher video filter bandwidths may be used (see C.2.1). Figure C.1 and Figure C.2 show the weighting function of a pulse with 10 ms pulse duration versus pulse repetition frequency f_p with peak reading (CISPR AV) and with true averaging (AV) for meter time constants of 160 ms (Figure C.1) and 100 ms (Figure C.2).

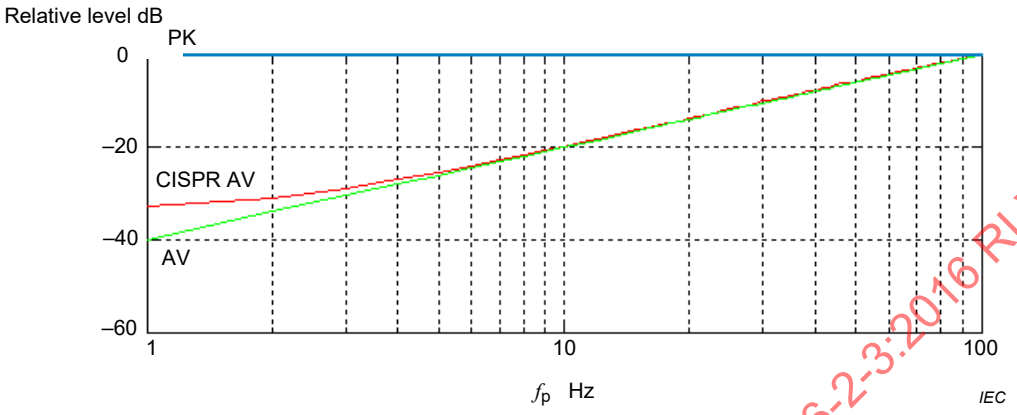


Figure C.1 – Weighting function of a 10 ms pulse for peak (PK) and average detections with (CISPR AV) and without (AV) peak reading: meter time constant 160 ms

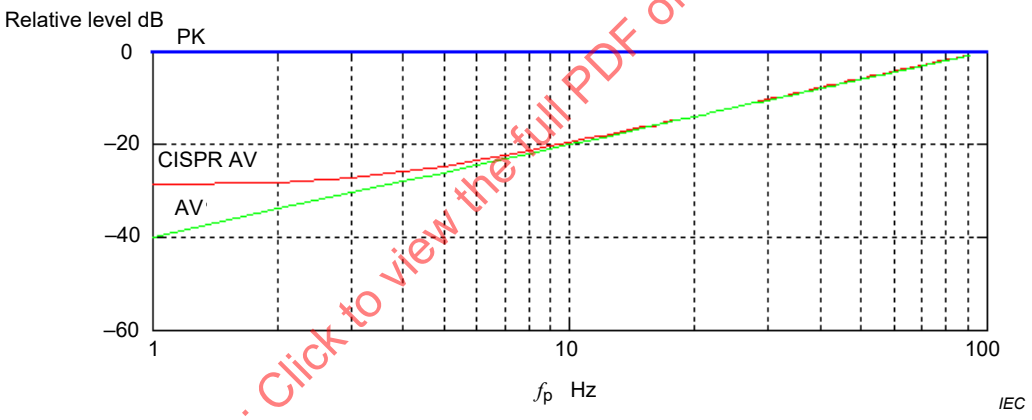


Figure C.2 – Weighting functions of a 10 ms pulse for peak (PK) and average detections with (CISPR AV) and without (AV) peak reading: meter time constant 100 ms

Figure C.1 and Figure C.2 imply that the difference between average with peak reading (CISPR AV) and without peak reading (AV) increases as the pulse repetition frequency f_p decreases. Figure C.3 and Figure C.4 show the difference for f_p = 1 Hz, as a function of pulse width.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

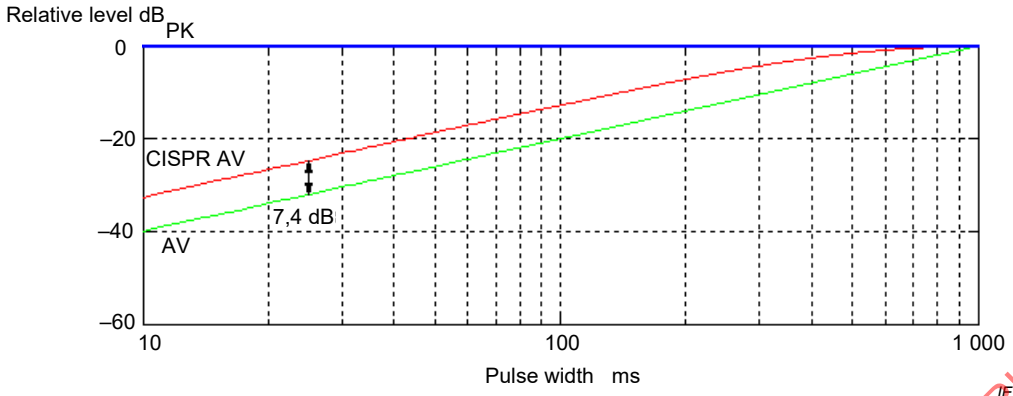


Figure C.3 – Example of weighting functions (of a 1 Hz pulse) for peak (PK) and average detections as a function of pulse width: meter time constant 160 ms

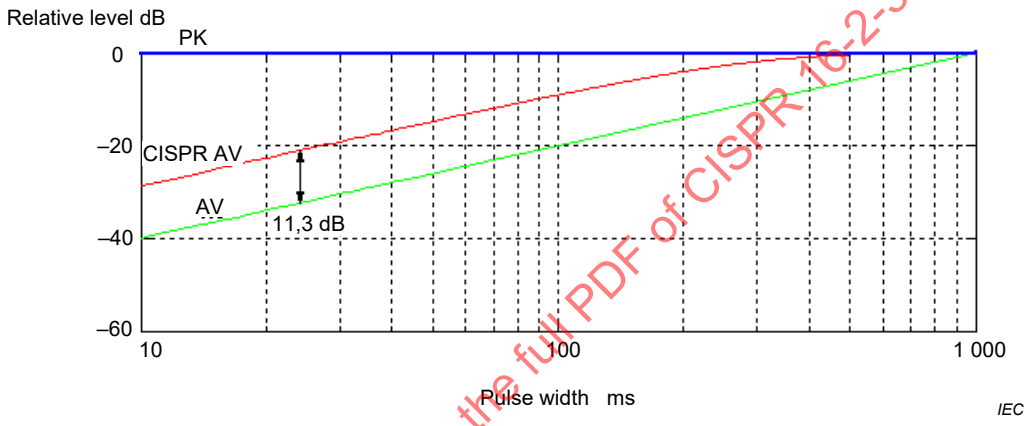


Figure C.4 – Example of weighting functions (of a 1 Hz pulse) for peak (PK) and average detections as a function of pulse width: meter time constant 100 ms

C.4 Recommended procedure for automated or semi-automated measurements

When measuring EUTs that do not emit slowly intermittent, unsteady or drifting narrowband disturbances, it is recommended to measure with the average detector using a video filter bandwidth of e.g. 100 Hz, i.e. a short averaging time during a pre-scan procedure. At frequencies where the emission is found to be close to the average limit, it is recommended to make a final measurement using a lower video filter bandwidth, i.e. a longer averaging time. (For the pre-scan/final measurement procedure, see also Clause 8).

For slowly intermittent, unsteady or drifting narrowband disturbances, manual measurements are the preferred method.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Annex D
(informative)

Explanation of the APD measurement method applying to the compliance test

One of the following two methods is used when the APD measurement is applied for a compliance test. Figure D.1 and Figure D.2 illustrate the specifics of the APD measurement methods, involving the measurement of the level of disturbance (i.e. Method 1, see 7.6.6.3.2) and the measurement of the probability (i.e. Method 2, see 7.6.6.3.3), respectively.

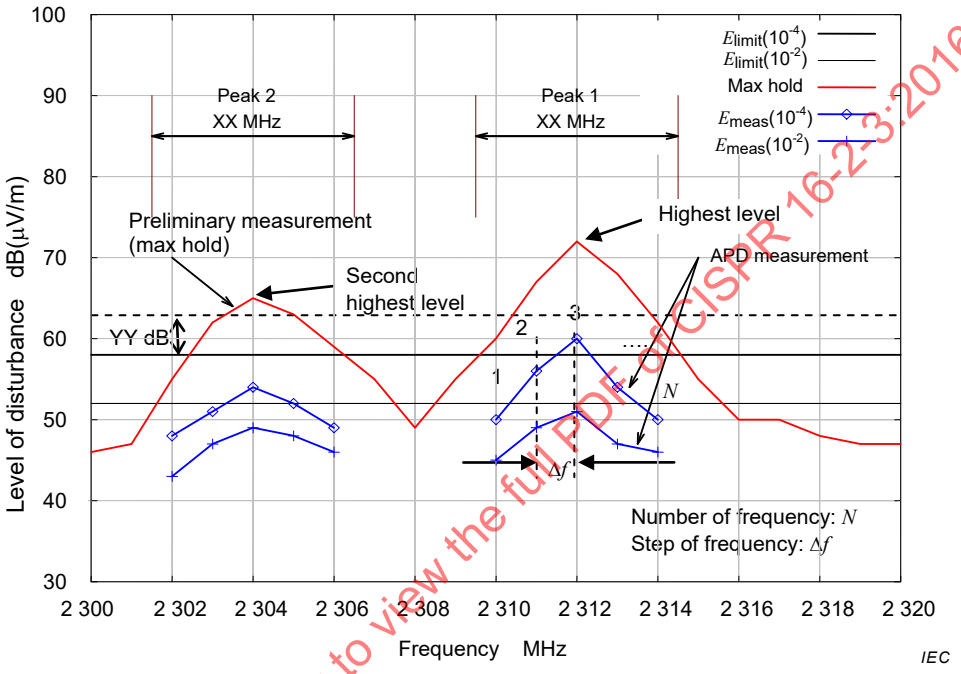


Figure D.1 – Example of APD measurement Method 1 for fluctuating disturbances

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

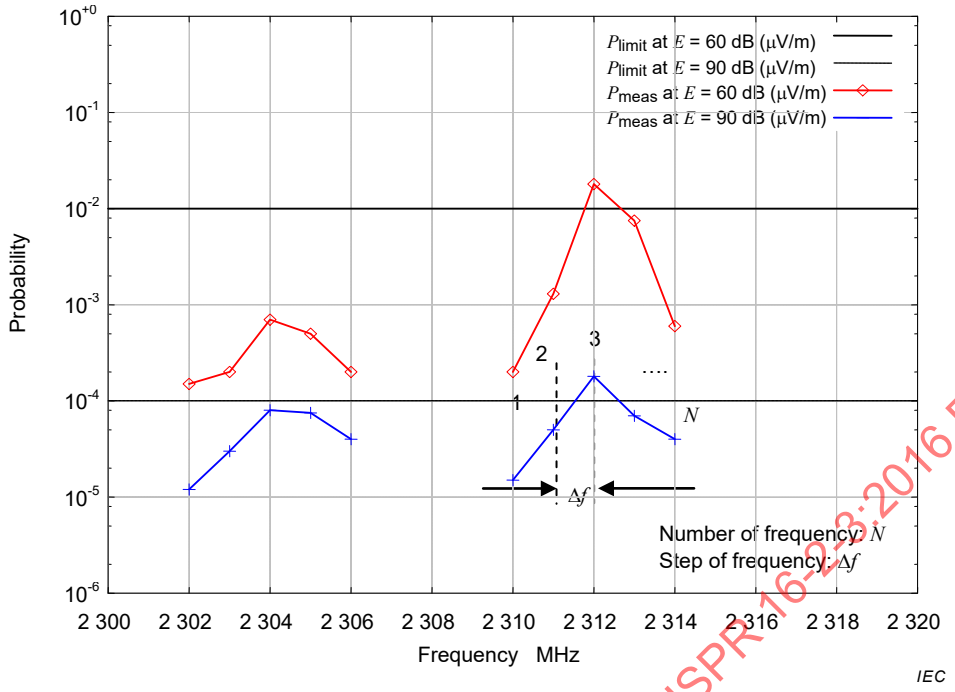


Figure D.2 – Example of APD measurement Method 2 for fluctuating disturbances

If the preliminary measurement results, obtained by using the maximum-hold display mode and peak detection, exceed the specified APD limit (the higher limit should be used if two APD limits apply) by YY dB at certain frequencies, then the APD measurement should be performed at these identified frequencies. The value YY dB is to be specified by the relevant product committee (e.g. YY = 5, 10, etc.).

In case of fluctuating disturbances, the product committee should specify the frequency range XX (= $\Delta f \times N$) MHz in which the APD measurements are to be performed, where Δf is the frequency step size and N is the number of frequencies. This frequency range should be specified according to the characteristics of the product.

As a first step, XX is determined by the preliminary measurement results. Then, Δf should be equal to the resolution bandwidth (RBW = 1 MHz for measurements above 1 GHz) of the spectrum analyzer. However, all frequencies that have an APD value within approximately 6 dB of the APD limit may require further investigation with a smaller frequency step size (i.e. $B_6/2$, where B_6 is the 6-dB bandwidth of the spectrum analyzer). RBW of the spectrum analyzer for measurements above 1 GHz is defined by the impulse bandwidth B_{imp} rather than the 6-dB bandwidth B_6. The relation between B_{imp} and B_6 is dependent upon the filter type, and cannot be generalized. If B_{imp} can be approximated to B_6, then the smaller frequency step size $B_6/2$ is recommended to be $B_{imp}/2$ (i.e. 0,5 MHz) for measurements above 1 GHz. Finally, N is determined from the values of XX and Δf.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Annex E
(normative)

Determination of suitability of spectrum analyzers for compliance tests

The user of a spectrum analyzer shall be able to demonstrate, either through specifications from the manufacturer or by measurement, that the analyzer meets the quasi-peak detection requirements for pulse-repetition frequencies greater than 20 Hz in the frequency range of use. For the average detector the response to pulses is called out in CISPR 16-1-1.

Since the measurement of the pulse repetition frequency of an emission may not always be possible, a simple method to verify the validity of the quasi-peak measurement shall be applied when a spectrum analyzer is used. This method is based on a comparison of measurement results with the peak and quasi-peak detectors. From the quasi-peak weighting functions, the amplitude differences shown in Table E.1 are the results of measurements for a signal with a pulse repetition frequency of 20 Hz.

Table E.1 – Maximum amplitude difference between peak and quasi-peak detected signals

Band A	Band B	Bands C and D
7 dB	13 dB	21 dB

The comparison measurement is to be made at signal frequencies that show an amplitude~~s~~ close to the applicable limit in quasi-peak detection. If the difference between the peak and quasi-peak detected amplitude is smaller than the value in Table E.1 the quasi-peak measurement is valid and the result obtained with a spectrum analyzer can be used to demonstrate compliance. If the amplitude difference is larger than the stated values in Table E.1 a measuring receiver that fully complies with the low-PRF requirements of CISPR 16-1-1 is to be used for the quasi-peak measurement instead of a spectrum analyzer. This comparison measurement requires an adequate signal-to-noise ratio to ensure proper results.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Bibliography

[1] CISPR 11:~~2009~~ 2015, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*

[2] CISPR 16-1-6:2014, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-6: Radio disturbance and immunity measuring apparatus – EMC antenna calibration*

[3] CISPR TR 16-3:~~2003~~ 2010, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 3: CISPR technical reports*
CISPR TR 16-3:2010/AMD1:2012
CISPR TR 16-3:2010/AMD2:2015

[4] CISPR 22:2008, *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement*

[5] IEC 61140:~~2001~~ 2016, *Protection against electric shock – Common aspects for installation and equipment*

[6] ISO/IEC Guide 2:2004, *Standardization and related activities – General vocabulary*

[7] ISO/IEC 17000:2004, *Conformity assessment – Vocabulary and general principles*

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

[9] ISO/IEC Guide 99:2007, *International vocabulary of metrology – Basic and general concepts and associated terms (VIM)*

[10] IEC 60050-151:2001, *International Electrotechnical Vocabulary – Part 151: Electrical and magnetic devices*
IEC 60050-151:2001/AMD1:2013
IEC 60050-151:2001/AMD2:2014

[11] Chen, Z., Foegelle, M.D. and Harrington, T., *Analysis of log periodic dipole array antennas for site validation and radiated emissions testing*, IEEE EMC Symposium, Seattle, 1999, p. 618-623

[12] Ryser, H., *Motivation for the use of CMAD in radiated emission measurements (CMAD: Common mode absorption devices)*, Report 2007-218-630, Federal Office of Metrology (METAS), Bern-Wabern, Switzerland, 11 September 2007, available as a downloaded PDF from http://www.metas.ch/2007-218-630

[13] IEC Guide 107, *Electromagnetic compatibility – Guide to the drafting of electromagnetic compatibility publications*

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

CISPR 16-2-3

Edition 4.0 2016-09

INTERNATIONAL STANDARD

NORME INTERNATIONALE

colour inside

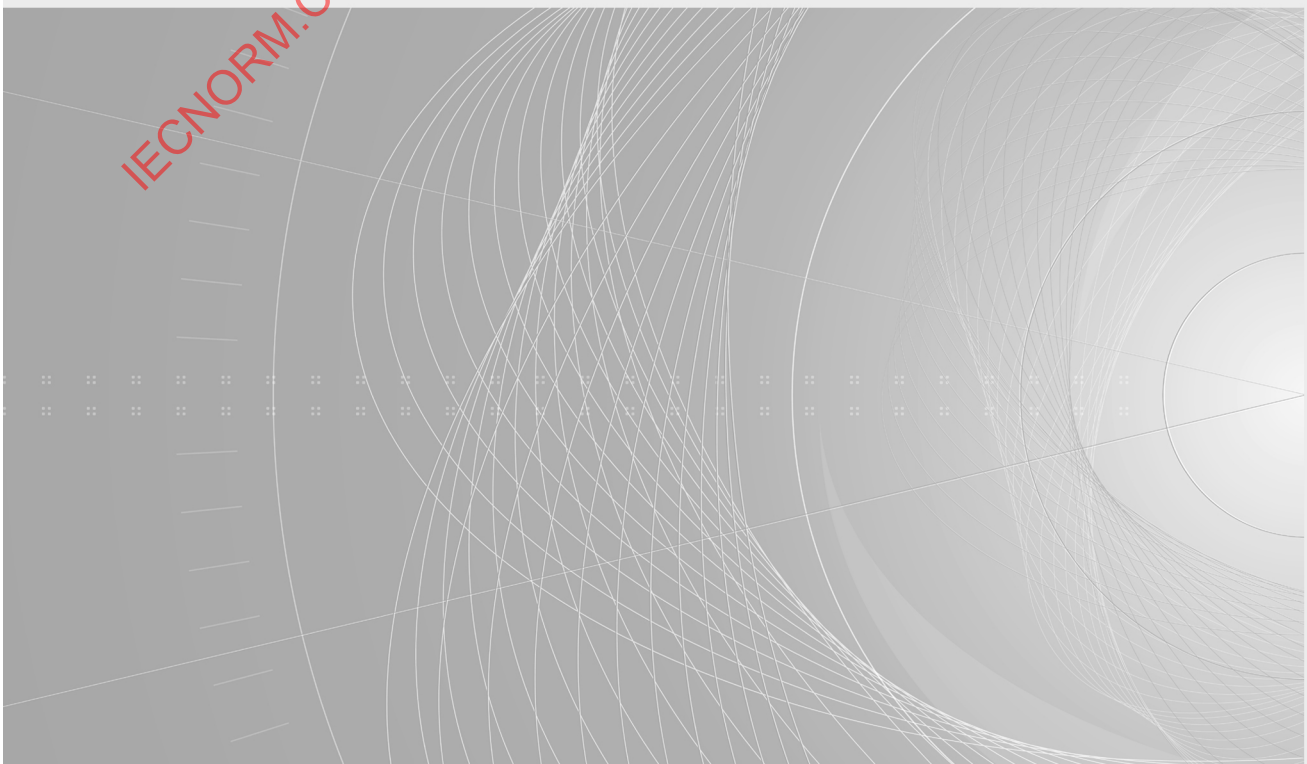
INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE
COMITÉ INTERNATIONAL SPÉCIAL DES PERTURBATIONS RADIOÉLECTRIQUES

BASIC EMC PUBLICATION
PUBLICATION FONDAMENTALE EN CEM

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

Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques –
Partie 2-3: Méthodes de mesure des perturbations et de l'immunité – Mesurages des perturbations rayonnées

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



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

CONTENTS

FOREWORD 7
1 Scope 9
2 Normative references 9
3 Terms, definitions and abbreviations 10
3.1 Terms and definitions 10
3.2 Abbreviated terms 15
4 Types of disturbance to be measured 16
4.1 General 16
4.2 Types of disturbance 16
4.3 Detector functions 16
5 Connection of measuring equipment 16
6 General measurement requirements and conditions 17
6.1 General 17
6.2 Disturbance not produced by the equipment under test 17
6.2.1 General 17
6.2.2 Compliance (conformity assessment) testing 17
6.3 Measurement of continuous disturbance 17
6.3.1 Narrowband continuous disturbance 17
6.3.2 Broadband continuous disturbance 17
6.3.3 Use of spectrum analyzers and scanning receivers 17
6.4 EUT arrangement and measurement conditions 18
6.4.1 General arrangement of the EUT 18
6.4.2 Operation of the EUT 20
6.4.3 EUT time of operation 20
6.4.4 EUT running-in time 21
6.4.5 EUT supply 21
6.4.6 EUT mode of operation 21
6.4.7 Operation of multifunction equipment 21
6.4.8 Determination of arrangement(s) causing maximum emissions 21
6.4.9 Recording of measurements 21
6.5 Interpretation of measuring results 22
6.5.1 Continuous disturbance 22
6.5.2 Discontinuous disturbance 22
6.5.3 Measurement of the duration of disturbance 22
6.6 Measurement times and scan rates for continuous disturbance 22
6.6.1 General 22
6.6.2 Minimum measurement times 23
6.6.3 Scan rates for scanning receivers and spectrum analyzers 23
6.6.4 Scan times for stepping receivers 24
6.6.5 Strategies for obtaining a spectrum overview using the peak detector 25
6.6.6 Timing considerations using FFT-based instruments 29
7 Measurement of radiated disturbances 32
7.1 Introductory remarks 32
7.2 Loop-antenna system measurements (9 kHz to 30 MHz) 33
7.2.1 General 33
7.2.2 General measurement method 33

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

7.2.3 Test environment 34
7.2.4 Configuration of the equipment under test 35
7.2.5 Measurement uncertainty for LAS 35
7.3 Open-area test site or semi-anechoic chamber measurements (30 MHz to 1 GHz) 35
7.3.1 Measurand 35
7.3.2 Test site requirements 38
7.3.3 General measurement method 38
7.3.4 Measurement distance 39
7.3.5 Antenna height variation 40
7.3.6 Product specification details 40
7.3.7 Measurement instrumentation 42
7.3.8 Field-strength measurements on other outdoor sites 42
7.3.9 Measurement uncertainty for OATS and SAC 42
7.4 Fully-anechoic room measurements (30 MHz to 1 GHz) 42
7.4.1 Test set-up and site geometry 42
7.4.2 EUT position 45
7.4.3 Cable layout and termination 46
7.4.4 Measurement uncertainty for FAR 47
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 47
7.5.1 Applicability 47
7.5.2 EUT perimeter definition and antenna-to-EUT separation distance 47
7.5.3 Uniform test volume 48
7.5.4 Specifications for EUT set-up in common emissions/immunity test set-up 49
7.5.5 Measurement uncertainty for common emission/immunity set-up and method 55
7.6 Fully-anechoic room and absorber-lined OATS/SAC measurements (1 GHz to 18 GHz) 55
7.6.1 Quantity to measure 55
7.6.2 Measurement distance 55
7.6.3 Set-up and operating conditions of the equipment under test (EUT) 56
7.6.4 Measurement site 56
7.6.5 Measurement instrumentation 56
7.6.6 Measurement procedure 57
7.6.7 Measurement uncertainty for FAR 63
7.7 *In situ* measurements (9 kHz to 18 GHz) 64
7.7.1 Applicability of and preparation for *in situ* measurements 64
7.7.2 Field-strength measurements *in situ* in the frequency range 9 kHz to 30 MHz 65
7.7.3 Field-strength measurements *in situ* in the frequency range above 30 MHz 65
7.7.4 *In situ* measurement of the disturbance effective radiated power using the substitution method 66
7.7.5 Documentation of the measurement results 70
7.7.6 Measurement uncertainty for *in situ* method 70
7.8 Substitution measurements (30 MHz to 18 GHz) 70
7.8.1 General 70
7.8.2 Test site 71

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

7.8.3 Test antennas 71
7.8.4 EUT configuration 72
7.8.5 Test procedure 72
7.8.6 Measurement uncertainty for substitution method 72
7.9 Reverberation chamber measurements (80 MHz to 18 GHz) 72
7.10 TEM waveguide measurements (30 MHz to 18 GHz) 72
8 Automated measurement of emissions 72
8.1 Introduction – Precautions for automated measurements 72
8.2 Generic measurement procedure 73
8.3 Pre-scan measurements 73
8.3.1 General 73
8.3.2 Determination of the required measurement time 74
8.3.3 Pre-scan requirements for different types of measurements 74
8.4 Data reduction 75
8.5 Emission maximization and final measurement 76
8.6 Post-processing and reporting 77
8.7 Emission measurement strategies with FFT-based measuring instruments 77
Annex A (informative) Measurement of disturbances in the presence of ambient emissions 78
A.1 General 78
A.2 Terms and definitions 78
A.3 Problem description 78
A.4 Proposed solution 78
A.4.1 Overview 78
A.4.2 Pre-testing the EUT in a shielded room 81
A.4.3 Method of measurement of EUT disturbances in the presence of narrowband ambient emissions 82
A.4.4 Method of measurement of EUT disturbance in the presence of broadband ambient emissions 85
A.5 Determination of the EUT disturbance in case of superposition 87
Annex B (informative) Use of spectrum analyzers and scanning receivers 92
B.1 General 92
B.2 Overload 92
B.3 Linearity test 92
B.4 Selectivity 92
B.5 Normal response to pulses 92
B.6 Peak detection 92
B.7 Frequency scan rate 93
B.8 Signal interception 93
B.9 Average detection 93
B.10 Sensitivity 93
B.11 Amplitude accuracy 94
Annex C (informative) Scan rates and measurement times for use with the average detector 95
C.1 Purpose 95
C.2 Suppression of disturbances 95
C.2.1 Suppression of impulsive disturbance 95
C.2.2 Suppression of impulsive disturbance by digital averaging 96
C.2.3 Suppression of amplitude modulation 96

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

C.3 Measurement of slowly intermittent, unsteady or drifting narrowband disturbances 96
C.4 Recommended procedure for automated or semi-automated measurements 98
Annex D (informative) Explanation of the APD measurement method applying to the compliance test 99
Annex E (normative) Determination of suitability of spectrum analyzers for compliance tests 101
Bibliography 102

Figure 1 – Measurement of a combination of a CW signal (NB) and an impulsive signal (BB) using multiple sweeps with maximum hold 26
Figure 2 – Example of a timing analysis 27
Figure 3 – A broadband spectrum measured with a stepped receiver 28
Figure 4 – Intermittent narrowband disturbances measured using fast short repetitive sweeps with maximum hold function to obtain an overview of the emission spectrum 29
Figure 5 – FFT scan in segments 31
Figure 6 – Frequency resolution enhanced by FFT-based measuring instrument 32
Figure 7 – Concept of magnetic field induced current measurements made with the loop antenna system 34
Figure 8 – Measurement distance 36
Figure 9 – Separation distance relative to the phase centre of an LPDA antenna 38
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 39
Figure 11 – Position of CMAD for table-top equipment on OATS or in SAC 42
Figure 12 – Typical FAR site geometry where a, b, c, e depend upon the room performance 43
Figure 13 – Typical test set-up for table-top equipment within the test volume of a FAR 44
Figure 14 – Typical test set-up for floor-standing equipment within the test volume of a FAR 45
Figure 15 – Positions of reference planes for uniform field calibration (top-view) 48
Figure 16 – Test set-up for table-top equipment 52
Figure 17 – Test set-up for table-top equipment – Top view 53
Figure 18 – Test set-up for floor-standing equipment 54
Figure 19 – Test set-up for floor-standing equipment – Top view 55
Figure 20 – Measurement method above 1 GHz, receive antenna in vertical polarization 57
Figure 21 – Illustration of height scan requirements for two different categories of EUTs 59
Figure 22 – Determination of the transition distance 69
Figure 23 – Substitution method set-up geometries for: a) measurement, b) calibration 71
Figure 24 – Process to give reduction of measurement time 73
Figure A.1 – Flow diagram for the selection of bandwidths and detectors and the estimated measurement errors due to that selection 80
Figure A.2 – Relative difference in adjacent emission amplitudes during preliminary testing 82
Figure A.3 – Disturbance by an unmodulated signal (dotted line) 83

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Figure A.4 – Disturbance by an amplitude-modulated signal (dotted line) 83
Figure A.5 – Indication of an amplitude-modulated signal as a function of modulation frequency with the QP detector in CISPR bands B, C and D 84
Figure A.6 – Indication of a pulse-modulated signal (pulse width 50 μs) as a function of pulse repetition frequency with peak, QP and average detectors 85
Figure A.7 – Disturbance by a broadband signal (dotted line) 85
Figure A.8 – Unmodulated EUT disturbance (dotted line) 86
Figure A.9 – Amplitude-modulated EUT disturbance (dotted line) 87
Figure A.10 – Increase of peak value with superposition of two unmodulated signals 88
Figure A.11 – Determination of the amplitude of the disturbance signal by means of the amplitude ratio d and the factor i (see Equation (A.3) and Equation (A.6)) 89
Figure A.12 – Increase of average indication measured with a real receiver and calculated from Equation (A.8) 90
Figure C.1 – Weighting function of a 10 ms pulse for peak (PK) and average detections with (CISPR AV) and without (AV) peak reading: meter time constant 160 ms 97
Figure C.2 – Weighting functions of a 10 ms pulse for peak (PK) and average detections with (CISPR AV) and without (AV) peak reading: meter time constant 100 ms 97
Figure C.3 – Example of weighting functions (of a 1 Hz pulse) for peak (PK) and average detections as a function of pulse width: meter time constant 160 ms 98
Figure C.4 – Example of weighting functions (of a 1 Hz pulse) for peak (PK) and average detections as a function of pulse width: meter time constant 100 ms 98
Figure D.1 – Example of APD measurement Method 1 for fluctuating disturbances 99
Figure D.2 – Example of APD measurement Method 2 for fluctuating disturbances 100

Table 1 – Minimum measurement times for the four CISPR bands 23
Table 2 – Minimum scan times for the three CISPR bands with peak and quasi-peak detectors 23
Table 3 – Applicable frequency ranges and document references for CISPR radiated emission test sites and test methods 33
Table 4 – Minimum dimension of w (w_{min}) 58
Table 5 – Example values of w for three antenna types 59
Table 6 – Horizontal polarization correction factors as a function of frequency 69
Table 7 – Recommended antenna heights to guarantee signal interception (for pre-scan) in the frequency range 30 MHz to 1 000 MHz 75
Table A.1 – Combinations of EUT disturbance and ambient emissions 79
Table A.2 – Measurement error depending on the detector type and on the combination of ambient and disturbing signal spectra 91
Table C.1 – Pulse suppression factors and scan rates for a 100 Hz video bandwidth 96
Table C.2 – Meter time constants and the corresponding video bandwidths and minimum scan times 96
Table E.1 – Maximum amplitude difference between peak and quasi-peak detected signals 101

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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

FOREWORD

1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
6) All users should ensure that they have the latest edition of this publication.
7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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

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

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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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 14-1:2016, *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 16-1-2:2014, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-2: Radio disturbance and immunity measuring apparatus – Coupling devices for conducted disturbance measurements*

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

CISPR 16-2-1:2014, *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*

CISPR 16-4-2, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-2: Uncertainties, statistics and limit modelling – Measurement instrumentation uncertainty*

---

1 Numbers in square brackets refer to the Bibliography.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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, *International Electrotechnical Vocabulary – Chapter 161: Electromagnetic compatibility*

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.

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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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]

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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

[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
enclosure, whose six internal surfaces are lined with radio-frequency absorbing material (i.e. RF absorber) that 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

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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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 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 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.

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]]

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

3.1.22
semi-anechoic chamber
SAC
shielded enclosure in which five of the six internal surfaces are lined with radio-frequency absorbing material (i.e. RF absorber) that 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

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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

2 Figures in square brackets refer to the Bibliography.

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;

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

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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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.

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 ambient noise level exceed 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.

When evaluating compliance 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. Further guidance on measurement of disturbances in the presence of ambient emissions is provided in Annex A.

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 shall be given to certain characteristics of these instruments, which include overload, linearity, selectivity,

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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 EUT arrangement and measurement conditions

The EUT shall be operated under the following conditions.

6.4.1 General arrangement of the EUT

6.4.1.1 General

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.

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.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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).

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.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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.

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 EUT shall be continuously operated throughout the test.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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 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 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.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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:

- 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.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

6.6.2 Minimum measurement times

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

Depending on the type of disturbance, the scan time may have to be increased – even for quasi-peak measurements. In 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 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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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:

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

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 $T_{\mathrm{s\,min}}$ 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 $T_{\mathrm{s\,min}}$ for a stepping receiver can be calculated using the following equation:

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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

where $T_{\mathrm{m\ min}}$ 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

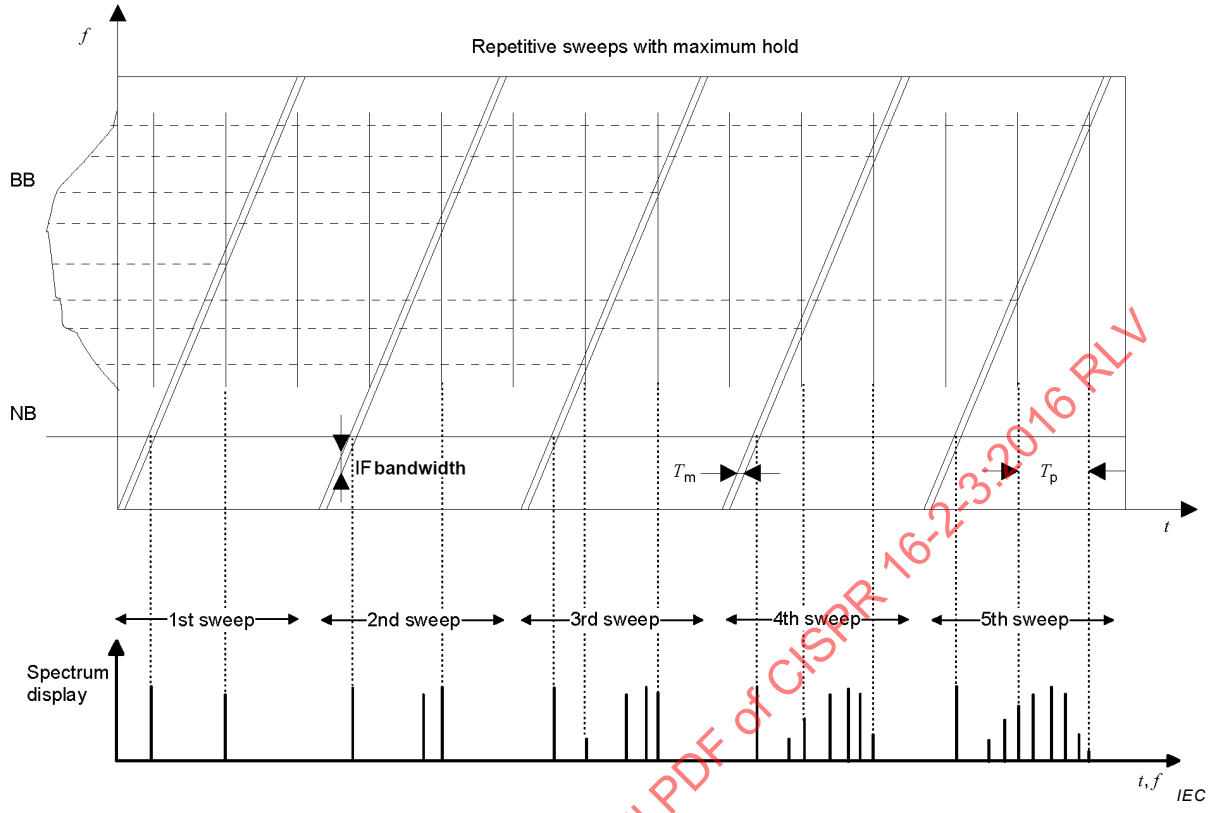
For each pre-scan measurement, the probability of intercepting all critical spectral components of the EUT spectrum shall be equal to 100 % or as close to 100 % as possible. Depending on the type of measuring receiver and the characteristics of the disturbance, that may contain narrowband and broadband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

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.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



Key:

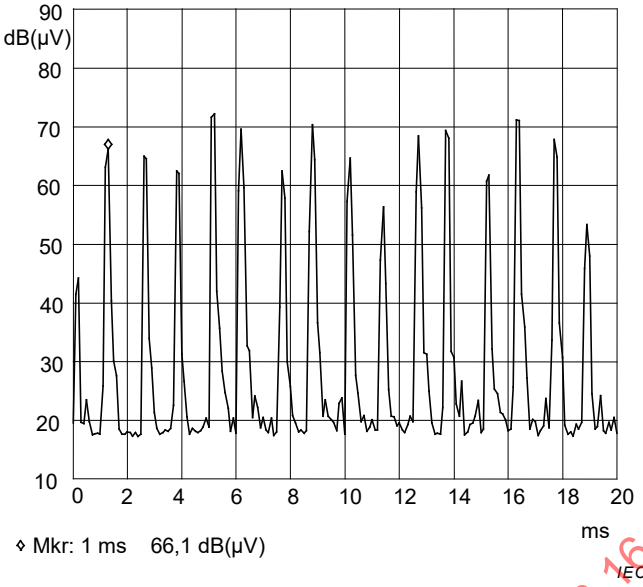
T_o is the pulse-repetition interval of the impulsive signal. A pulse occurs at each vertical line of the spectrum versus time display (upper part of the figure).

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.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



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:

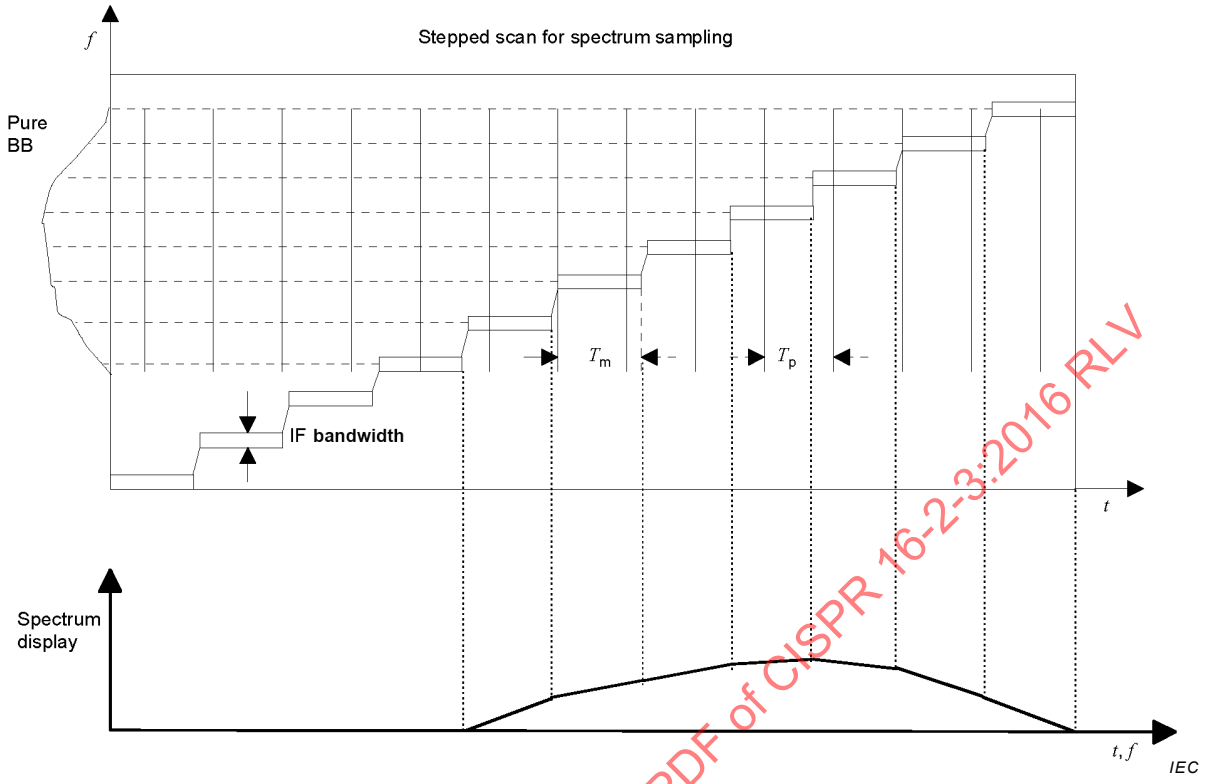
– for **continuous unmodulated narrowband** disturbances, the fastest scan time possible for the selected instrument settings may be used;

– 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.

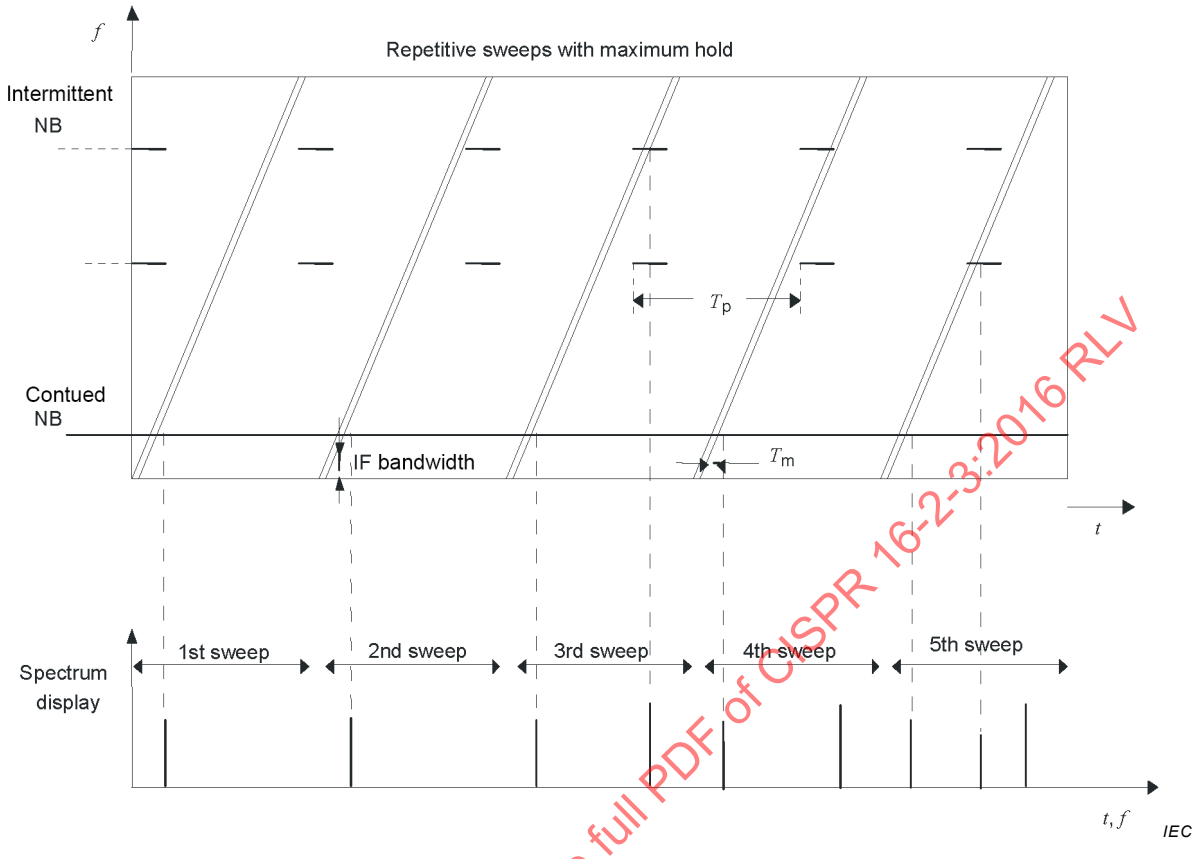
IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



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, $f_{step\ final}$.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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].

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

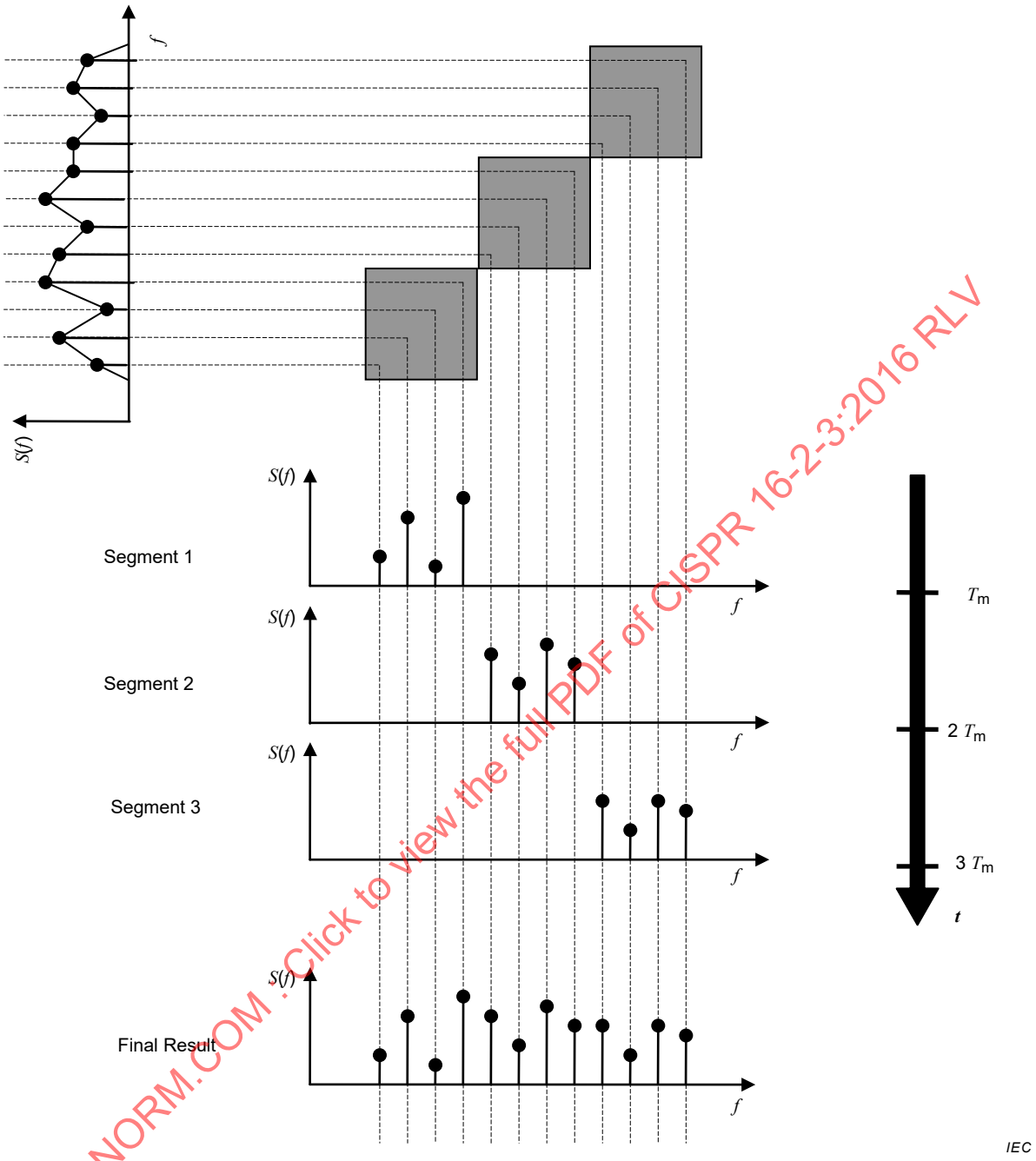
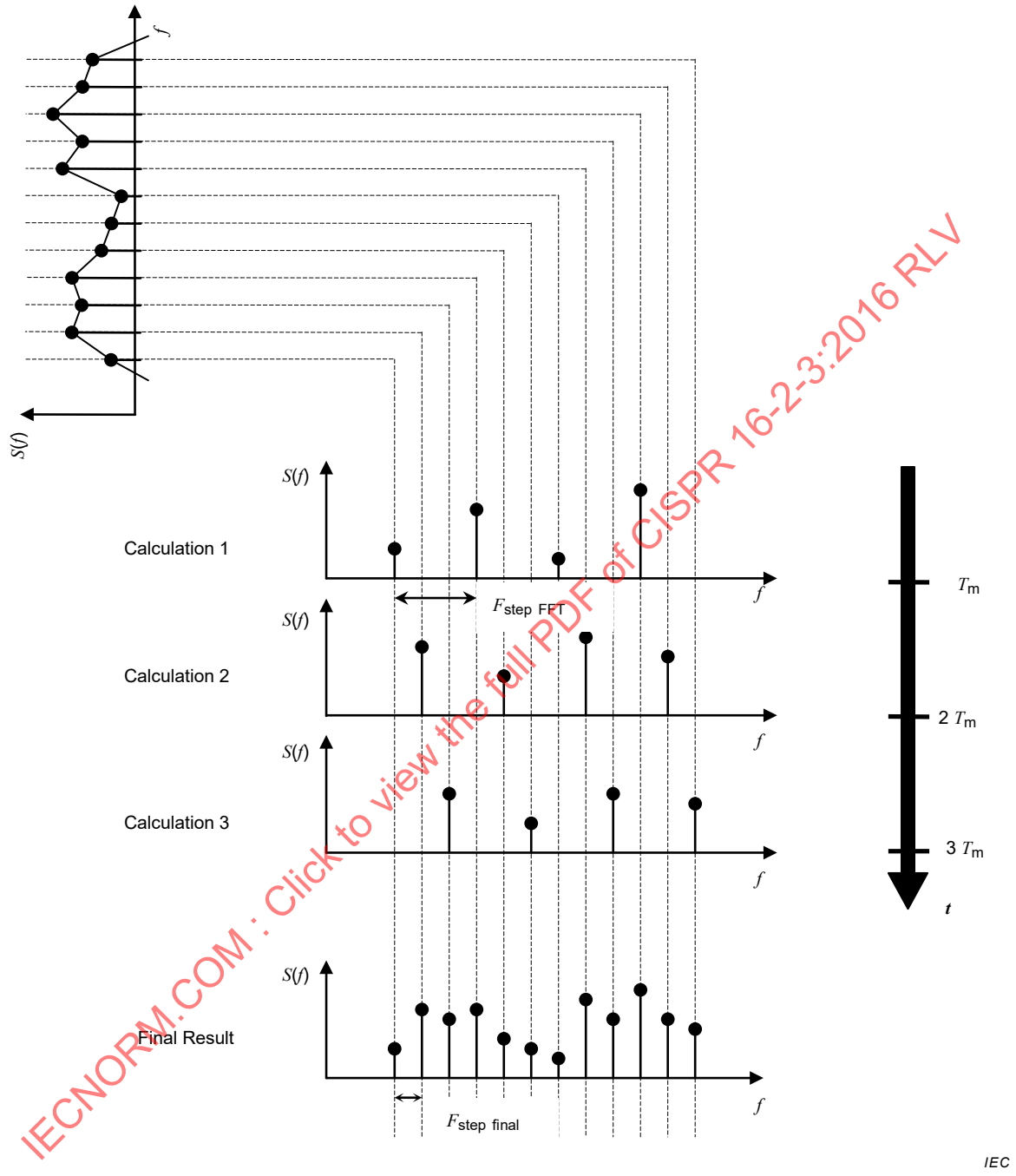


Figure 5 – FFT scan in segments

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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

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			

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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

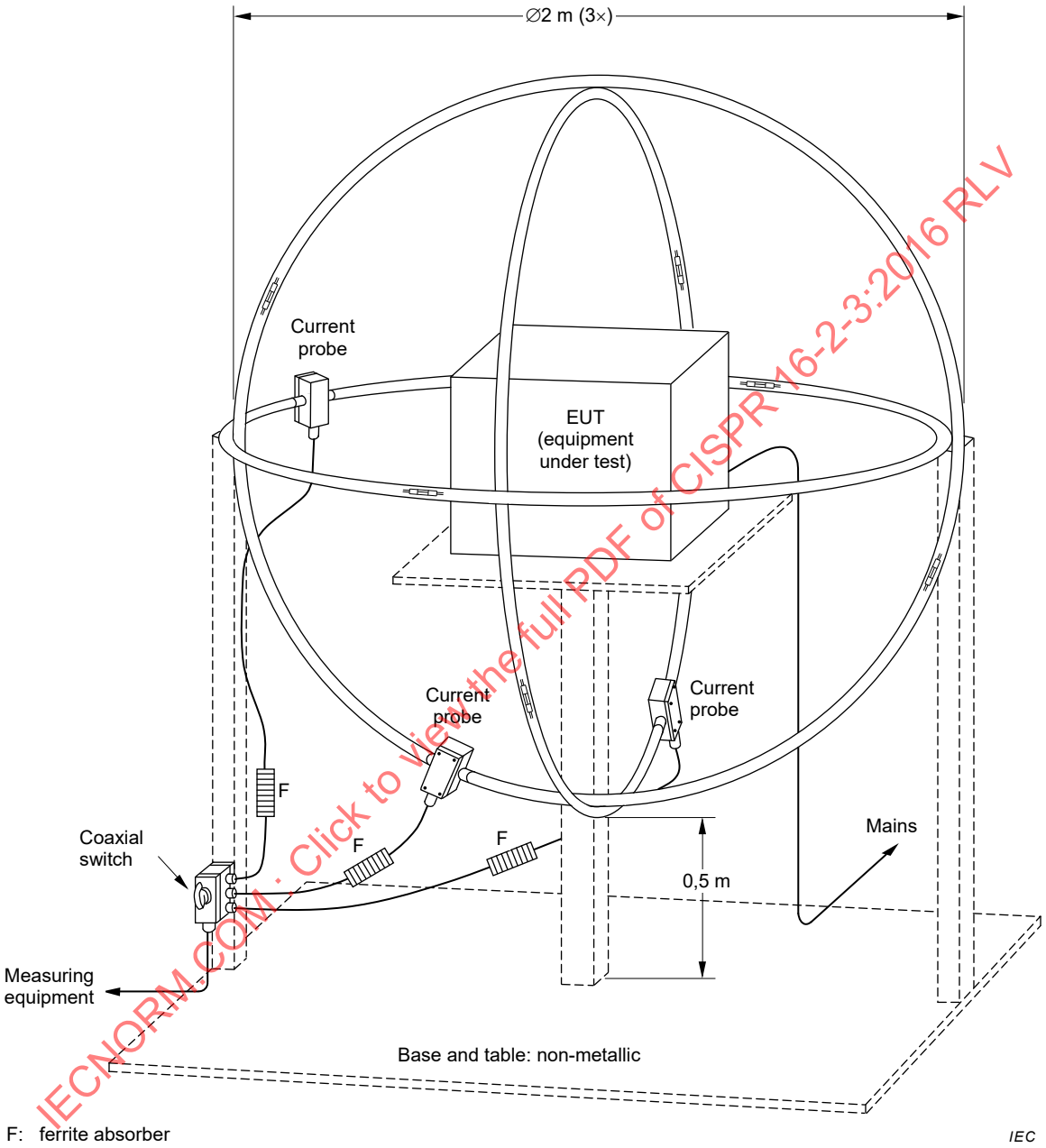
7.2.1 General

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.

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.



IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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.

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:

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

$$E = V_r + A_c + F_a \quad (7)$$

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.

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.

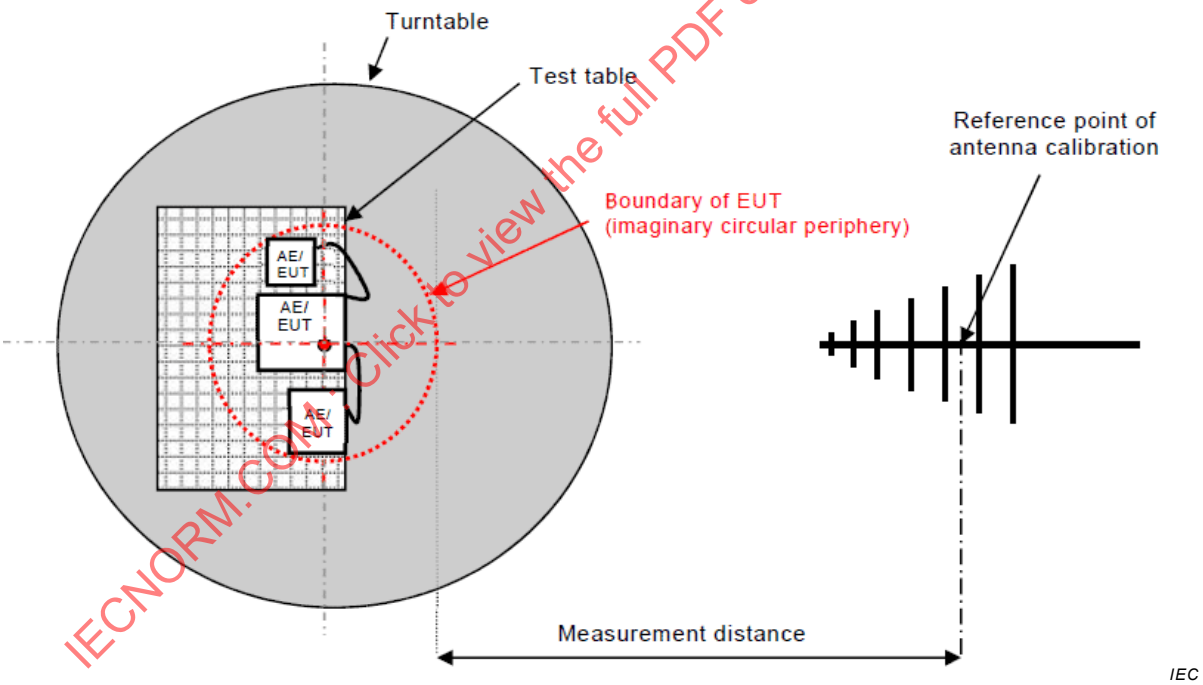


Figure 8 – Measurement distance

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.

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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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

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_{1P} 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.

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

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 $0{,}9 \times 150/f$ 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.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

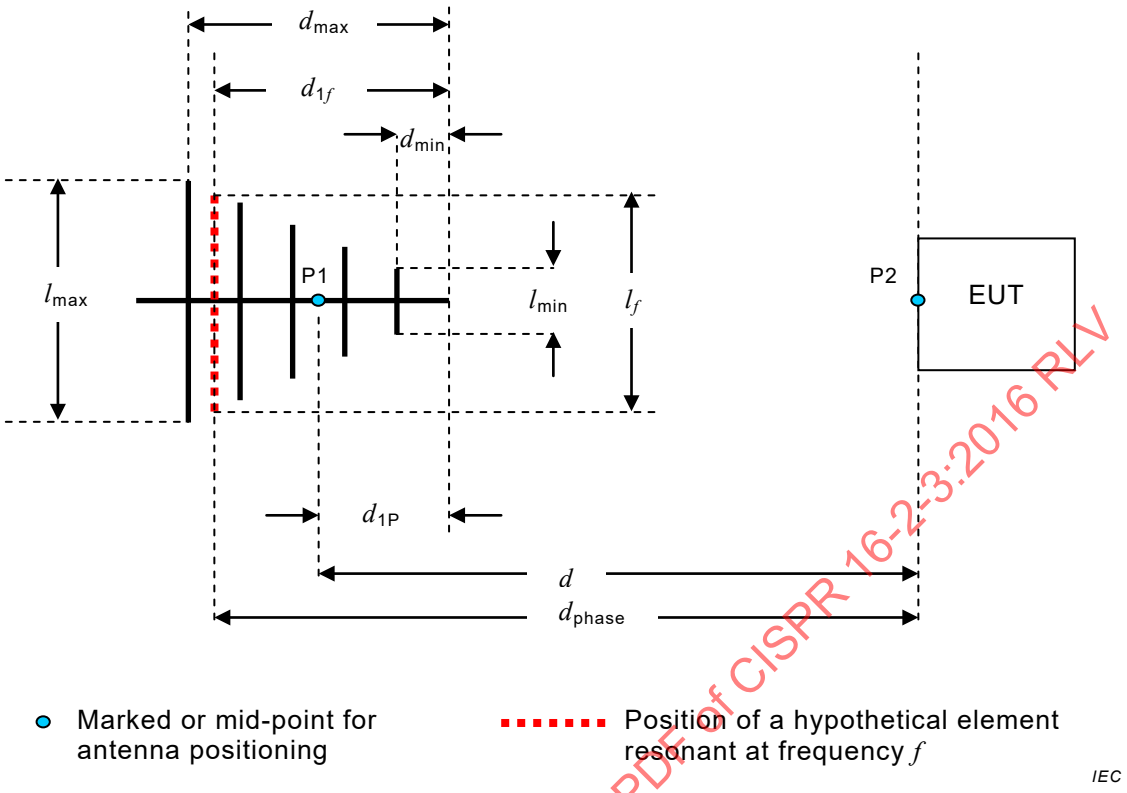


Figure 9 – Separation distance relative to the phase centre of an LPDA antenna

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.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

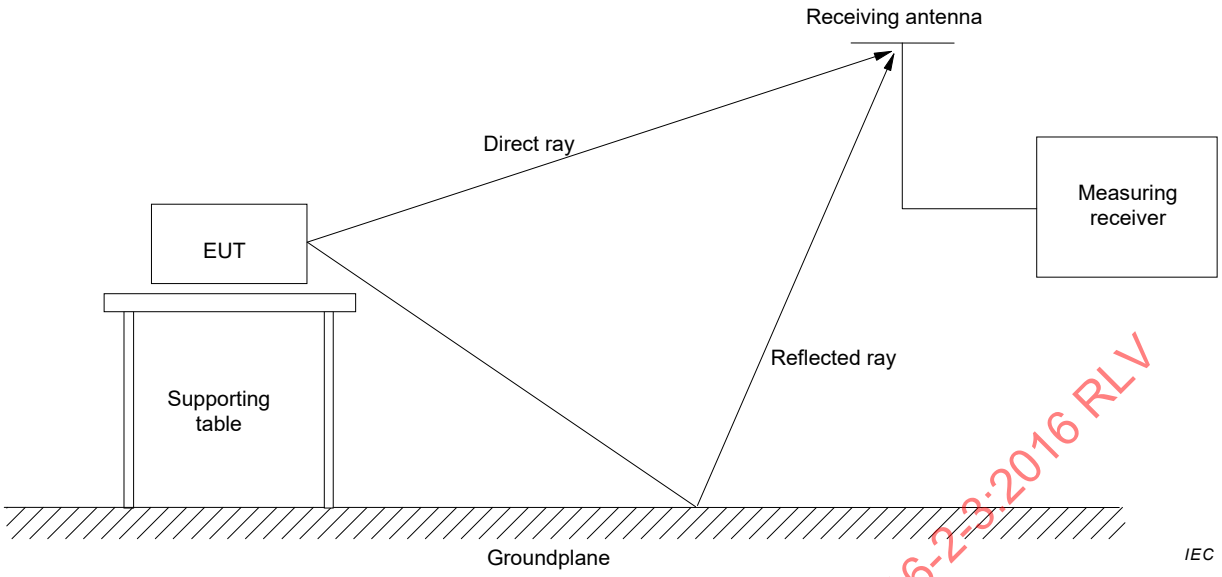


Figure 10 – Concept of electric field strength measurements made on an open-area test site (OATS) or semi-anechoic chamber (SAC) showing the direct and reflected rays arriving at the receiving antenna

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: $\lg(f_{centre}) = (\lg f_{min} + \lg f_{max})/2$; $f_{centre} = 10^{\lg(f\ centre)}$.

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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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. 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 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.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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 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 EUT

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.

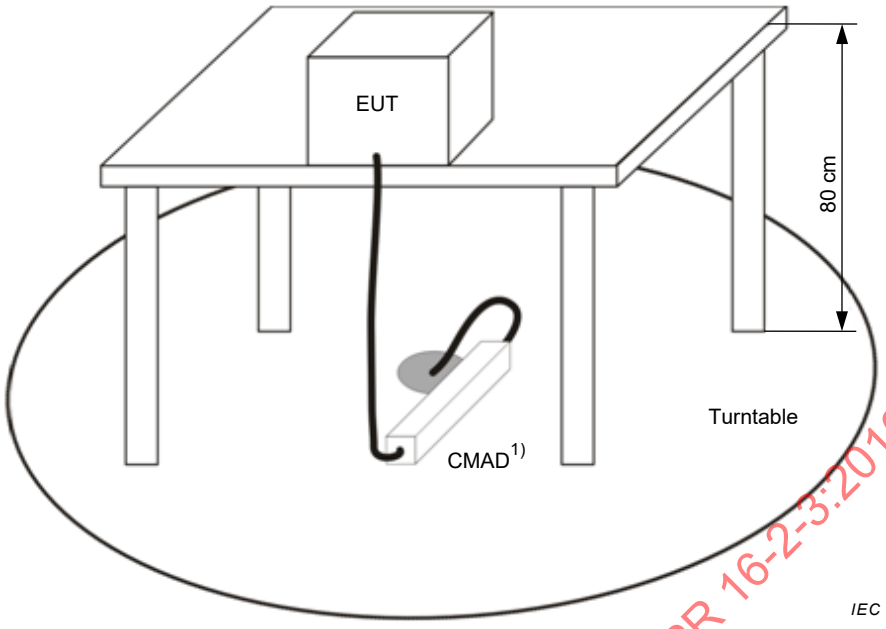
In order to avoid saturation, high common mode current power cables (e.g. the output port of inverters) should not be treated with CMADs unless the CMADs in use are specifically designed for high common mode currents.

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].

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



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.

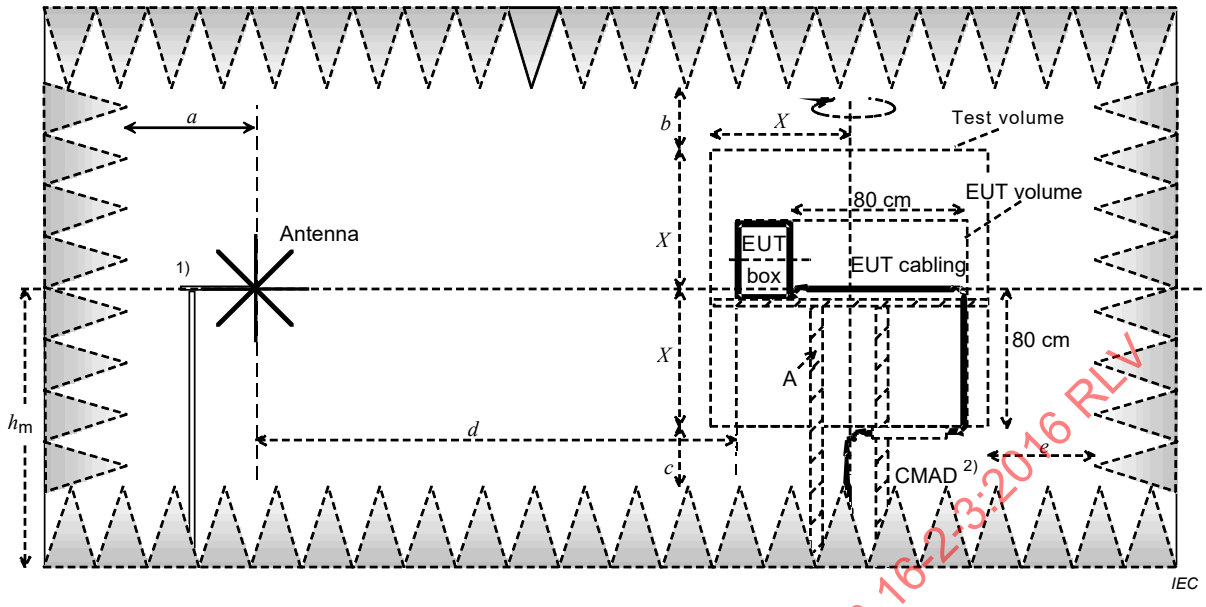
7.4 Fully anechoic room measurements (30 MHz to 1 GHz)

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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



Key

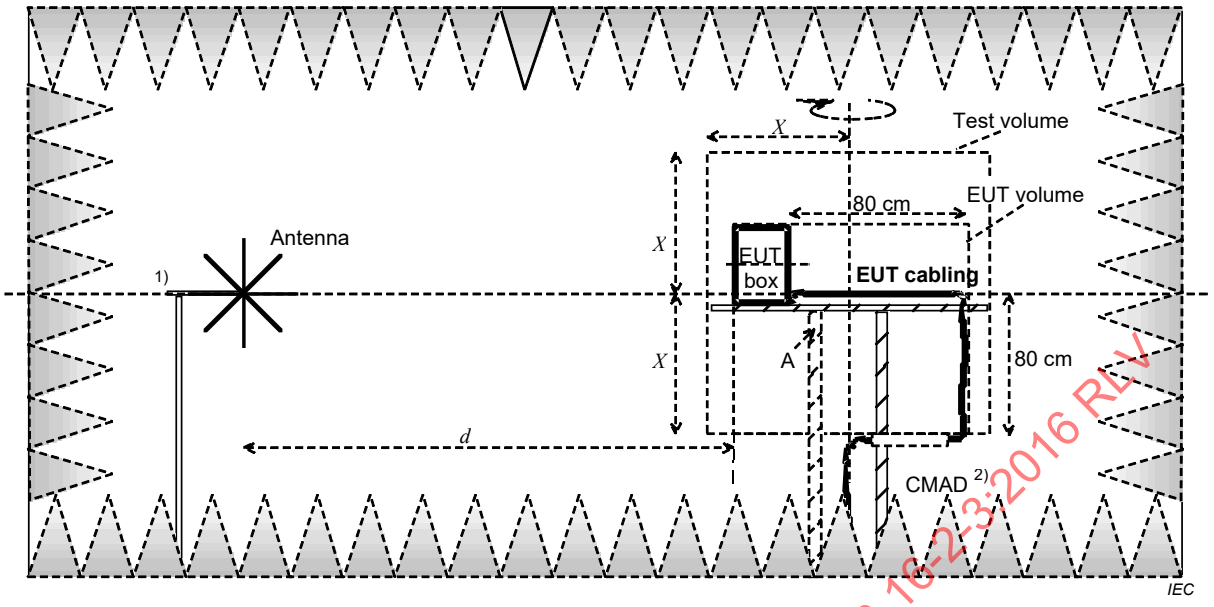
A	turntable and EUT support fixture
2X	1,5 m, 2,5 m, 5 m – corresponds to test distance used (3 m, 5 m, or 10 m respectively)
h_m	middle level of the test volume
a, b, c, e	≥0,5 m recommended (≥1 m is more convenient), the actual value is consistent with the FAR validation procedure of CISPR 16-1-4
d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

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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



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).

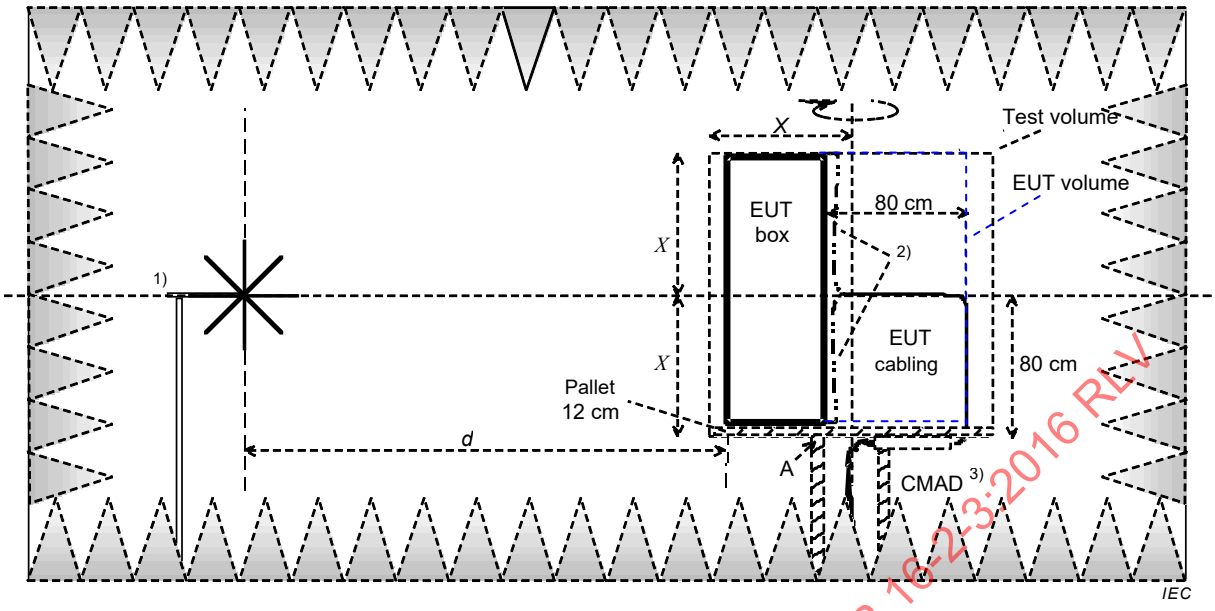
2) CMADs shall comply with the relevant specifications of CISPR 16-1-4. Their use shall be documented in the test report.

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.

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.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



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 shall comply with the relevant specifications of CISPR 16-1-4. Their use 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 normal 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.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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 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 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 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 whenever possible. Measures against RF-leakage into the FAR through the interconnection cables shall be taken.

e) The test set-up, including cable layout and details of attached cables and terminations, 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.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

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 determining its distance from the EUT is the identified reference point. However, if the reference point is not specified, the reference point is a point along the horizontal antenna boom midway between the dipole antenna elements that correspond to a half wavelength of the upper and lower frequency limits to be evaluated.

NOTE For a log-periodic antenna, the manufacturer may specify the reference point.

For a given frequency, the correction ΔE in dB in Equation (8) is 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. If a phase centre correction is not included, it shall be considered in the uncertainty budget. Refer to 7.3.1 for more details.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

The EUT perimeter is defined by the smallest virtual (imaginary) rectangle encompassing the EUT. All intersystem cables shall be included within this perimeter (see Figure 15). Each edge of this perimeter shall lie in one of the four face planes of the EUT, co-planar with (and possibly residing within) the uniform field areas (UFAs) calibrated for immunity tests, depending upon the horizontal test distance.

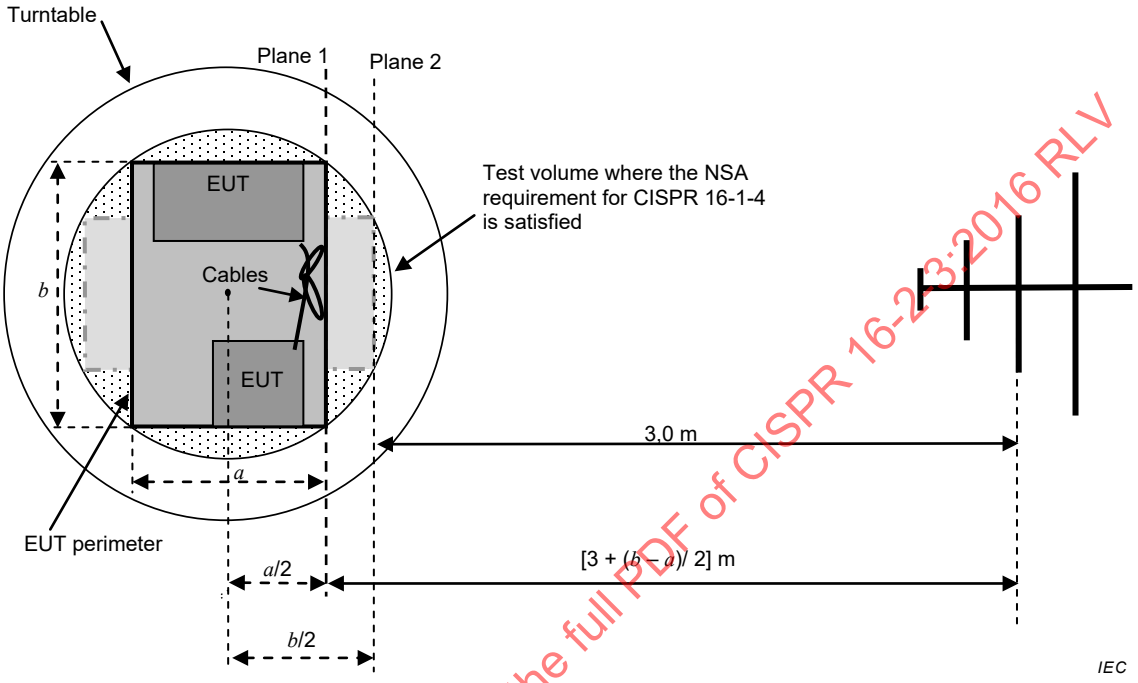


Figure 15 – Positions of reference planes for uniform field calibration (top-view)

7.5.3 Uniform test volume

The uniform test volume is defined by the following conditions.

- The EUT and its auxiliary equipment (AuxEq) (e.g. peripherals and cables) shall fit into a test volume where the site validation requirements of CISPR 16-1-4 are fulfilled. Refer to the site validation procedure for alternative test sites for use in emission measurements of CISPR 16-1-4;
- The EUT and its AuxEq shall fit into a test volume that allows each of the faces of the EUT and its AuxEq to be aligned with the uniform field area according to the requirements of IEC 61000-4-3 and as described in this subclause.

Evaluation of EUTs having unequal or non-symmetric boundaries at two antenna separation distances necessitate uniform field area calibrations according to the requirements of IEC 61000-4-3. In the example shown in Figure 15, this is at the plane with length b along the front face of the EUT (0° azimuth) and the plane with length a along the side face of the EUT (90° azimuth).

To accommodate EUTs with a maximum width of 1,5 m, the uniform field area may be calibrated for the two conditions:

- in a plane orthogonal to the axis of the antenna through the centre of the turntable;
- in a plane orthogonal to the axis of the antenna 0,75 m in front of the centre of the turntable, perpendicular to the measurement axis.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

A linear interpolation can be performed to test any EUT whose exposed front is between the two calibrated UFAs. It is presumed that:

- the −0 dB to +6 dB criteria complies at the number of points defined by IEC 61000-4-3 for each of the two surfaces, and
- the average field strengths of the points satisfying the −0 dB to +6 dB criterion in the two UFAs are inversely proportional to the antenna-to-UFA distance when applying a constant forward power to the antenna.

Designate P_{c1} as the forward power (logarithmic scale) for the UFA at the centre of the turntable, evaluated by either the calibration with constant field strength or the calibration method with constant power, and P_{c2} as the corresponding forward power for the UFA at 0,75 m in front of the centre of the turntable. The required forward power to illuminate an EUT surface can be calculated by linear interpolation from P_{c1} and P_{c2} and the corresponding distances (also in logarithmic scale) to the antenna. For other measurement details and descriptions, refer to 6.2 of IEC 61000-4-3:2006 calibration of field.

For EUT perimeter dimensions that differ by 20 % or less of the 3 m separation distance (that is, 0,6 m or less), only a single uniform field area calibration is required at the separation distance corresponding to Plane 1 in Figure 15 (the widest face of the EUT).

NOTE When using the method described in the preceding paragraph, two faces of the EUT will be tested at a higher immunity field-strength level due to their closer distance to the transmitting antenna.

The EUT perimeter, including the connecting cables, shall fit within the test volume where the site validation requirement is satisfied. For the common emission/immunity set-up, the facility shall be calibrated at two vertical planes corresponding to the minimum and maximum dimensions of the EUT perimeter at 0°, 90°, 180° and 270° to the EUT faces. The types of equipment to be tested in the facility may be considered for selection of the two plane locations.

If floor absorbers are used to achieve the field uniformity criterion, these absorbers shall be placed between the transmitting antenna and Plane 2. If only one plane is calibrated (that is, an EUT with a difference of the two boundary dimensions being less than 0,6 m), the floor absorbers, when used, shall be placed between the transmitting antenna and the calibrated plane.

7.5.4 Specifications for EUT set-up in common emissions/immunity test set-up

The tests shall be performed with the equipment configured as closely as possible to its typical, practical operation. Unless stated otherwise, cables and wiring shall be as specified by the manufacturer and the equipment shall be in its housing (or cabinet) with all covers and access panels in place. Any deviation from normal EUT operating conditions shall be included in the test report. The specifications of 7.3.6.3 apply. The EUT (on a non-conductive support structure, where applicable) shall be placed on a remotely operated turntable, as specified in 7.3.6.3, to allow the EUT to be rotated.

The height of the EUT above the ground plane shall be in accordance with the following requirements.

- Tabletop equipment is placed on a non-conductive set-up table with height 0,8 m ± 0,01 m, see 7.3.6.3. CISPR 16-1-4 specifies the method to determine the impact of the non-conductive set-up table on test results.
- Floor-standing equipment is placed on a non-conductive support, as specified in the applicable product standard. If there are no EUT height placement requirements in the product standard, the EUT shall be placed on a non-conductive support at a height of 5 cm to 15 cm above the ground plane.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Equipment designed for wall-mounted operation shall be tested as table-top equipment. The orientation of the EUT shall be consistent with that of normal operation (that is, positioned as normally installed).

Interface cables, loads, and devices should be connected to at least one of each type of the interface ports of the EUT and, where practical, each cable shall be terminated in a device typical for its actual use. Where there are multiple interface ports of the same type, a typical number of these devices shall be connected to devices or loads. It is sufficient to connect only one of the loads, provided that it can be shown, for example by preliminary testing, that the connection of further ports would not significantly increase the level of disturbance (that is, more than 2 dB) or significantly degrade the immunity level. The rationale for the configuration and loading of ports shall be documented in the test report.

The number of additional cables should be limited to the condition where the addition of another cable does not decrease the margin by a significant amount (for example, 2 dB) with respect to the limit. In some cases the optimum arrangement of features, loads, interface types, and cables for emissions and immunity tests are different, which may result in the need for some reconfiguration of the EUT within the confines of the uniform EUT arrangement.

The cable layout and termination shall be according to the following requirements.

- The cables shall be oriented so that vertically- and horizontally-polarized radiation fields are not excluded. The cable layout rules and cable lengths defined in the applicable product emission and immunity standards shall be applied. However, in case of conflicting requirements, the layout and maximum cable lengths defined in the product emission standard shall be used. Fulfilling the rules can be accomplished by applying the cable placement rules of the emissions standard and exposing a minimum length of 1 m of cable, with a mix of horizontal or vertical parts, to the electromagnetic field during immunity testing (unless the manufacturer's specifications require shorter cables). Excess cable lengths should be bundled in the approximate centre of the length of the cable to form a bundle 30 cm to 40 cm in length. If no information is provided about cable layout in the product emission standard, the following arrangement is applied.
  - For a table-top EUT (Figure 16 and Figure 17), the cables leaving the uniform test volume (that is, those that connect the EUT to the outside world) shall be exposed to the electromagnetic field according to Figure 16 and Figure 17 for a total length of 1 m (±0,1 m), and then extended vertically down towards the floor (with a minimum length of 0,8 m imposed by the EUT table height). Interconnecting cables that hang from the table shall be at a minimum distance of 0,4 m (±0,04 m) from the ground plane. If cables that hang closer than 40 cm to the ground plane cannot be shortened to the appropriate length, the excess cable shall be folded back and forth to form a bundle 30 cm to 40 cm long. If the maximum length declared by the manufacturer for certain cables does not allow a one meter horizontal cable layout, including a length to get to the ground plane for table-top products (placed on the 0,8 m height table), the horizontal layout shall depend on the length of cable in excess of 0,8 m. Bundling is not required.
  - For a floor-standing EUT (Figure 18 and Figure 19), cables leaving the uniform test volume shall be arranged with a length of at least 0,3 m run horizontally within the test volume and with a vertical run according to typical, normal use (depending on the height above the floor of the I/O port). Horizontal cables shall be insulated from the ground planes by a minimum height of 10 cm for the entire length of the cable that is intended to be laid out along the floor.

Cabling between enclosures of the EUT shall be treated as follows.

- The manufacturer's specified cabling types and connectors shall be used.
- If the manufacturer's specification requires a cable length of less than or equal to 3 m, then the specified length shall be used. The cables shall be exposed for a length of 1 m (±0,1 m) and the excess shall be folded back and forth, forming a bundle 30 cm to 40 cm

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

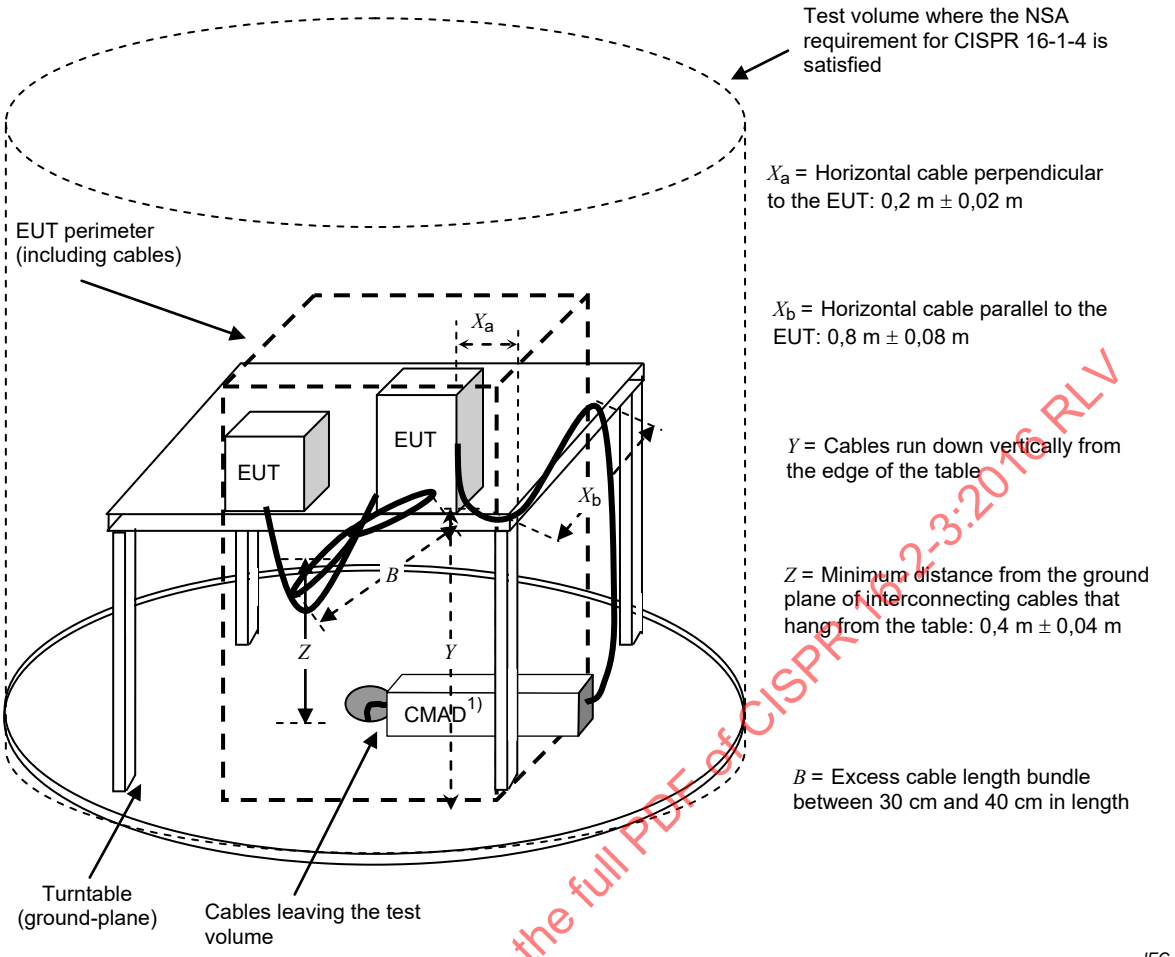
long, for table-top equipment (see Figure 16 and Figure 17) and approximately 1 m for floor-standing equipment (see Figure 18 and Figure 19).

- If the specified length is greater than 3 m or is not specified, then the illuminated length shall be 1 m. The excess cables shall be extended outside the test volume.
- EUT combinations of table-top equipment and floor-standing equipment shall be arranged according to the set-up of each individual equipment configuration and the interconnecting cables between table-top equipment and floor-standing equipment shall be according to these rules.
- For the cables not terminated into auxiliary equipment, differential- and common-mode terminations should be simulated to represent the auxiliary equipment that would be connected to the cables and represent the required functional impedance.
- Cables not connected to another device may be terminated as follows (see also 7.3.6.3).
  - Coaxial shielded cables shall be terminated with a coaxial termination (usually 50 Ω or 75 Ω).
  - Shielded cables with more than one inner wire should have common- and differential-mode termination according to the EUT manufacturer's specifications. This common-mode termination is to be connected appropriately between the inner wires or their differential-mode termination and cable shield. If no information is available about the common-mode terminations, 150 Ω common-mode terminations should be used.
  - Unshielded cables shall have differential-mode termination according to the manufacturer's specifications.
  - All cables that have been shortened in respect to their maximum lengths declared by the manufacturer and provided with artificial terminations for testing convenience, according to this paragraph, should also be provided with additional 150 Ω common-mode terminations to the test chamber wall or floor.

The following items should be considered with 7.3.6.3.

- If the EUT needs associated equipment (AE) to operate properly, special care shall be taken to ensure that the AE does not affect the radiated emissions measurements or the radiated immunity tests. The AE may be located outside the anechoic chamber during testing if proper connecting interfaces are available on the chamber shielding. Measures to prevent RF-leakage into or out of the anechoic chamber through the interconnection cable may be necessary.
- Other methods or equipment used to suppress unwanted emissions from AE shall be located outside the test chamber or beneath the raised floor.
- The test set-up, including cable layout, specifications of attached cables and terminations, use of CMAD(s) on cables leaving the test volume, and other measures taken to suppress emissions from AE outside the test volume, shall be clearly described in the test report.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



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

Figure 16 – Test set-up for table-top equipment

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

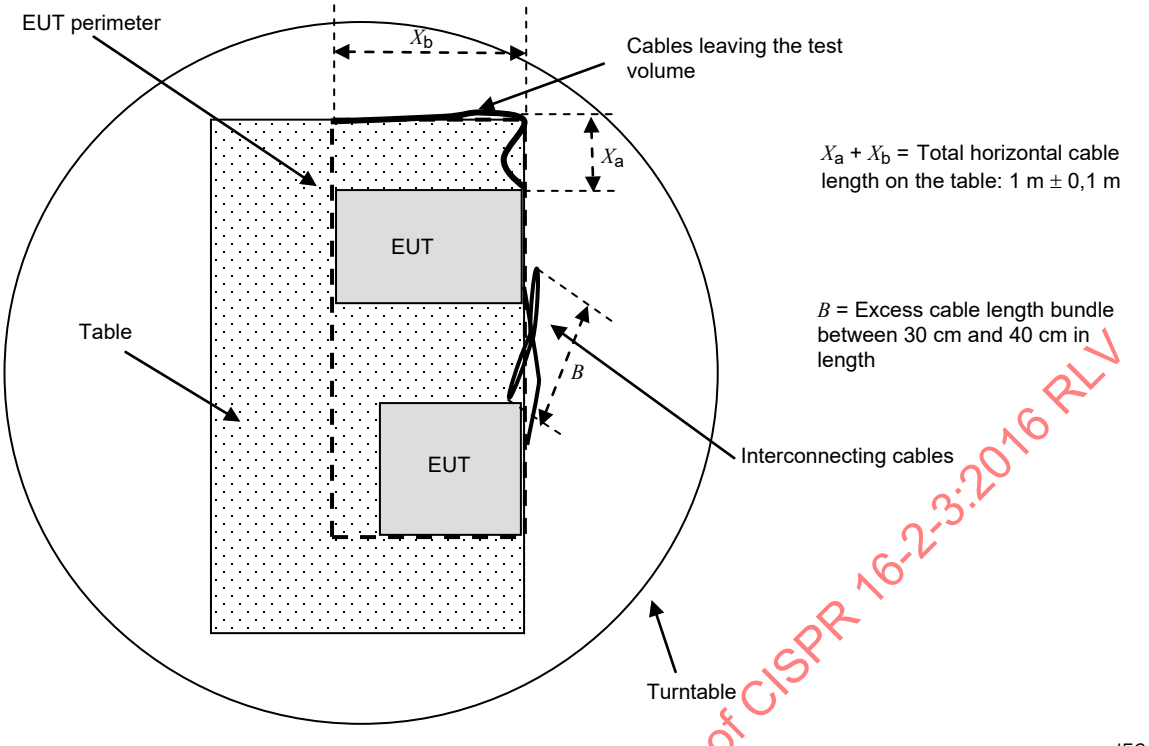
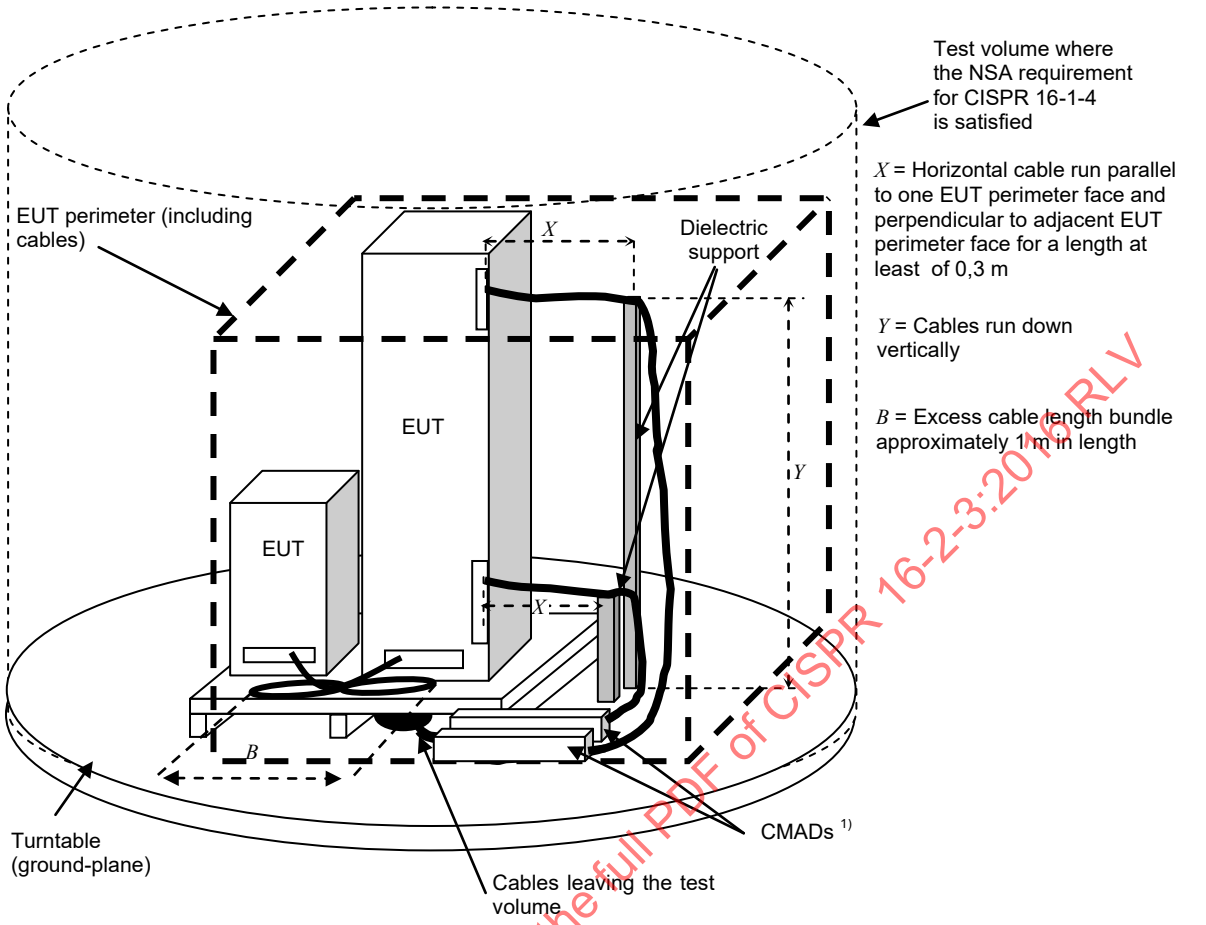


Figure 17 – Test set-up for table-top equipment – Top view

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

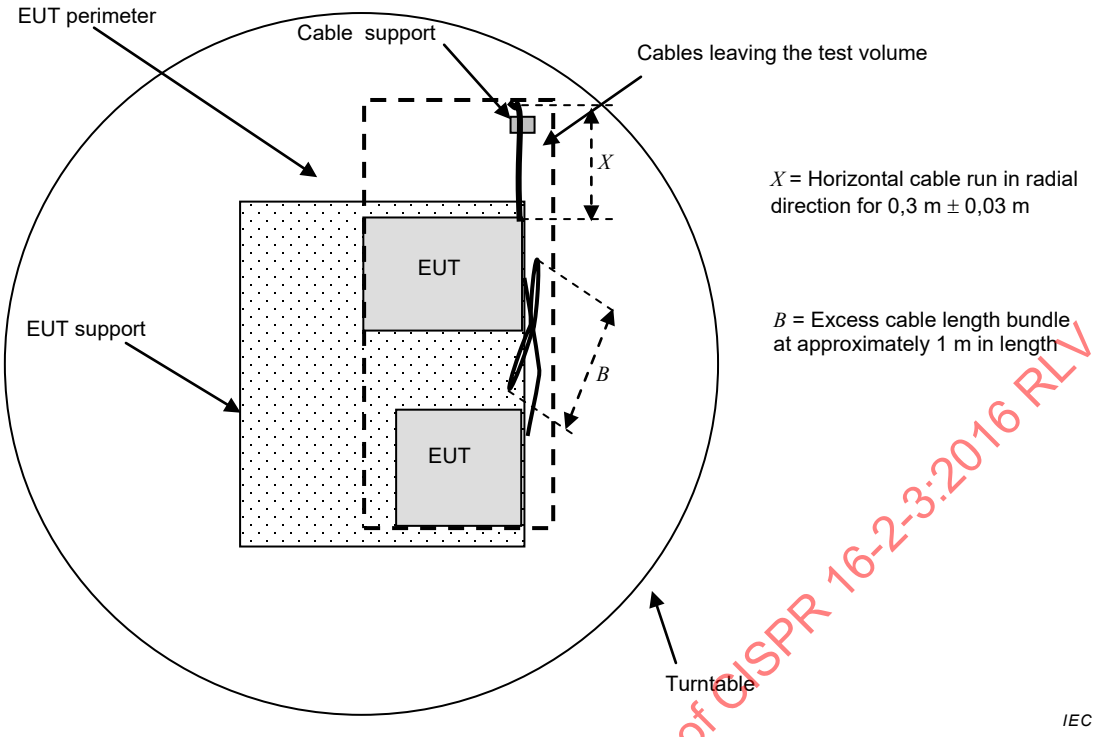


Note that the bend radius of cables shall not be exceeded to meet the bundled cable length.

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

Figure 18 – Test set-up for floor-standing equipment

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



Note that the bend radius of cables shall not be exceeded to meet the bundled cable length.

Figure 19 – Test set-up for floor-standing equipment – Top view

7.5.5 Measurement uncertainty for common emission/immunity set-up and method

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

7.6 Fully-anechoic room and absorber-lined OATS/SAC measurements (1 GHz to 18 GHz)

7.6.1 Quantity to measure

The electric field strength emitted by the EUT at the measuring distance is the quantity to be measured. The result shall be expressed in terms of field strength.

In some standards, emission limits above 1 GHz for equipment are expressed in terms of effective radiated power (P_{RE}) in dB(pW). Under free-space far-field conditions, the equation to convert P_{RE} into field strength, in dB(μV/m), at a 3 m distance is:

$$E_{3m} = P_{RE} + 7{,}4 \tag{11}$$

For distances d, in m, other than 3 m:

$$E_d = P_{RE} + 7{,}4 + 20\lg\left(\frac{3}{d}\right) \tag{12}$$

7.6.2 Measurement distance

The field strength emitted by the EUT is measured at a preferred distance of 3 m. The measurement distance, d, is the horizontal distance between the periphery of the EUT and the

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

receive antenna reference point (see Figure 20). The EUT encompasses all portions of the EUT, including cable racks and support equipment and a minimum cable length of 30 cm.

Other distances may be used in practical situations, i.e.:

– shorter distances in the case of high ambient noise, or to reduce the effect of unwanted reflections, but care should be taken to ensure the measurement distance is greater than or equal to D2/(2λ);
– greater distances for large EUTs to allow the antenna beam to encompass the EUT.

Because dominant components of the EUT disturbance signals may be assumed to be incoherent and radiated from a point source, the minimum distance mentioned above, i.e. $D^2/(2\lambda)$, is to be established using the measuring antenna dimensions, and not the EUT dimensions.

If measurements are carried out at a distance other than 3 m, the measurement distance shall be greater than or equal to 1 m and less than or equal to 10 m. In such a case, the measurement data is to be adjusted to a 3 m distance, assuming free-space propagation. Users are advised that comparison of measurements at different distances and extrapolation of results typically will not correlate as well as measurements made at the same distance. Standards or specifications that reference this test method should identify a preferred measurement distance.

7.6.3 Set-up and operating conditions of the equipment under test (EUT)

As a general guideline, test set-ups and operating conditions of the EUT shall be the same as those used below 1 GHz. Whenever possible, the test set-up should be representative of the most typical configuration of the EUT (table-top, floor-standing, rack-mounted, wall-mounted, etc.).

The test set-up should also consider that for measurements above 1 GHz absorbers are typically required on the floor between the antenna and EUT. Whenever practical, for emission measurements above 1 GHz the EUT should be raised above the height of the absorbers. If it is not possible to raise the entire EUT above the absorbers (i.e. for rack-mounted or floor-standing equipment), efforts should be made to configure the EUT (within a rack or chassis, for example) such that the radiating elements are located above the absorbers. The EUT shall be located in the test volume established during site validation, as described in CISPR 16-1-4. If it is not practical and safe to raise the EUT or its radiating elements above the absorber height, the maximum extent of the EUT that is permitted to be located below the highest point of the absorbers is 30 cm (see 7.6.6.1 and Figure 20).

The actual EUT configuration and set-up used shall be documented in the test report with photographs or diagrams clearly showing the location of the EUT with respect to the facility floor or turntable surface, absorber placement on the floor (height and location) and receive antenna location.

7.6.4 Measurement site

The measurement site shall comply with the requirements described in CISPR 16-1-4.

7.6.5 Measurement instrumentation

The measurement instrumentation shall comply with the requirements described in CISPR 16-1-1 and CISPR 16-1-4.

Measurements to verify compliance with a peak limit shall be conducted with the peak measuring spectrum analyzer or receiver using a measurement bandwidth of 1 MHz (impulse bandwidth) as defined CISPR 16-1-1.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Measurements to verify compliance with an average limit shall be conducted with a peak measuring spectrum analyzer using a measurement bandwidth of 1 MHz (impulse bandwidth) and a reduced video bandwidth, set as defined in CISPR 16-1-1. The value of video bandwidth required for an average measurement shall be less than the lowest spectral component of the input signals to be measured.

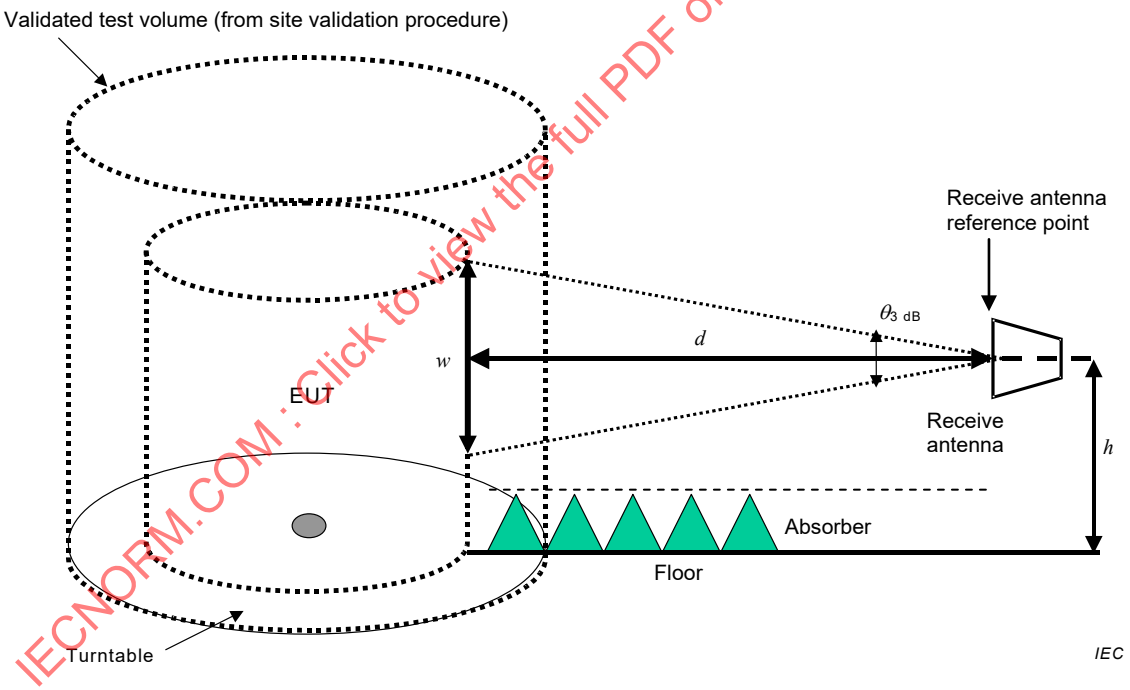
NOTE A spectrum analyzer can be used to perform average measurements by setting the display mode to linear and the video bandwidth to a value that is lower than the lowest spectrum component of the input signal to be measured. For example, if the input signal has a 1 kHz pulse repetition frequency (PRF), for a video bandwidth less than 1 kHz, only the d.c. component of the signal (i.e. the average value) will pass through the video filter.

The use of other types of linear average detectors that comply with these requirements is allowed. In general, the spectrum analyzer shall be set to linear display mode when performing average measurements, not the logarithmic display mode. The sweep time of the spectrum analyzer shall be increased, due to the use of narrower video bandwidths, to ensure accurate measurement results. The logarithmic mode is permitted for average measurements when the specification limits assume a logarithmic detector will be used.

7.6.6 Measurement procedure

7.6.6.1 General description of the radiated field measurement method above 1 GHz

The radiated field measurement method above 1 GHz is based on measurement of the maximum electric field emitted from the EUT, with a set-up as shown in Figure 20.



NOTE The anechoic material placed on the ground plane is for illustration purposes only. Consult CISPR 16-1-4 for more detailed guidance about placement of absorber to comply with the site validation requirements.

Figure 20 – Measurement method above 1 GHz, receive antenna in vertical polarization

The following descriptions apply to the parameters and terms given in Figure 20.

- Validated test volume: the volume evaluated during the site validation procedure (see CISPR 16-1-4). Typically, this determines the largest diameter EUT that can be tested in the facility.
- EUT (volume): the smallest diameter cylinder that will fully encompass all portions of the actual EUT, including cable racks and a minimum length of 30 cm of cables. The EUT that

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

is located within this cylinder shall be capable of rotating about its centre (typically by a remotely controlled turntable). The EUT shall be located within the validated test volume. A maximum of 30 cm of w (see definition of w below) may be below the height of absorbers on the floor only when the EUT is floor-standing and cannot be raised above the height of the absorbers (see 7.6.3).

- $\theta_{3\ dB}$: Minimum 3 dB beamwidth of the receive antenna at each frequency of interest. $\theta_{3\ dB}$ is the minimum of both the E-plane and H-plane values at each frequency. θ_{3dB} may be obtained from manufacturer-provided data for the receive antenna.
- d: The measurement distance (in meters). This is measured as the horizontal distance between the periphery of the EUT and the reference point of the receive antenna.
- w: The dimension of the line tangent to the EUT formed by $\theta_{3\ dB}$ at the measurement distance d. Equation (15) shall be used to calculate w for each actual antenna and measurement distance used. The values of w shall be included in the test report. This calculation may be based on the manufacturer-provided receive-antenna beamwidth specifications:

$$w = 2d \tan\left(0{,}5\,\theta_{3\,dB}\right) \tag{13}$$

  w shall be of the minimum dimension as specified in Table 4.
- h: Height of the receive antenna, measured from its reference point to the floor.

Table 4 specifies the minimum acceptable dimension of w (w_{min}). The minimum requirements shown in Table 4 are calculated from Equation (13) based on testing at the minimum permitted measurement distance of 1 m specified in 7.6.2, and the values of $\theta_{3\ dB(min)}$ shown. The selection of measurement distance d and antenna type shall be made such that w is equal to or greater than the values shown in Table 4 at any frequency where the field is measured. At frequencies not shown in Table 4, the limit of w_{min} shall be linearly interpolated between the nearest two frequencies listed. Table 5 gives example values of w calculated using Equation (13) for three antenna types at measurement distances of 1 m, 3 m, and 10 m.

The maximum emission is measured by moving the receive antenna in height along with rotation of the EUT in azimuth (0° to 360°). The required range of height investigation is specified below and illustrated in Figure 21 for two typical categories of EUTs.

Table 4 – Minimum dimension of w (w_{min})

Frequency GHz	$\theta_{3\ dB,\ min}$	w_{min} m
1,00	60	1,15
2,00	35	0,63
4,00	35	0,63
6,00	27	0,48
8,00	25	0,44
10,00	25	0,44
12,00	25	0,44
14,00	25	0,44
16,00	5	0,09
18,00	5	0,09

a) The dimension, w, is permitted to be larger than the minimum shown, and other antennas and distances may be used to satisfy the minimum required value of $w = w_{min}$ shown, provided that Equation (13) is met.

b) Because both polarizations are required to be measured for each height of the receive antenna, w forms a minimum square observation area equal to w^2 (m^2).

c) In some cases, w may encompass multiple physical components of the EUT that are physically separated. For example, multiple separate cabinets of a multi-cabinet system that are tested simultaneously.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

d) The height scan requirement depends on w such that it may be advantageous to maximize w by selection of a wider beamwidth antenna and a larger measurement distance than the minimum requirements shown.

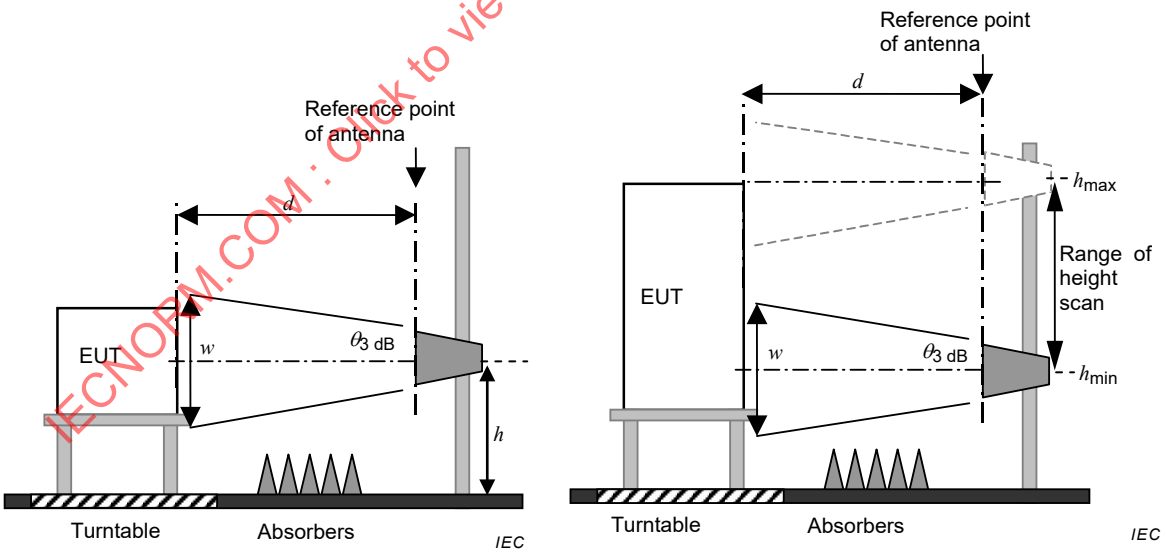
e) The pattern and beamwidth of the antenna used can affect the measurement result. The antenna has at least two influence factors in addition to uncertainty in the antenna factor: 1) ripple or other anomalies in the antenna pattern, and 2) beamwidth differences between antennas, which may give different results depending on how many (constructive) emissions emanating from separate physical locations on the EUT fall within the antenna beamwidth.

Table 5 – Example values of w for three antenna types

Frequency	DRG horn				LPDA or LPDA-V [a]			
GHz	$\theta_{3\ dB}$ °	d = 1 m	d = 3 m	d = 10 m	$\theta_{3\ dB}$ °	d = 1 m	d = 3 m	d = 10 m
		w m	w m	w m		w m	w m	w m
1,00	60	1,15	3,46	11,55	60	1,15	3,46	11,55
2,00	35	0,63	1,89	6,31	55	1,04	3,12	10,41
4,00	35	0,63	1,89	6,31	55	1,04	3,12	10,41
6,00	27	0,48	1,44	4,80	55	1,04	3,12	10,41
8,00	25	0,44	1,33	4,43	50	0,93	2,80	9,33
10,00	25	0,44	1,33	4,43	50	0,93	2,80	9,33
12,00	25	0,44	1,33	4,43	50	0,93	2,80	9,33
14,00	25	0,44	1,33	4,43	45	0,83	2,49	8,28
16,00	5	0,09	0,26	0,87	40	0,73	2,18	7,28
18,00	5	0,09	0,26	0,87	40	0,73	2,18	7,28

[a] LPDA-V: V-type log periodic dipole array. The values shown for $\theta_{3\ dB}$ and w are typical of both the LPDA and LPDA-V. However, these antennas typically have different gains.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



a) w encompasses EUT height (fixed-height measurement)

b) w does not encompass EUT height (height scan required)

Figure 21 – Illustration of height scan requirements for two different categories of EUTs

For any EUT with maximum dimensions equal to or smaller than w, the centre of the receive antenna shall be fixed at the height of the centre of the EUT (Figure 21 a)). For any EUT with a maximum vertical dimension larger than w, the centre of the antenna shall be scanned vertically along the line parallel to w, as shown in Figure 21 b). The required scanning range

for h is 1 m to 4 m. If the EUT height is less than 4 m, scanning the centre of the receive antenna to heights above the top of the EUT is not required. In both cases the fixed height, h, or the range of heights investigated shall be recorded in the test report.

When a height scan is required per the above paragraph, a continuous height scan within the required height range is recommended, to obtain the final, maximum emission. If stepped height increments are used, caution is advised to ensure that the height increments are sufficiently small in order to capture the maximum emission.

Regarding the horizontal extent of w, the EUT is not required to be fully within w. In cases where the EUT width is larger than w, the EUT shall be centred horizontally on the measurement axis, and rotation of the EUT provides the necessary horizontal scan for the determination of the maximum field strength. Horizontal-line (sideways, transverse) scanning by moving the receive antenna horizontally off the measurement axis is not required, but may be used if specified in a product standard.

7.6.6.2 Measurements using conventional (non-statistical) detectors

7.6.6.2.1 General measurement procedure

For any EUT, the frequencies of emission should first be detected by a preliminary emission maximization procedure (see 7.6.6.2.3). Then the final emission test is performed (see 7.6.6.2.4). Both of these measurements are to be made preferably at the specific limit distance. If, for any justified reason, the final measurement is performed at a distance other than the limit distance, a measurement at the limit distance should be made first, to help in interpreting the resulting data.

In performing these measurements, the sensitivity of the measurement equipment relative to the limit shall be determined before the test. If the overall measurement sensitivity is inadequate, low-noise amplifiers, closer measurement distances or higher-gain antennas may be used. If closer measurement distances or higher gain antennas are used, the beam width versus size of the EUT shall be accounted for. Also, measurement system overload levels shall be determined to be adequate when preamplifiers are used.

Burn-out and saturation protection for the measuring instrumentation is required when low-level emissions are to be measured in the presence of a high level signal. A combination of band-pass, band-stop, low-pass and high-pass filters may be used. However, the insertion loss of these or any other devices at the frequencies of measurement shall be known and included in any calculations in the report of measurements.

NOTE A simple method of determining whether non-linear effects (overload, saturation, etc.) occur, consists of inserting a 10 dB attenuator at the input of the measurement instrument (ahead of any pre-amplifier if one is used) and verifying that the amplitude of all the harmonics of the high-amplitude signal (that may cause non-linear effects) is reduced by 10 dB.

7.6.6.2.2 Conditional testing procedure

If the highest internal frequency of the EUT (see 3.1.27) is less than 108 MHz, emissions shall be measured at least up to 1 GHz.

If the highest internal frequency of the EUT is between 108 MHz and 500 MHz, emissions shall be measured at least up to 2 GHz.

If the highest internal frequency of the EUT is between 500 MHz and 1 GHz, emissions shall be measured at least up to 5 GHz.

If the highest internal frequency of the EUT is above 1 GHz, emissions shall be measured up to the lower of 5 times the highest internal frequency or the highest frequency at which the limits are defined.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

7.6.6.2.3 Preliminary measurement procedure

The procedures of this subclause are for informative purposes – normative measurement requirements are listed in 7.6.6.2.4. The maximum radiated disturbance for a given mode of operation may be found during a preliminary test. To minimize measurement time, it is suggested to first perform measurements using peak detection, and then compare the test results to the average limit. Subsequent measurements with the average detector and comparison of results to the average limit will only be performed in those frequency ranges where the average limit was exceeded by data collected with peak detection.

Guidelines for a preliminary procedure to identify the radiated disturbance are as follows.

a) Use scan or sweep mode over the complete frequency range of the antenna using peak detection and maximum-hold mode.

b) Determine the proper sweep or scan time to ensure adequate signal interception.

c) If necessary, during preliminary tests, reduce the resolution bandwidth in sweep mode to reduce the displayed noise level of the measuring receiver. Note that this may reduce the amplitude of broadband disturbance, so additional investigations to determine whether the disturbance is broadband or narrowband may be necessary.

d) Rotate the EUT continuously or in increments of 15° or less, then repeat for the other polarization. The EUT should be rotated 360° in azimuth for both polarizations to determine the maximum disturbance at each frequency of interest.

e) For continuous turntable rotation mode, set the measuring receiver sweep time such that the selected frequency span can be swept within a time that is equal to or less than the time needed for the turntable to rotate 15°. If the rotational speed of the turntable is such that an angle larger than 15° is covered during a complete sweep or scan of the measuring receiver, a smaller frequency range should be used to reduce measuring receiver sweep time and to achieve the maximum 15° turntable rotation per sweep.

f) As needed to identify the frequencies corresponding to the maximum disturbance, apply the method described above for all the height levels required by 7.6.6.1 (and Figure 21), and for the various operating modes of the EUT.

g) To further evaluate the frequencies found in steps a) to d), use a small frequency span (typically 5 MHz or less) and investigate around frequencies near the limit using additional smaller turntable increments and height steps. Typically, all frequencies within approximately 10 dB of the specification limit warrant further investigation with a narrow frequency span and additional finer rotation/height increments.

7.6.6.2.4 Final measurement procedure

The field strength emitted by the EUT at the given measurement distance is measured using the configuration (antenna height, EUT azimuth, etc.) producing the maximum disturbance, as identified during the preliminary disturbance maximization. Final measurements shall be done using the EUT operational mode identified by preliminary measurements to have the highest disturbance.

This final measurement shall be the result of a maximum hold on the measuring receiver during a given time proportional to the frequency span used. This given time should be defined for each product or product family, taking into account the duration of the operating modes and the time constants associated with each specific product to be tested. Final measurements shall be performed using all required detectors. Alternatively, peak measurement results may be used to demonstrate compliance with all specified limits.

If the configuration of the EUT (antenna height, EUT azimuth, operation mode, etc.) producing the maximum disturbance was not conclusively determined by a preliminary measurement the following additional measurements shall be done:

a) for any EUT with maximum dimension equal to or smaller than w, the centre of the receiving antenna shall be fixed at the height of the centre of the EUT (see Figure 21a));

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

b) for any EUT with maximum vertical dimension larger than w, height scanning shall be performed in accordance with the height scan requirements (upper and lower bounds) specified in 7.6.6.1;

c) in all cases, in order to find the maximum disturbance, the EUT shall be rotated in azimuth through all angles in the range of 0° to 360°, and the measurements shall be performed for both horizontal and vertical polarizations.

In summary, the requirements for final measurements above 1 GHz are as follows.

The maximum disturbance shall be recorded from the following required investigations, some of which may be performed during the preliminary measurement procedure:

1) the EUT shall be rotated in azimuth through all angles from 0° to 360° either by a turntable or movement of the receive antenna around the volume;

   If a preliminary measurement was performed with azimuth steps of $1° < a \leq 15°$, the final measurement shall include an azimuth search continuous through all angles of at least $\pm a$ around the azimuth angle found in the preliminary measurement, where a is the azimuth angle.

2) the receive antenna shall be height-scanned if the EUT height is larger than w in the vertical direction;

3) both horizontal and vertical polarizations shall be investigated.

7.6.6.3 Measurements using APD (statistical) function

7.6.6.3.1 General

The measurement of the amplitude probability distribution (APD) of a disturbance signal provides a statistical characterization of the disturbance signal in question. Background material on the application of the APD-measuring function is provided in 4.7 of CISPR TR 16-3:2014 [2]. A product committee may choose the APD measurement as the method to be used for final emission testing. The APD measurement shall be made at those frequencies where the EUT generates high disturbance field strengths. The number and selection method of frequencies shall be established by a product committee.

The APD measurement shall be made using one of the following two methods. The first method is for measurement of the disturbance level E_{meas} in dB(μV/m) related to the specified probability of time p_{limit} designated as Method 1 (see 7.6.6.3.2). The second method is the measurement of the probability of time p_{meas} during which the disturbance envelope exceeds a specified level E_{limit} in dB(μV/m), designated as Method 2 (see 7.6.6.3.3). Additional information and figures are given in Annex D to show the specifics of the two APD measurement methods.

If a product committee decides to use the APD approach, either Method 1 or Method 2 shall be selected. If the APD measuring instrument does not include an A/D converter, only Method 2 shall be used. If the APD measuring instrument includes an A/D converter, either Method 1 or Method 2 may be used.

The number of pairs of limits (E_{limit}, p_{limit}) and their values shall be specified by the product committee. The product committee shall also decide whether to also use a peak limit together with the APD limits.

7.6.6.3.2 Method 1 – Measurement of the level of disturbance

The measurement shall be performed using the following procedure.

1) Set the resolution bandwidth (RBW) and the video bandwidth (VBW) of the spectrum analyzer according to CISPR 16-1-1 (for measurements above 1 GHz).

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

2) Find the frequencies at which high disturbances are observed. This can be accomplished by using the maximum hold function in the frequency span of interest. Peak detection shall be used when applying this procedure.

NOTE In cases where narrowband emissions are hidden by broadband emissions, the maximum hold mode in combination with the peak detector may overlook narrowband emissions. Therefore, an additional measurement may be needed to find the frequencies of the narrowband emissions to be measured. The product committee may require additional sweeps using the average detector or digital video averaging. Furthermore, the number of frequencies for the APD measurement may also be specified by the product committee.

3) Determine the frequencies for the APD measurement. The number of the frequencies shall be specified by the product committee.

4) Set the centre frequency of the spectrum analyzer to the frequency at which the highest level is observed during the application of step 2) of this procedure.

5) Set the reference level of the spectrum analyzer to minimum 5 dB above the maximum level of disturbance that is obtained in step 2).

6) Set the spectrum analyzer to the zero frequency span mode and measure the APD of disturbance during the measurement time that is specified by the product committee. The measurement time shall be longer than the period of the disturbance.

In case of fluctuating disturbance frequencies, the product committee shall specify the frequency range XX (in MHz) in which the APDs of the disturbance shall be measured. APDs within the range XX MHz shall be measured with a 1 MHz frequency step size. However, for frequency ranges with APD measurement values that are greater than -6 dB from the APD limit, additional measurements may be needed with a smaller frequency step size (e.g. 0,5 MHz). The product committee shall define the smaller frequency step size.

7 Change the centre frequency of the spectrum analyzer to the next frequency determined in step 2), then repeat the procedures of steps 4) to 6) until the APD measurements for all frequencies are carried out.

8) Read the disturbance level E_{meas} in dB(μV/m) related to the specified probability p_{limit} from the results of step 6).

9) Compare E_{meas} dB(μV/m) against the limit E_{limit} dB(μV/m). The EUT complies if E_{meas} is less than or equal to E_{limit} at all frequencies.

7.6.6.3.3 Method 2 – Measurement of the probability of time

The measurement shall be performed using the following procedure.

Steps 1), 2), 3), 4), 5) and 7) of Method 2 are the same as the corresponding steps of Method 1 (7.6.6.3.2).

For Method 2, modify step 6), step 8), and step 9) of Method 1 as follows:

6) Set the spectrum analyzer to the zero frequency span mode and measure the APD (or measure the probability p_{meas} related to the specified levels directly) of the disturbance during the measurement time that is to be specified by the product committee.

8) Read the probabilities p_{meas} during which the disturbance envelope exceeds a specified level E_{limit} in dB(μV/m) from the results of step 6).

9) Compare p_{meas} against the limits p_{limit}. The EUT complies if p_{meas} is less than or equal to p_{limit} at all frequencies.

7.6.7 Measurement uncertainty for FAR

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

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

7.7 *In situ* measurements (9 kHz to 18 GHz)

7.7.1 Applicability of and preparation for *in situ* measurements

In situ measurements may be necessary for the investigation of an interference problem at a particular location, i.e. where electrical equipment is suspected of causing interference to radio reception in its vicinity. Where allowed by the relevant product standard, *in situ* measurements may be made for the evaluation of compliance, if it is not possible for technical reasons to make radiated emission measurements on a standard test site. Technical reasons for *in situ* measurements are excessive size and/or weight of the EUT or situations where the interconnection to the infrastructure for the EUT is too expensive for the measurement on standard test sites. *In situ* measurement results of an EUT type will normally deviate from site-to-site or from results obtained on a standard test site and can therefore not be used for type testing.

NOTE In general, however, due to imperfections such as mutual coupling between the conductive structures present in the *in situ* environment, which may also be more or less corrupted by ambient electromagnetic fields, and the measuring antenna/equipment under test, *in situ* measurements cannot fully replace measurements on a suitable test site (open-area test site or alternative test site, for example (semi-) anechoic chamber) as specified in CISPR 16-1-4.

The EUT usually consists of one or more devices and/or systems, is part of an installation, or is interconnected with an installation. A perimeter connecting the outer parts of the EUT is usually taken as the reference point to determine the measurement distance. In some product standards, the exterior walls or boundaries of business parks or industrial areas are taken as the reference points.

Preliminary measurements shall be made to identify the frequency and amplitude of the disturbance field strengths amongst the ambient signals taking into account the potential sources of interference (for example, oscillators) in the EUT. For these measurements the use of a spectrum analyzer is recommended in place of a receiver because a large frequency spectrum can be analysed. For the identification of the frequency and amplitude of the disturbance signals the use of a current probe on the connected cables, or near-field probes or the measurement antennas placed closer to the EUT, is recommended.

Measurements shall also be made on selected frequencies to determine, where possible, the modes of operation in which the EUT generates the highest disturbance field strengths. The subsequent measurements shall be made with the EUT in these modes of operation.

Where the EUT is a piece of equipment for which the operating mode cannot be switched independently of the operation of other equipment, the selection of conditions producing the highest disturbances may be infeasible. For some equipment and operating modes, these conditions may be dependent on time, particularly if operations are cyclic. In such cases, the period of observation should be chosen to approach the conditions producing the highest disturbances.

Measurements shall be made around the EUT at approximately the same measurement distance on each of the selected frequencies to determine the direction of the highest disturbance field strength. The EUT should be tested in at least three different directions. The final disturbance field-strength measurements on each frequency shall be made in the directions of the highest disturbance field strengths, which may vary from frequency to frequency, taking into account the local (ambient) conditions. The highest disturbance field strengths shall be measured with the antenna in vertical and horizontal polarization. If the ratio of the measured disturbance field strength to any ambient emission is lower than 6 dB, the measurement methods described in Annex A can be used.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

7.7.2 Field-strength measurements *in situ* in the frequency range 9 kHz to 30 MHz

7.7.2.1 Measurement method

The magnetic disturbance field strength shall be measured in the direction of maximum radiation with the EUT in the mode of operation generating the highest disturbance field strength.

The horizontally-polarized disturbance field strength shall be measured at the standard measurement distance d_{limit} using a loop antenna as described in 4.3.2 of CISPR 16-1-4:2010 at a height of 1 m (between the ground and lowest part of the antenna). The maximum disturbance field strength shall be determined by rotating the antenna.

For the measurement of the maximum disturbance field strength along radial lines arranged in any direction, the antenna should be oriented in three orthogonal directions, and the measured field strength is calculated by

$$E_{\text{sum}} = \sqrt{E_x^2 + E_y^2 + E_z^2}$$

In cases where limits are given for the E-field equivalent but the measured field strengths are the magnetic components, the H field strength can be converted to the corresponding E field strength using the free space impedance of 377 Ω by multiplying the H field reading by 377. The H field in this case is given by

$$H_{\text{sum}} = \sqrt{H_x^2 + H_y^2 + H_z^2}$$

This H field value can be used directly in cases where limits are directly given for the magnetic field strength.

If the antenna cannot be oriented in three orthogonal directions, it can be turned by hand in the direction of maximum reading for the measurement of the maximum disturbance field strength.

7.7.2.2 Measurement distances other than the standard distance

If it is not possible to adhere to the standard distance d_{limit}, as specified in the product or generic standard, the measurements should be made at distances either less or greater than the standard measuring distance in the direction of the maximum radiation. At least three measurements at different measuring distances less or greater than the standard measuring distance shall be used, if it is not possible to use the standard distance.

The measurement results (in decibels) shall be plotted as a function of the measurement distance on a logarithmic scale. One line shall be drawn to join up the measurement results. This line represents the decrease in the field strength and can be used to determine the disturbance field strength at distances other than the measurement distance, for example, at the standard distance.

7.7.3 Field-strength measurements *in situ* in the frequency range above 30 MHz

7.7.3.1 Measurement method

The disturbance electric field strength shall be measured in the direction of maximum radiation at the standard distance with the EUT in the mode of operation generating the highest disturbance field strength. The maximum horizontally- and vertically-polarized disturbance field strengths shall be measured using broadband antennas with, as far as practicable, a variable height of 1 m to 4 m. The highest value shall be taken as the measured value.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

It is recommended that biconical antennas be used for measurements in the frequency range up to 200 MHz, and log-periodic antennas for measurements in the frequency range above 200 MHz. The distance between the measuring antenna and any nearby metallic elements (including cables) should be greater than 2 m.

7.7.3.2 Measurement distances other than the standard distance

The standard measurement distance d_{std} is specified in the product or generic standard. If it is not possible to adhere to the standard measurement distance, the disturbance field strength shall be measured in different measuring distances as described in 7.7.2.2. A height scan of the antenna shall be used for each measurement The disturbance field strength at the standard distance d_{std} shall be determined according to 7.7.2.2 by plotting the measured field strength as a function of the measurement distance on a logarithmic scale.

If it is not possible to measure at varying distances, and the measurement distance refers to the outer wall of a building or the border of the premises, the measurement results shall be converted to the standard distance using Equation (14).

$$E_{std} = E_{meas} + 20\, n \lg \frac{d_{meas}}{d_{std}} \quad (14)$$

where

E_{std} is the field strength at the standard distance in dB(μV/m) for comparison with the emission limit;

E_{meas} is the field strength at the measurement distance in dB(μV/m);

d_{meas} is the measurement distance in metres;

d_{std} is the standard distance in metres.

The factor n depends on the distance d_{meas} as follows:

if $30\ m \leq d_{meas}$, $n = 1$;

if $10\ m \leq d_{meas} < 30\ m$, $n = 0{,}8$;

if $3\ m \leq d_{meas} < 10\ m$, $n = 0{,}6$.

NOTE $n < 1$ accommodates the difference between the measuring distance and the distance to the EUT.

Measurement distances closer than 3 m shall not be used.

If it is not possible to measure at varying distances, and Equation (14) is not used because the measurement distance does not refer to the outer wall of a building or boundary of premises, the field strength should be determined by measurement of the radiated disturbance power (see 7.7.4).

7.7.4 *In situ* measurement of the disturbance effective radiated power using the substitution method

7.7.4.1 General measurement condition

The substitution method can be used without additional conditions if, and only if, the EUT can be switched off and if the EUT can be removed for the substitution.

If the EUT cannot be removed, and if its front face is a large plane surface, the effect of this face on the substitution shall be accounted for (see Equation (14)). If the front surface of the EUT does not fit into a two-dimensional plane in the measurement direction, the additional measurement uncertainty is not considered.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

If the EUT cannot be switched off, it is still possible to use the substitution method to measure the radiated power of a disturbance from the EUT at a particular frequency, by using a nearby frequency at which the field strength of the disturbance from the EUT is at least 20 dB below that of the frequency of interest ("nearby" means within one or two receiver IF-bandwidths). The frequency selected should, where possible, be chosen with regard to possible interference to radio services.

7.7.4.2 Frequency range of 30 MHz to 1 000 MHz

7.7.4.2.1 Measurement distance

The measurement distance chosen shall be such that the measurement is made in the far field. This requirement is generally met, if:

- d is greater than $\lambda/(2\pi)$ and
- $d \geq 2D^2/\lambda$ (15)

where

d is the measurement distance in m;
D is the maximum dimension of the EUT with cabling in m;
λ is the wavelength in m;

or if measurement distance d is equal to or greater than 30 m. In the far field, the exponent n in Equation (14) may be assumed to be one (1). If a shorter measurement distance is chosen, this assumption can be validated by using the procedure of 7.7.3.2 to verify that the field strength falls off inversely with distance. If the local conditions require that a shorter measurement distance be chosen, this shall be indicated.

7.7.4.2.2 Measurement method

The effective radiated disturbance power shall be measured in the direction of maximum radiation with the EUT in the mode of operation generating the highest disturbance field strength. The measurement distance shall be chosen according to 7.7.4.2.1 and the highest disturbance field strength on the selected frequency determined by varying the antenna height at least in the range of 1 m to 4 m as far as practicable.

For measurement of the effective radiated disturbance power, the following steps a) to g) shall be used.

a) The EUT shall be disconnected and removed. A half-wave dipole or antenna with similar radiation characteristics and known gain G, relative to a half-wave dipole is substituted in its place. If it is impractical to remove the EUT, a half-wave or broadband dipole (in the frequency range lower than about 150 MHz to minimize mutual coupling to the EUT) is positioned in the vicinity of the EUT. The vicinity is a range up to 3 m.

b) The half-wave (or broadband) dipole shall then be fed by a signal generator operating on the same frequency.

c) The position and polarization of the half-wave dipole (or broadband antenna) shall be such that the measuring receiver receives the highest field strength. If the EUT is not removed, then, if possible, it shall be switched off and the dipole is moved in a range up to 3 m around the EUT.

d) The power of the signal generated shall be varied until the measuring receiver shows the same reading as when the highest disturbance field strength from the EUT was measured.

e) If the EUT constitutes the front of a large plane surface (e.g. a building with a cable-TV network), the substitution antenna (half-wave dipole) is positioned about 1 m in front of the large plane surface (e.g. the front wall of a building). The location of the substitution measurement shall be selected such that an imaginary line between the substitution antenna and the measuring antenna is perpendicular to the direction of the face of the building.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

f) The height, polarization and distance between the half-wave dipole (or broadband antenna) and the plane surface shall be varied such that the receiver displays the highest field-strength reading.

g) The power of the signal generator shall be varied as in d).

For removed EUTs, and EUTs that cannot be removed (see steps a) and c), respectively), the power at the signal generator, P_g, plus the gain of the transmit antenna relative to a half-wave dipole, G, yields the effective radiated disturbance power, P_r, to be measured:

$$P_r = P_g + G \tag{16}$$

For EUTs having a large plane surface (e.g. buildings with telecommunication networks), the increase in gain of the dipole positioned in front of this surface is given by:

$$P_r = P_g + G + 4 \text{ dB} \tag{17}$$

where

P_r is in dB(pW);
P_g is in dB(pW); and
G is in dB.

The effective radiated disturbance power can be used to calculate the disturbance field strength at the standard measurement distance d_{std}. The free-space field strength E_{free} shall be calculated using the following equation:

$$E_{free} = \frac{7\sqrt{P_r}}{d_{std}} \tag{18}$$

where

E_{free} is in μV/m;
P_r is in pW and
d_{std} is in m.

If the calculated free-space field strength of Equation (21) is compared with limits of disturbance field strength measured at a standard test site, it shall be considered that the amplitude field strength measured at a standard test site is approximately 6 dB higher than the free-space field strength of Equation (21), due to the reflections from the ground plane. Equation (21) can be modified to take into account this difference. The disturbance field strength at the standard distance E_{std} can therefore be calculated, for the vertical polarization case, using the following equation:

$$E_{std} = P_r - 20 \lg d_{std} + 22{,}9 \tag{19}$$

For horizontal polarization below 160 MHz the maximum field strength is not measured at standard test sites. Therefore the 6 dB factor shall be corrected using the following equation, for which Table 6 shows several calculated values:

$$E_{std} = P_r - 20 \lg d_{std} + 16{,}9 + (6 - c_c) \tag{20}$$

where

E_{std} is in dB(μV/m);

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

f is the measuring frequency;

d_{std} is in m; and

c_c is the correction factor for horizontal polarization. This was determined assuming a radiation source at 1 m in height.

This method for determining the disturbance field strength can be used mainly when there are obstacles between the measuring antenna and the EUT.

Table 6 – Horizontal polarization correction factors as a function of frequency

f MHz	30	40	50	60	70	90	100	120	140	160	180	200	750	1 000
c_c dB	11	10,2	9,3	8,5	7,6	5,9	5,1	3,4	1,7	0	0	0	0	0

7.7.4.3 Frequency range of 1 GHz to 18 GHz

7.7.4.3.1 Measurement distance

The measurement distance chosen shall be such that the measurement is made in the far field. The far-field condition shall be verified by measuring the radiated disturbance power with a double-ridged waveguide horn or log-periodic antenna as a function of distance. The requirement is met if the measurement distance is equal to, or greater than, the transition distance. The transition distance is marked by the transition point that shall be determined as shown in Figure 22. The measurement results shall be plotted and two parallel lines separated by 5 dB drawn to enclose as many of the measurement results; the transition point is the point where the lines intersect and after which the radiated power decreases by 20 dB/decade.

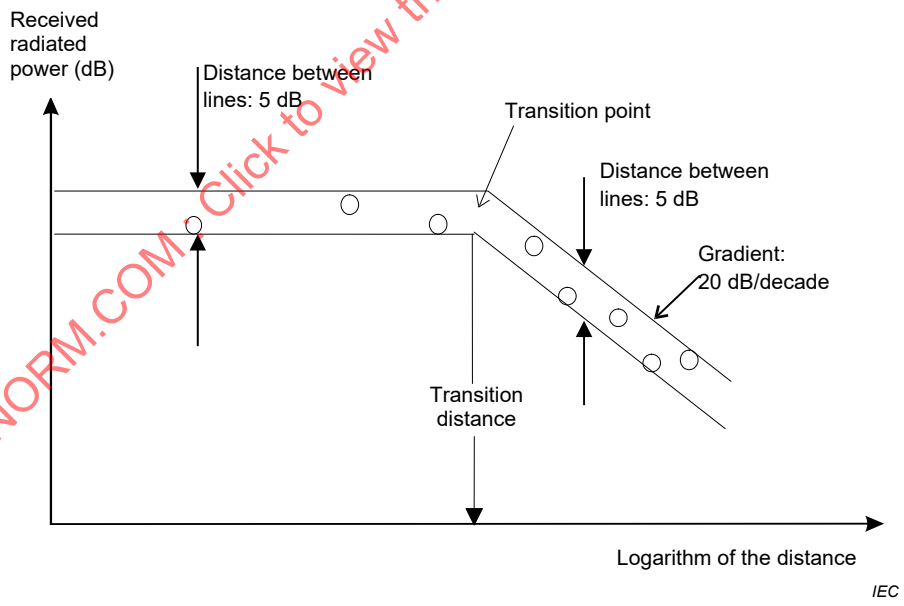


Figure 22 – Determination of the transition distance

7.7.4.3.2 Measurement method

The radiated disturbance power shall be measured in the direction of maximum radiation with the EUT in the mode of operation generating the highest disturbance field strength. A double-ridged waveguide horn or log-periodic antenna shall be used to determine the direction of maximum radiation. The measurement distance shall then be chosen according to 7.7.4.2.1 and the disturbance field strength on the selected frequency is measured. The antenna

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

position shall be varied slightly to ensure that the measured field strength is not at a local minimum (for example, due to reflections).

For measurement of the radiated disturbance power, the EUT shall be disconnected and a double-ridged horn or log-periodic antenna positioned either in the immediate vicinity of the EUT or in its place. The antenna shall then be fed by a signal generator operating at the same frequency. The orientation of the antenna shall be such that the test receiver receives the highest field strength. This antenna position shall be fixed. The power of the signal generated shall be varied until the test receiver receives the same power as that generated by the EUT. The power at the signal generator P_g plus the gain G of the transmitting antenna relative to a half-wave dipole yields the required radiated disturbance power P_r:

$$P_r = P_g + G \quad (21)$$

where

P_r is in dB(pW);
P_g is in dB(pW) and
G is in dB.

7.7.5 Documentation of the measurement results

The particular circumstances and conditions of the *in situ* measurements should be documented to enable the operational conditions to be reproduced if the measurements are repeated. The documentation should include

– reasons for the *in situ* measurement instead of using a standard test site,
– description of the EUT,
– technical documentation,
– scale drawings of the measurement site, showing the points at which measurements were made,
– description of the measured installation,
– details of all connections between the measured installation and the EUT: technical data and details of their location/configuration,
– description of the operating conditions,
– details of the measuring equipment;
– measurement results:
  - antenna polarization;
  - measured values: frequency, measured level and disturbance level;

    NOTE The disturbance level is the level referred to the standard measuring distance.
  - assessment of the degree of interference (if applicable).

7.7.6 Measurement uncertainty for *in situ* method

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

7.8 Substitution measurements (30 MHz to 18 GHz)

7.8.1 General

The substitution method is intended for measuring radio disturbance radiated from the cabinet, including wiring and circuitry inside the cabinet, of an equipment under test. The EUT may be either a self-contained unit with no port for any connection or have one or several

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

ports for power and other external connections. For future product standards, product committees are invited to use the field-strength measurement method described in 7.6 for 1 GHz to 18 GHz.

7.8.2 Test site

The test site shall be a level area. Indoor sites may be used, but may need special arrangements, especially in the upper part of the frequency range, in order to meet the requirements of stable and non-critical reflections from the surroundings, for example, a corner reflector added to the measuring antenna and an absorbing wall behind the EUT. The suitability of the site shall be determined as follows.

Two horizontal half-wavelength dipoles, designated A and B (see also 7.8.3), shall be placed parallel to each other, at the same height h, with height not less than 1 m above the floor and spaced at the measurement distance d. Dipole B shall be connected to a signal generator and dipole A connected to the input of the measuring receiver. The signal generator shall be tuned to give maximum indication on the measuring receiver and its output adjusted to a convenient level. The site shall be considered suitable for the purpose of measurement at the test frequency if the indication on the measuring receiver does not vary more than ±1,5 dB when dipole B is moved 100 mm in any direction. The test shall be repeated throughout the frequency range at frequency intervals small enough to ensure that the site is satisfactory for all measurements intended. If an EUT requires that measurements also be made with vertical polarization (see 7.8.4), the suitability test of the site shall be repeated with the two dipoles positioned for vertical polarization.

7.8.3 Test antennas

The test antennas A and B of Figure 23 have been described above as half-wave dipoles. For the frequency range below 1 GHz, this requirement applies primarily to the transmitting antenna B for which the radiated power in the direction of maximum radiation shall be relatable to the power at the terminals of antenna B. The measuring antenna A should also be a half-wave dipole. Its actual sensitivity will be included in the substitution calibration of the test configuration. In the frequency range of 1 GHz to 18 GHz linearly-polarized horn antennas are recommended.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

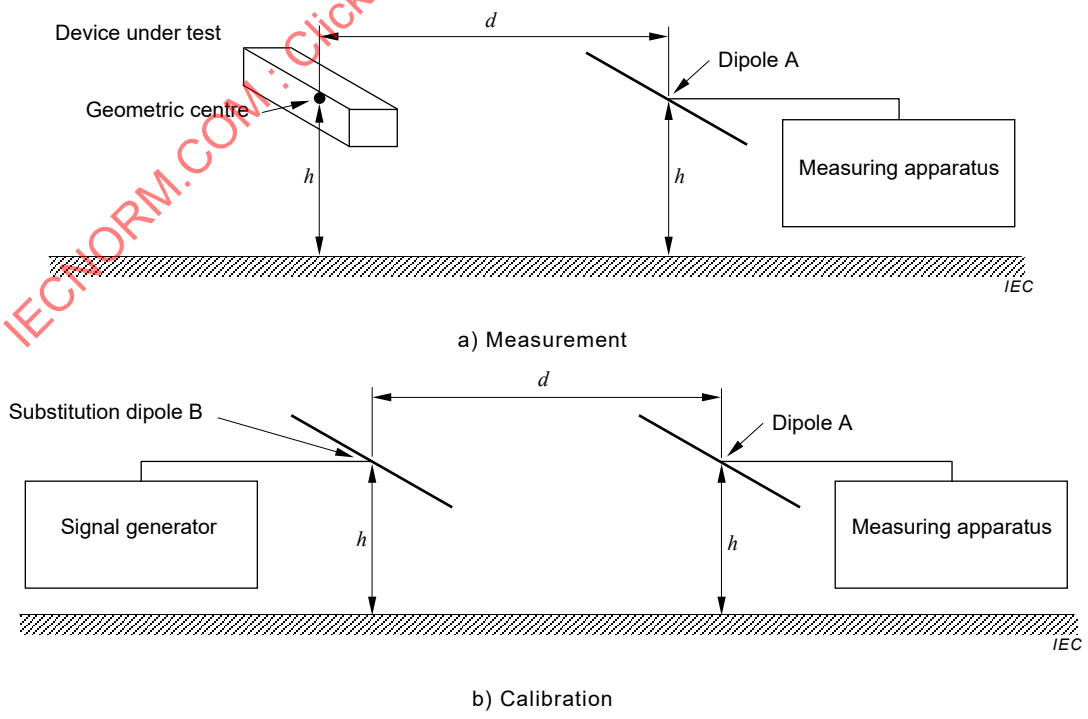


Figure 23 – Substitution method set-up geometries for: a) measurement, b) calibration

7.8.4 EUT configuration

The EUT shall be placed on a non-conducting table with provision to rotate in the horizontal plane (azimuth). The EUT shall be configured so that the geometric centre of the EUT coincides with the point earlier used as the centre point for dipole B (see Figure 23). If the EUT consists of more than one unit, each unit shall be measured separately. Detachable leads to the EUT should be removed if operation is not affected adversely. Required leads shall be provided with absorbing ferrite rings and be so positioned that they will not influence the measurements. For shielded EUTs, all connectors not used shall be terminated by shielded terminations.

7.8.5 Test procedure

With the EUT arranged as described in 7.8.4, the horizontally polarized measuring dipole A shall be placed in the same position as when checking the test site. The dipole shall be normal to a vertical plane through its centre and that of the EUT. The EUT is first measured in its normal table-standing position and secondly when tilted 90° to stand on a normally vertical side. In each position it shall be rotated 360° in the horizontal plane. The highest reading shall be the characteristic value for the EUT.

The measuring system is calibrated by replacing the EUT with a half-wave dipole B. The centre of this calibrating dipole B shall be placed in the same spot as the geometric centre of the previously measured EUT and parallel with the measurement antenna A, and be connected to a signal generator. The radiated power from the cabinet of the EUT is defined as the power at the terminals of the half-wave dipole B when the signal generator is adjusted to give the same reading on the measuring receiver as the maximum reading recorded earlier (Y), at each frequency of measurement.

When measurements are made with both horizontally and vertically polarized measuring dipoles, separate calibrations shall be made for the two modes.

7.8.6 Measurement uncertainty for substitution method

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

7.9 Reverberation chamber measurements (80 MHz to 18 GHz)

Radiated emission measurements may be performed in reverberation chambers using the methods specified in IEC 61000-4-21 [8]. Conditions for the use of alternative test methods are given in CISPR 16-4-5. General and basic considerations about uncertainties of emission measurements are given in CISPR 16-4-1.

7.10 TEM waveguide measurements (30 MHz to 18 GHz)

Radiated emission measurements may be performed in TEM waveguides using the methods specified in IEC 61000-4-20. Conditions for the use of alternative test methods are given in CISPR 16-4-5. General and basic considerations about uncertainties of emission measurements are given in CISPR 16-4-1.

8 Automated measurement of emissions

8.1 Introduction – Precautions for automated measurements

Much of the tedium of making repeated EMI measurements can be removed by automation. Operator errors in reading and recording measurement values are minimized. By using a computer to collect data, however, new forms of error can be introduced that may have been detected by an operator. Automated testing can lead, in some situations, to greater measurement uncertainty in the collected data than manual measurements performed by a

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

skilled operator. Fundamentally, there is no difference in the accuracy with which an emission value is measured whether manually or under software control. In both cases, the measurement uncertainty is based on the accuracy specifications of the equipment used in the test set-up. Difficulties may arise, however, when the present measurement situation is different from the scenarios the software was configured for.

For example, an EUT emission adjacent in frequency to a high level ambient signal may not be measured accurately, if the ambient signal is present during the time of the automated test. A knowledgeable tester, however, is more likely to distinguish between the actual interference and the ambient signal; therefore the method for measuring the EUT emission can be adapted as required. However, valuable test time can be saved by performing ambient scans prior to the actual emission measurement with the EUT turned off to record ambient signals present on the OATS. In this case the software may be able to warn the operator of the potential presence of ambient signals at certain frequencies by applying appropriate signal identification algorithms. Operator interaction is recommended if the EUT emission is slowly varying, if the EUT emission has a low on-off cycle or when transient ambient signals (e.g. arc welding transients) may occur.

8.2 Generic measurement procedure

Signals need to be intercepted by the EMI receiver before they can be maximized and measured. The use of the quasi-peak detector during the emission maximization process for all frequencies in the spectrum of interest leads to excessive test times (see 6.6.2). Time-consuming processes like antenna height scans are not required for each emission frequency. These should be limited to frequencies at which the measured peak amplitude of the emission is above or near the emission limit. Therefore, only the emissions at critical frequencies whose amplitudes are close to or exceed the limit will be maximized and measured. The generic process depicted in Figure 24 will yield a reduction in measurement time.

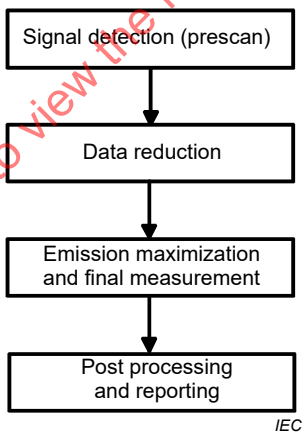


Figure 24 – Process to give reduction of measurement time

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

8.3 Pre-scan measurements

8.3.1 General

This initial step in the overall measurement procedure serves multiple purposes. Pre-scan places the least number of restrictions and requirements upon the test system since its main purpose is to gather a minimal amount of information upon which the parameters of additional testing or scanning will be based. This measurement mode can be used to test a new product, where the familiarity with its emission spectrum is very low. In general, pre-scan is a data acquisition procedure used to determine where in the frequency range of interest, significant signals are located. Depending on the goal of this measurement, antenna tower and turntable movement may be necessary (for the radiated emission test) as well as improved frequency accuracy (e.g. for further processing on an OATS) and data reduction through amplitude comparison. These factors define the measurement sequence during the execution of

pre-scan. In any case, the results will be stored in a signal list for further processing. When a pre-scan measurement is made to quickly obtain information on the unknown emission spectrum of an EUT, frequency scanning can be performed by applying the considerations of 6.6.

8.3.2 Determination of the required measurement time

If the emission spectrum and especially the maximum pulse repetition interval T_p of the EUT are not known, they shall be investigated to assure the measurement time T_m is not shorter than T_p. The intermittent character of the emission of an EUT is especially relevant for critical peaks of the emission spectrum. First it should be determined at which frequencies the amplitude of the emission is not steady. This can be done by comparing the maximum-hold with a minimum-hold or clear/write function of the measuring equipment or software, and observing the emission for a period of 15 s. During this period no change in the set-up should be made (no change of lead in case of conducted emission, no movement of absorbing clamp, no movement of turntable or antenna in case of radiated emission). Signals with e.g. more than 2 dB difference between the maximum-hold result and minimum-hold result are marked as intermittent signals. (Care should be taken not to mark noise as intermittent signals.)

In case of radiated emission, the polarization of the antenna is changed and the measurement is repeated, to reduce the risk that certain intermittent peaks are not found because they remain below noise level. From each intermittent signal the pulse repetition period T_p can be measured, by applying zero-span or using an oscilloscope connected to the IF-output of the measurement receiver. The correct measurement time can also be determined by increasing it until the difference between maximum-hold and clear/write displays is below e.g. 2 dB. During further measurements (maximization and final measurement), it shall be assured for each part of the frequency range that the measuring time T_m is not smaller than the applicable pulse repetition period T_p.

8.3.3 Pre-scan requirements for different types of measurements

The type of measurement determines the definition of a pre-scan measurement in the following way.

- For radiated emissions in the frequency range from 9 kHz to 30 MHz, e.g. per CISPR 11 [1], both the loop antenna and the EUT need to be rotated to find the maximum field strength while the receiver is scanning the emission spectrum. In the frequency range from 30 MHz to 1 000 MHz, the antenna height may be preset to fixed heights given in Table 7, based on measurement distance, frequency range and polarization. The necessary pre-scan measurements shall be made for a sufficient number of EUT azimuths. For quick overview measurements this will yield an indication of the radiated emission amplitudes as a starting point for final maximization. If a more detailed determination of the worst-case antenna height, polarization and EUT azimuth is desired, the applicable standard should be used to determine the appropriate maximization procedure.
- In the frequency range above 1 GHz, the antenna needs to be positioned in horizontal and vertical polarization and the EUT rotated to find the maximum field strength while the emission spectrum is scanned. For details of the test procedure, see 7.6.6.1.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Table 7 – Recommended antenna heights to guarantee signal interception (for pre-scan) in the frequency range 30 MHz to 1 000 MHz

Measurement distance m	Polarization h – horizontal v – vertical	Frequency range MHz	Recommended antenna heights for each frequency range (minimum / maximum) m
3	h	30 to 100 100 to 250 250 to 1 000	2,5 1 / 2 1 / 1,5
	v	30 to 100 100 to 250 250 to 1 000	1 1 / 2 1 / 1,5 / 2
10	h	30 to 100 100 to 200 200 to 400 400 to 1 000	4 2,5 / 4 1,5 / 2,5 /4 1 /1,5 /2,5
	v	30 to 200 200 to 300 300 to 600 600 to 1 000	1 1 / 3,5 1 / 2 / 3,5 1 / 1,5 / 2 / 3,5
30	h	30 to 300 300 to 500 500 to 1 000	4 2,5 / 4 1,5 / 2,5 / 4
	v	30 to 500 500 to 800 800 to 1 000	1 1 / 3,5 1 / 2,5 / 3,5

a) The recommended antenna heights were derived for source phase-centre heights of between 0,8 m and 2,0 m for maximum errors of 3 dB (which is good for a pre-scan only). If the range of phase centre heights is reduced, the number of receive antenna heights may be reduced. If radiation pattern lobes exist (distinct peaks and nulls), e.g. in the upper frequency ranges, more antenna heights may be needed.

b) For very large EUTs, e.g. telecom systems, the receiving antenna may need to be positioned in several vertical and horizontal positions, depending on the antenna beam width.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

8.4 Data reduction

The second step in the overall measurement procedure is used to reduce the number of signals collected during pre-scan and is thus aimed at further reduction of the overall measurement time. These processes can accomplish various tasks, e.g. determination of significant signals in the spectrum, discrimination between ambient or auxiliary equipment signals and EUT emissions, comparison of signals to limit lines, and data reduction based on user-definable rules. Another example of data-reduction methods involving the sequential use of different detectors and amplitude versus limit comparisons is given by the decision tree in Annex C of CISPR 16-2-1:2014. Data reduction may be performed fully automated or interactively, involving software tools or manual operator interaction. It need not be a separate section of the automated test, i.e. it may be part of a pre-scan.

In certain frequency ranges, especially the FM band, an acoustic ambient discrimination is very effective. This requires signals to be demodulated to be able to listen to their modulation content. If an output list of pre-scan contains a large number of signals and acoustic discrimination is needed, it can be a rather lengthy process. However, if the frequency ranges for tuning and listening can be specified, only signals within these ranges will be

demodulated. The results of the data reduction process are stored in a separate signal list for further processing.

8.5 Emission maximization and final measurement

During the final test the emissions are maximized to determine their highest level. After the maximization of the signals, the emission amplitude is measured using quasi-peak detection and/or average detection, allowing for the appropriate measurement time (at least 15 s if the reading shows fluctuations close to the limit).

The type of the radiated emission measurement defines the maximization process yielding the highest signal amplitudes:

- in the frequency range from 9 kHz to 30 MHz – maximization of the indicated level by variation of the EUT azimuth angle and the azimuth angle of the (vertical) plane of the loop antenna (e.g. tests for CISPR 11 [1]);
- in the frequency range from 30 MHz to 1 000 MHz – maximization of the indicated level by variation of height and polarization of the measurement antenna as well as variation of the EUT azimuth;
- in the frequency range above 1 GHz – maximization of the indicated level by variation of the antenna polarization and variation of the EUT azimuth and, if the EUT surface is wider than the antenna beam, by moving the antenna along the EUT surface.

Before the actual maximization sequence can be executed, the worst-case EUT set-up shall be determined to ensure the detection of maximum emission amplitudes. The process of finding the EUT and cable configuration that yields the worst case emissions is primarily a manual operation. This can be done using a scanning receiver with a graphical display of the emission spectrum and signal maximum-hold capability for observing the changes in amplitudes as cable and equipment layouts are manipulated. The automated final measurement of emissions should begin after the worst case EUT operating mode and layout has been configured.

The measurement of a particular radiated emission includes a maximization process involving the rotation of the EUT, scanning the receive antenna over a height range, and changing antenna polarization. This time-consuming search process can be effectively automated, but it shall be recognized that a variety of search strategies may be used that can lead to different results. In case of previous knowledge of the radiation characteristics of an EUT, a maximization sequence should be chosen that allows the determination of the worst-case amplitude within the search ranges of the antenna mast and the turntable. For instance, if the EUT emits highly directive signals in the horizontal plane, e.g. due to slots in the case, the turntable should be rotated continuously while taking data with the receiver. A table movement in discrete steps, on the other hand, may not allow the detection of the maximum amplitude or may cause the signal to be missed completely if the chosen angular increments of the positions are too far apart. The scan time of the spectrum analyzer should be less than the time for 15º of rotation of the turntable to produce effective maximization data.

One search strategy might be to rotate the turntable 360° while leaving the antenna at a fixed height to find the angle for maximum emission amplitude. Next, the turntable is rotated back over the full range after the antenna polarization was changed (e.g. from horizontal to vertical). During this process test data is taken continuously with the receiver and at the end of the second table scan the highest amplitudes, based on turntable angle and antenna polarization, are determined. Then, the worst case positions of the antenna and turntable are selected and the antenna is scanned over the required height range to find the position yielding the maximum amplitude. At this point the emission level is either recorded using the receiver's quasi-peak detector after returning to the maximum emission height, or finer search continues with incremental rotation of the turntable and following incremental height search, to find the maximum emission amplitude at the given frequency with greater precision. Again, it is important to have some understanding of the radiation pattern of the EUT in order to configure the software for an optimum search strategy that finds the maximum of the EUT

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

emission in the shortest time. Variability is introduced into the test result when the final measurement is performed on the slope of the radiation pattern rather than on its peak.

NOTE The final measurement may be performed at several frequencies in parallel using FFT-based measurement instrumentation.

8.6 Post-processing and reporting

The last part of the test procedure addresses documentation requirements. The functionality for defining sorting and comparison routines that then can be automatically or interactively applied to signal lists supports a user in compiling the necessary reports and documentation. The corrected peak, quasi-peak or average signal amplitudes should be available as sorting or selection criteria. The results of these processes are stored in separate output lists or can be combined in a single list and are available for documentation or further processing.

Results shall be available in tabular and graphics format for use in a test report. Furthermore, information about the test system itself, e.g. transducers used, measuring instrumentation, and documentation of the EUT set-up as required by the product standard should also be part of the test report.

8.7 Emission measurement strategies with FFT-based measuring instruments

Depending on the implementation, FFT-based measuring instruments may perform weighted measurements significantly faster than the tunable selective voltmeters. A weighted measurement over the frequency range of interest may then be faster than a measurement consisting of a prescan and final scan performed with a superheterodyne receiver as described in 8.2.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Annex A
(informative)

Measurement of disturbances in the presence of ambient emissions

A.1 General

High ambient emissions have to be accounted for during *in situ* tests (conducted and radiated) and type tests on an open-area test site (OATS). It is the purpose of this annex to describe measurement procedures for a number of different situations.

In some circumstances, the procedures will not provide a solution to the problems caused by ambient signals. In particular, the procedures cannot be expected to overcome the problems of 5.2.4 of CISPR 16-1-4:2010. But aside from this caveat, the following procedures can be used.

A.2 Terms and definitions

A.2.1
EUT disturbance
EUT emission spectrum to be measured

A.2.2
ambient emission
emission spectrum superimposed on the EUT disturbance spectrum that influences the accuracy of the EUT disturbance measurement

A.3 Problem description

During *in situ* tests and type tests on an OATS the ambient emissions frequently do not correspond to the ambient radio frequency environment of the test site recommendations of CISPR 16-1-4.

The radio disturbance of the EUT is often located within the frequency bands of ambient emissions and cannot be measured with a radio disturbance measuring receiver as specified in CISPR 16-1-1 due to insufficient frequency spacing between the EUT disturbance and the ambient emission or due to superposition.

The CISPR standard measuring receiver is suitable to provide uniform test results for all types of radio-frequency emissions, where the EUT disturbance alone is to be measured. It is, however, not optimized to discriminate between EUT disturbance and ambient emissions or to measure the EUT disturbance in the aforementioned situation.

Because in actual interference investigation situations there are no alternatives to an *in situ* test, a solution is described below for cases when a differentiation between EUT disturbance and ambient emission is possible.

A.4 Proposed solution

A.4.1 Overview

EUT disturbance emissions a-nd ambient emissions can be categorized as in Table A.1.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Table A.1 – Combinations of EUT disturbance and ambient emissions

EUT disturbance	Ambient emission
Narrowband	Narrowband
	Broadband
Broadband	Narrowband
	Broadband

Narrowband ambient emissions may be, for example, AM- or FM-modulated; broadband ambient emissions may be, for example, TV or digitally-modulated signals. Here the terms “narrowband” and “broadband” are always relative to the bandwidth of the measuring receiver, as specified in CISPR 16-1-1. Narrowband signals are defined as signals that have a bandwidth less than the measuring receiver bandwidth. In this case, all the signal’s spectral components are contained in the receiver bandwidth. A CW signal will always be narrowband; a narrow FM signal can be either narrow or broadband, depending on the actual receiver bandwidth. On the contrary, an impulsive signal will usually be broadband because a few of its spectral components will be within and many of its spectral components outside the receiver bandwidth.

The measurement of the EUT disturbance is a manifold problem: first, to identify EUT disturbance and ambient emission and, second, to distinguish between narrowband and broadband emission. Modern measuring receivers and spectrum analyzers provide various resolution bandwidths and detector types. These can be used to analyse the combined spectrum, to distinguish between EUT disturbance and ambient emission spectra, to distinguish between narrowband and broadband emissions and to measure (or in difficult situations to estimate) the EUT disturbance.

In case of type testing on an OATS, identification and pre-measurement of the EUT disturbance may also be carried out by pre-testing the EUT in a non-compliant (for example, partially) absorber-lined shielded room, and final testing on an OATS, whereby levels of emissions hidden by ambients may be determined by comparison with emissions in the vicinity.

Superposition of the emissions shall be accounted for when EUT disturbance and ambient emissions cannot be separated. The separation needs an EUT disturbance-and-ambient-emission to ambient-emission ratio of about 20 dB.

In cases where IF-bandwidths and detectors are different from the specified bandwidth and the quasi-peak (QP) detector, the QP value in the specified bandwidth is the reference for the measurement-error determination.

Figure A.1 shows a flow diagram for the selection of bandwidths and detectors and the estimated measurement errors due to that selection.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

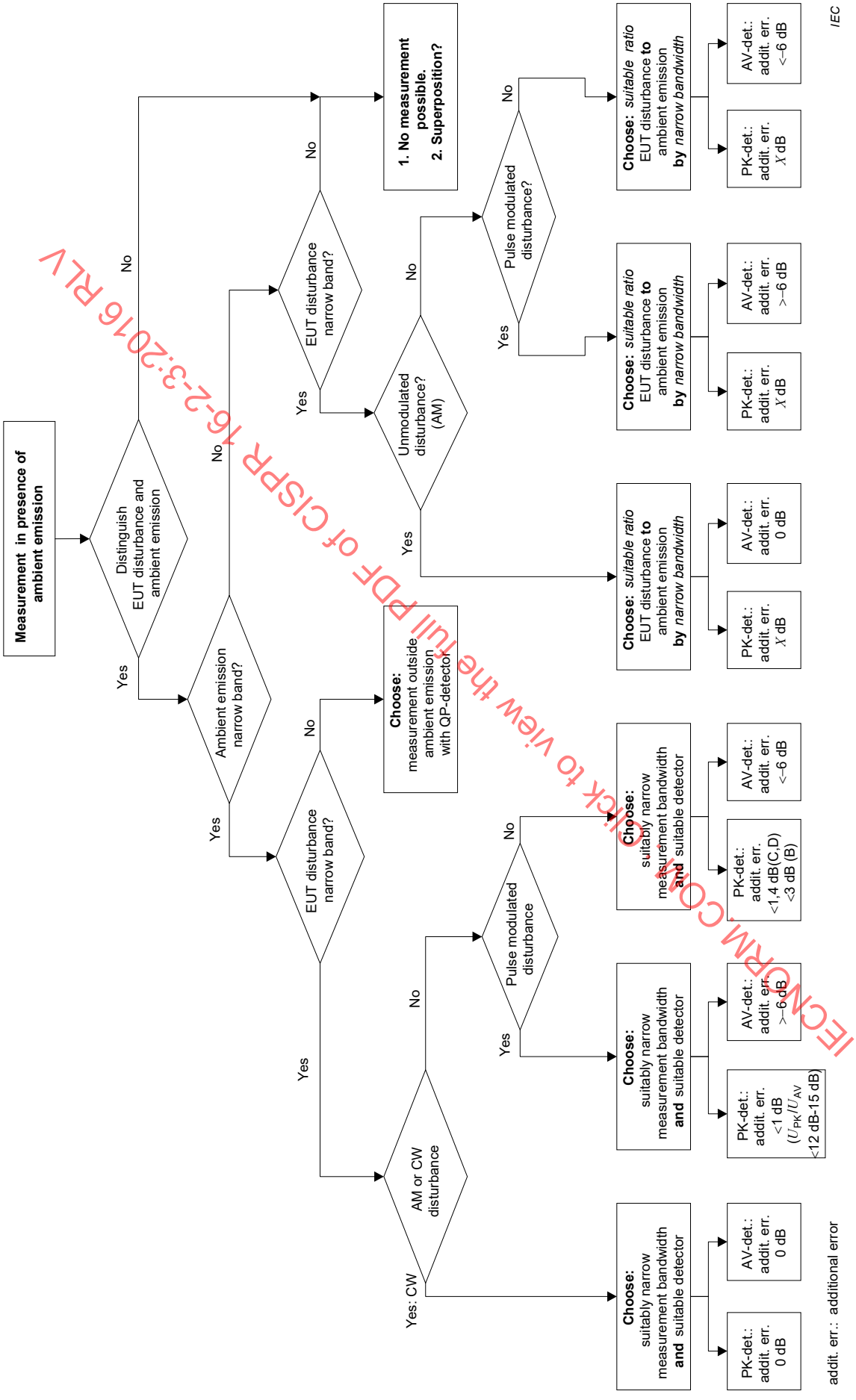


Figure A.1 – Flow diagram for the selection of bandwidths and detectors and the estimated measurement errors due to that selection

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

A.4.2 Pre-testing the EUT in a shielded room

Emission frequency and amplitude data acquired from preliminary testing in a shielded room may be used under certain restrictive conditions (a simple shielded room is not an absorber-lined shielded room – semi-anechoic or anechoic – and thus does not meet present NSA values in Annex E of CISPR 16-1-4:2010, (Annex A of [4])). This will give the emission spectrum that has significant amplitudes. In cases of narrowband emission the product emission spectrum contains harmonics and subharmonics of any clock frequency used in the product.

These pre-test results may be used to determine product emission amplitudes in certain restrictive situations. In particular, when the final compliance test is performed at an OATS and one (or more) of the frequencies are masked (hidden) by an RF ambient, chances are that an adjacent frequency to these masked frequencies will not coincide precisely with an RF ambient. Hence, the unmasked emission can be recorded in the usual manner using the required receiver or spectrum analyzer bandwidth. Then the amplitude of the EUT emission that is masked by the high RF ambient can be judged using the preliminary quiet-chamber measurements in the following way.

Assume that during the shielded room preliminary measurements two adjacent frequency emissions differ in amplitude by X dB (see Figure A.2). Next one of these frequencies that are not masked by the RF ambient is measured at the OATS. The difference in amplitude (X dB) of the masked frequency from the measurable adjacent frequency can be added to (or subtracted from, depending on the sign of the difference) the amplitude found in the shielded room to determine the amplitude of the adjacent frequencies. This is shown in Figure A.2, where (assuming that the frequency f_1 is the masked frequency and f_0 is not masked), the amplitude for f_1 is shown as X dB greater than the amplitude at f_0. Then to find the amplitude of f_1 at the OATS, X dB is added to the value of the measurable amplitude of f_0. Similarly, if the amplitude of f_6 were Y dB less than that for f_7 found during the quiet-chamber testing, the amplitude of f_6 (if masked by an ambient) would be Y dB less than that of f_7, which is assumed to be measurable at the OATS.

NOTE The above procedure emphasizes what is contained in point d) of 7.3.6.2 (Test environment).

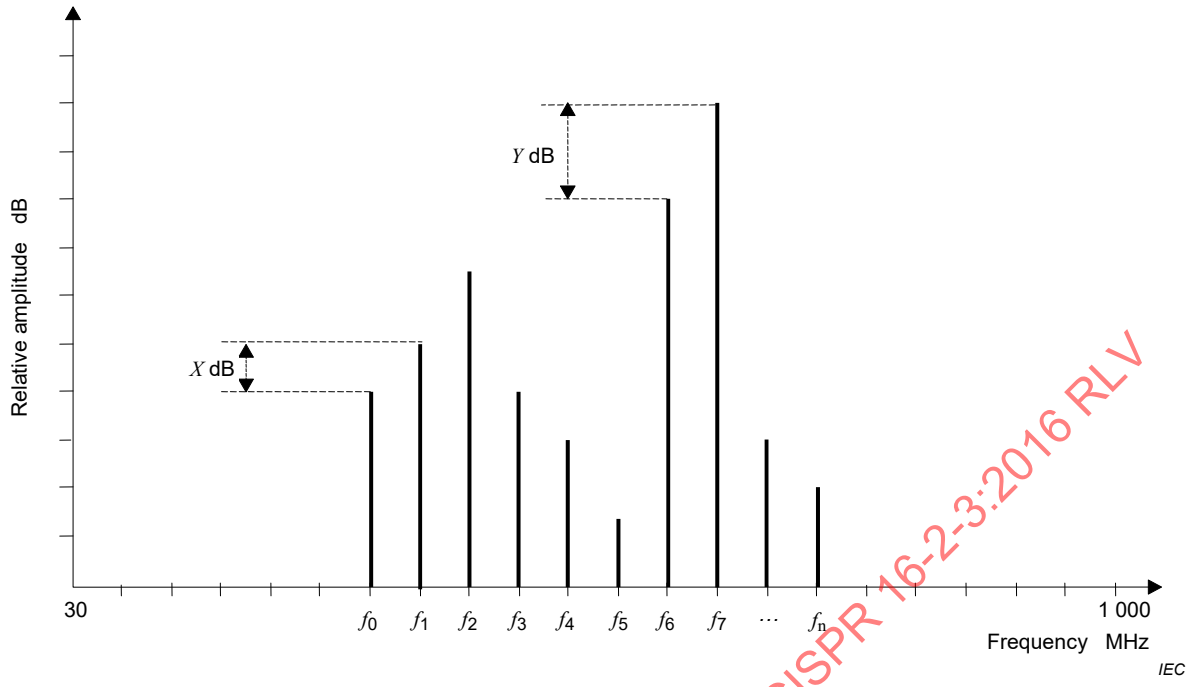
Several precautions should be taken in using this restricted procedure.

a) The adjacent frequency found in preliminary testing should not be more than one or two adjacent frequencies away (usually a sub-harmonic or harmonic of the basic clock frequency), so that the effect of the shielded room irregularities will not unnecessarily enhance or depress frequencies adjacent to the frequency to be estimated on the OATS. In this case, the value of X (or Y in Figure A.2) may not be suitable.

b) The amplitudes of adjacent frequencies need to be measured very carefully by height scan of the receive antenna in the quiet chamber (as would be the case for the final compliance measurement). If full height scan cannot be made, alternate correlations between the quiet-chamber measurements and the corresponding OATS measurements may have to be made before applying this OATS amplitude estimation technique (for emissions masked by the RF ambient).

c) For those quiet chambers that are fully absorber-lined on all six sides of the chamber, alternate height-scan techniques might be available, such as measurements at two or three fixed heights (since the ground plane reflections are suppressed and that contribution to the received signal diminished) and using the maximum of these readings. Such techniques may need the same correlation measurements as stated in item b) above.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



NOTE Generally f_n is n times f_0, the EUT fundamental emission frequency (basic clock frequency).

Figure A.2 – Relative difference in adjacent emission amplitudes during preliminary testing

A.4.3 Method of measurement of EUT disturbances in the presence of narrowband ambient emissions

A.4.3.1 General

Depending on the type of EUT disturbance, its measurement is based on

– the analysis of the combined spectrum with a bandwidth narrower than that of the CISPR measuring receiver,

– the determination of a suitable measurement bandwidth for the selection of narrowband disturbance close to ambient emissions,

– the use of the peak detector (if the disturbance is AM or pulse modulated) or the average detector,

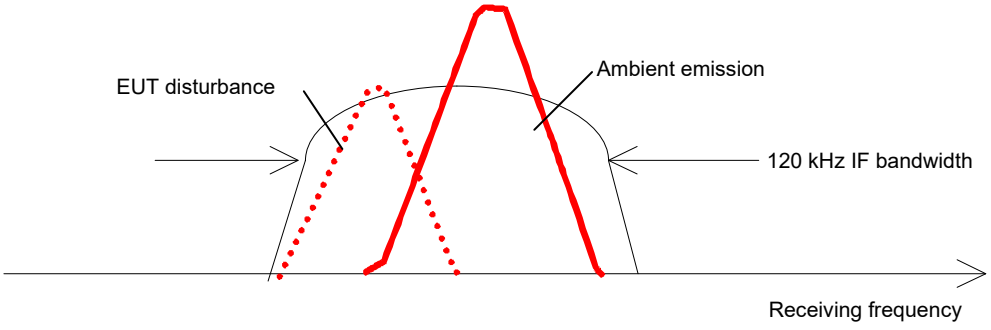
– the increase of the EUT disturbance to ambient emission ratio in case of a narrowband disturbance within a relatively broadband ambient emission when a narrower measurement bandwidth is used, and

– accounting for superposition of EUT disturbance and ambient emission, if separation is not possible.

A.4.3.2 Unmodulated EUT disturbance

The unmodulated EUT disturbance (see Figure A.3) can be separated from the ambient signal carrier by choosing a suitably narrow measurement bandwidth. Either the peak or the average detector may be used. There is no additional measurement error compared with the quasi-peak detector. If the difference in level between peak and average values is very small (for example, lower than 1 dB), the measured average value is equivalent to the quasi-peak value.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



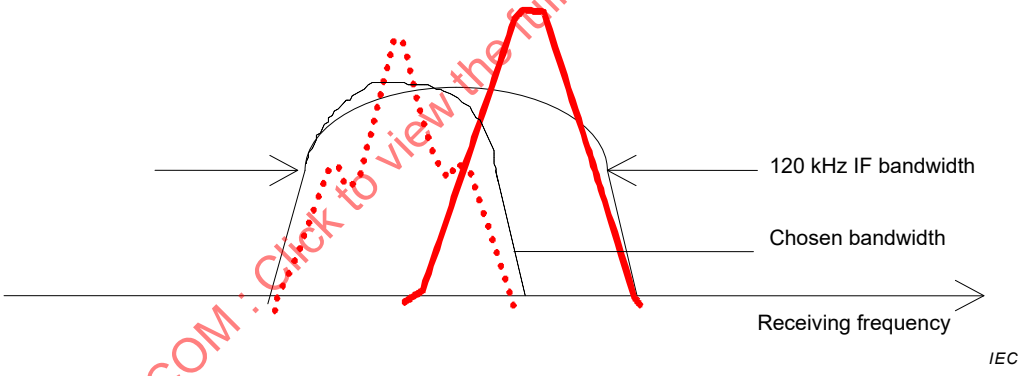
Key

dotted line	EUT disturbance
solid bold line	ambient emission
thin line	120 kHz IF bandwidth

Figure A.3 – Disturbance by an unmodulated signal (dotted line)

A.4.3.3 Amplitude-modulated EUT disturbance

The amplitude-modulated EUT disturbance (see Figure A.4) can be separated from the ambient signal carrier by choosing a suitably narrow measurement bandwidth. Care should be taken to ensure that the narrow measurement bandwidth chosen does not suppress the modulation spectra of the EUT disturbance. Suppression of the modulation spectra is recognised by a decrease in the peak amplitude of the EUT disturbance as a result of the increase of selectivity.



Key

dotted line	EUT disturbance
solid bold line	ambient emission
thin line	120 kHz IF bandwidth

Figure A.4 – Disturbance by an amplitude-modulated signal (dotted line)

Only the peak detector with a measurement time greater than the reciprocal of the modulation frequency can be used. An additional measurement error shall be accounted for at modulation frequencies below 10 Hz (0,4 dB at 10 Hz; 1,4 dB at 2 Hz for bands C and D and 0,9 dB at 10 Hz; 3 dB at 2 Hz for band B), where the peak value is above the quasi-peak value. The QP-value as a function of the modulation frequency is shown in Figure A.5.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

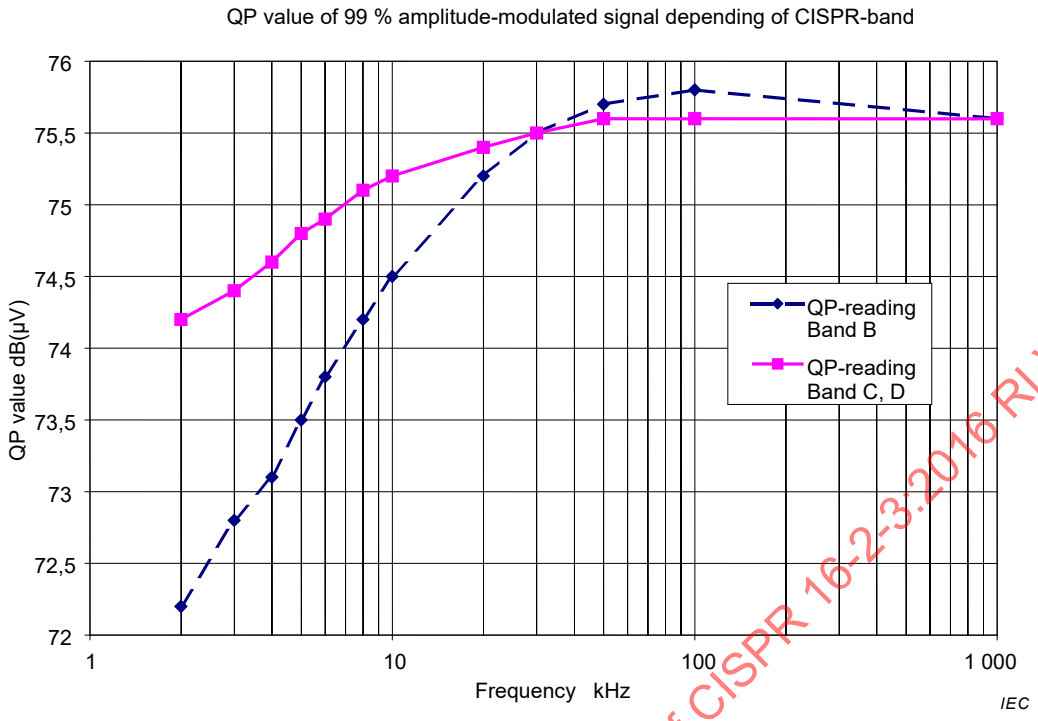


Figure A.5 – Indication of an amplitude-modulated signal as a function of modulation frequency with the QP detector in CISPR bands B, C and D

A.4.3.4 Pulse-modulated EUT disturbance

The narrowband pulse-modulated disturbance from the EUT is classified as a special case of amplitude modulation and can also be separated from the ambient signal carrier by a suitably narrow measurement bandwidth. The selectivity shall not lead to a suppression of the modulation spectra. Only the peak detector can be used.

In cases of low repetition frequency, an additional error is possible, but as long as the difference between peak- and average detector reading is in the order of 12 dB to 14 dB, additional measurement errors compared with the quasi-peak value need not be accounted for.

For a pulse width τ = 50 µs, Figure A.6 shows that as long as the difference between peak and average levels is less than or equal to 14 dB, the deviation between peak and QP levels is negligible. So, the comparison between peak and average levels may be used to verify the usability of the peak detector.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

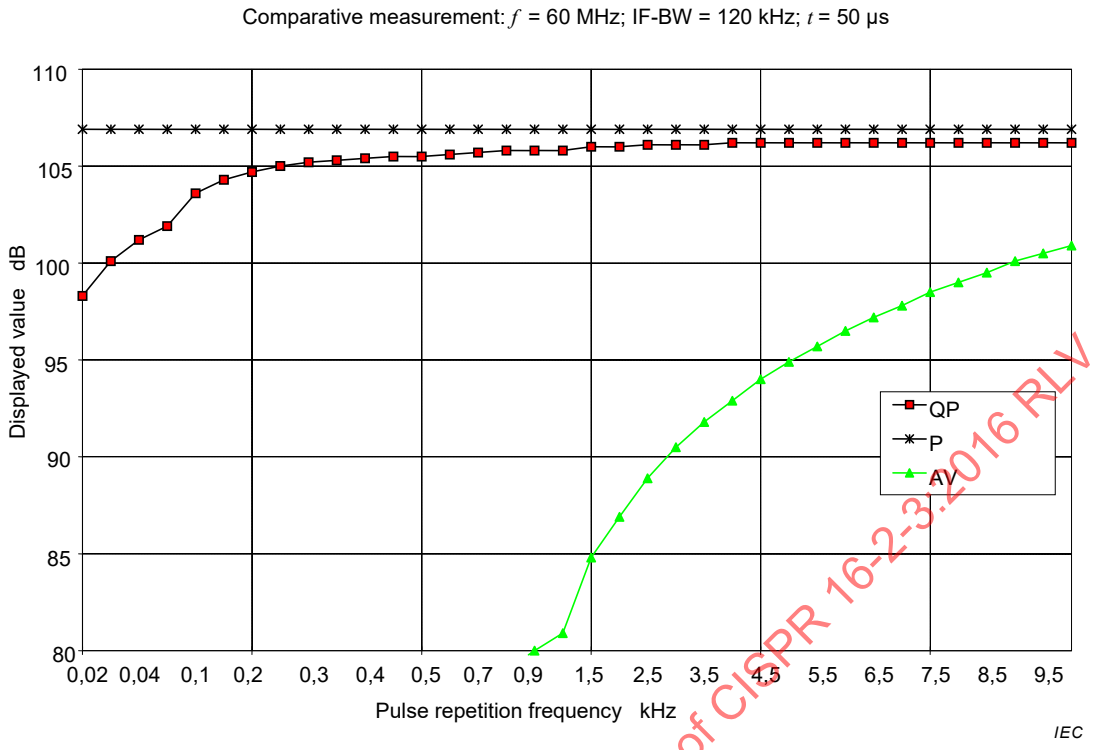
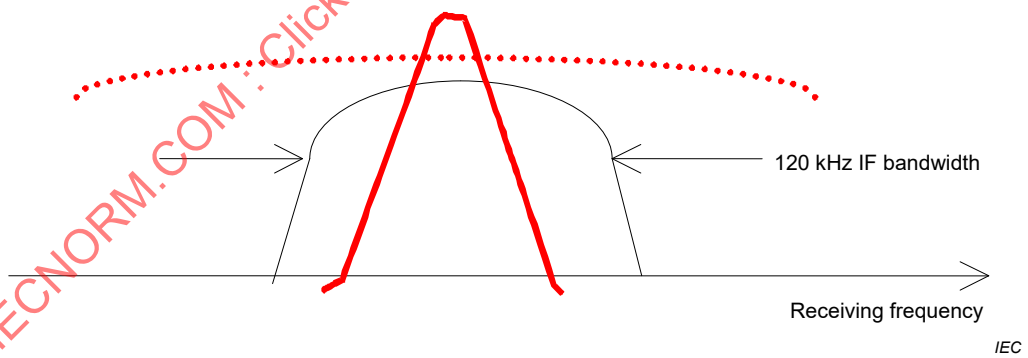


Figure A.6 – Indication of a pulse-modulated signal (pulse width 50 µs) as a function of pulse repetition frequency with peak, QP and average detectors

A.4.3.5 Broadband EUT disturbance

For the measurement of broadband disturbance (see Figure A.7) the quasi-peak detector shall be used. In fact it is not possible to carry out a measurement within the ambient signal bandwidth. Because of the finite bandwidth, the disturbance can generally be measured outside the ambient signal spectrum using the quasi-peak detector.



Key

dotted line	EUT disturbance
solid bold line	ambient emission
thin line	120 kHz IF bandwidth

Figure A.7 – Disturbance by a broadband signal (dotted line)

A.4.4 Method of measurement of EUT disturbance in the presence of broadband ambient emissions

A.4.4.1 General

For this case the measurement method is based on

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

– the analysis of the combined spectrum with a bandwidth equal to the CISPR measuring receiver,

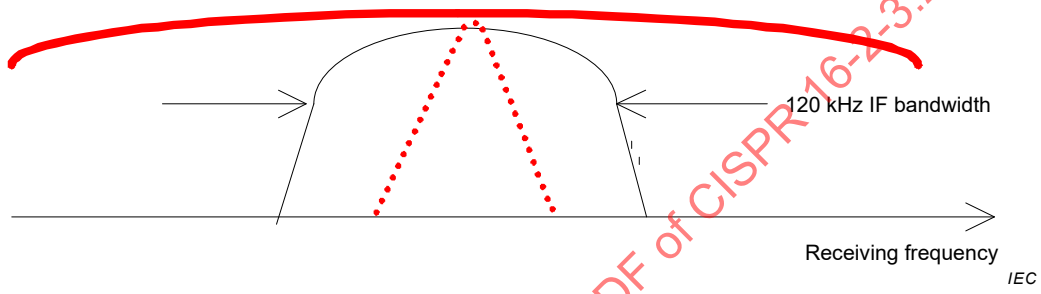
– measurement with a narrow bandwidth (in case of narrowband EUT disturbance; the use of a narrow bandwidth will increase the EUT disturbance to ambient emission ratio),

– the use of the average detector for narrowband EUT disturbance, and

– accounting for superposition of EUT disturbance and ambient emission, if separation is not possible.

A.4.4.2 Unmodulated EUT disturbance

The amplitude of the EUT disturbance (see Figure A.8) should be measured with the average detector (specified in CISPR 16-1-1). The measurement error depends on the average value of the broadband signal spectrum within the selected bandwidth. This measurement error can be minimized by choosing a measurement bandwidth that maximizes the EUT disturbance to ambient emission ratio (selectivity method).



Key

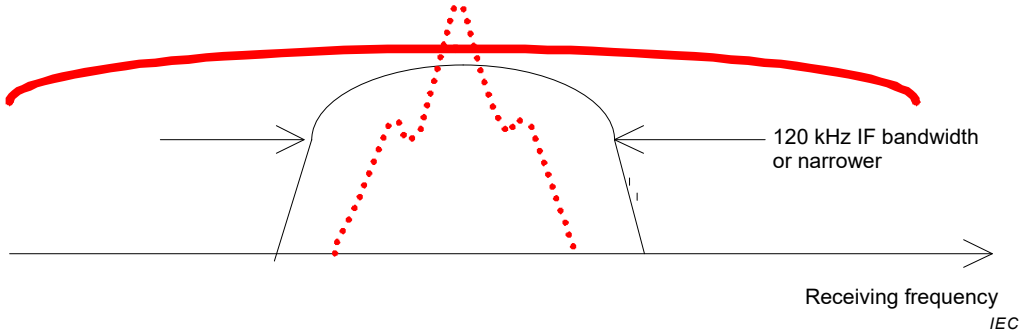
dotted line	EUT disturbance
solid bold line	ambient emission
thin line	120 kHz IF bandwidth

Figure A.8 – Unmodulated EUT disturbance (dotted line)

A.4.4.3 Amplitude-modulated EUT disturbance

The amplitude of the EUT disturbance (see Figure A.9) is measured with the average detector, although an additional measurement error of up to 6 dB (at 100 % modulation) compared with a quasi-peak detector shall be accounted for. The measurement bandwidths chosen should maximize the EUT disturbance to ambient emission ratio (selectivity method).

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



Key

dotted line	EUT disturbance
solid bold line	ambient emission
thin line	120 kHz IF bandwidth

Figure A.9 – Amplitude-modulated EUT disturbance (dotted line)

A.4.4.4 Pulse-modulated EUT disturbance

It is not easy to detect and recognise a pulse-modulated EUT disturbance in a broadband ambient signal spectrum with a high level of reliability, because the 100 % amplitude modulation of the disturbance may mask the EUT disturbance within the spectrum.

The amplitude of the EUT disturbance can be measured with the average detector in case of high duty cycles. Due to the 100 % amplitude modulation depth with smaller duty cycles, the use of the average detector will cause an increasing measurement error compared with the quasi-peak detector. In the case of a duty cycle of 1:1 and use of the linear average detector, the measurement error is 6 dB. The measurement bandwidth should be such that the relationship between the measured average value of the EUT disturbance and the average value of the broadband ambient signal is maximized.

In case of low duty cycles, the average value will substantially deviate from the QP value. In this case the peak detector should be used together with a measurement bandwidth as narrow as possible but still wide enough to capture the complete disturbance bandwidth. Superposition with the ambient emission may have to be accounted for.

A.4.4.5 Broadband EUT disturbance

As a rule, broadband disturbance cannot be detected or measured in a broadband ambient signal spectrum. It may be possible to measure such a disturbance outside the ambient signal spectrum or by accounting for superposition.

The combinations of EUT disturbance with the ambient emission, and the error involved in the measurement, are displayed in Table A.2.

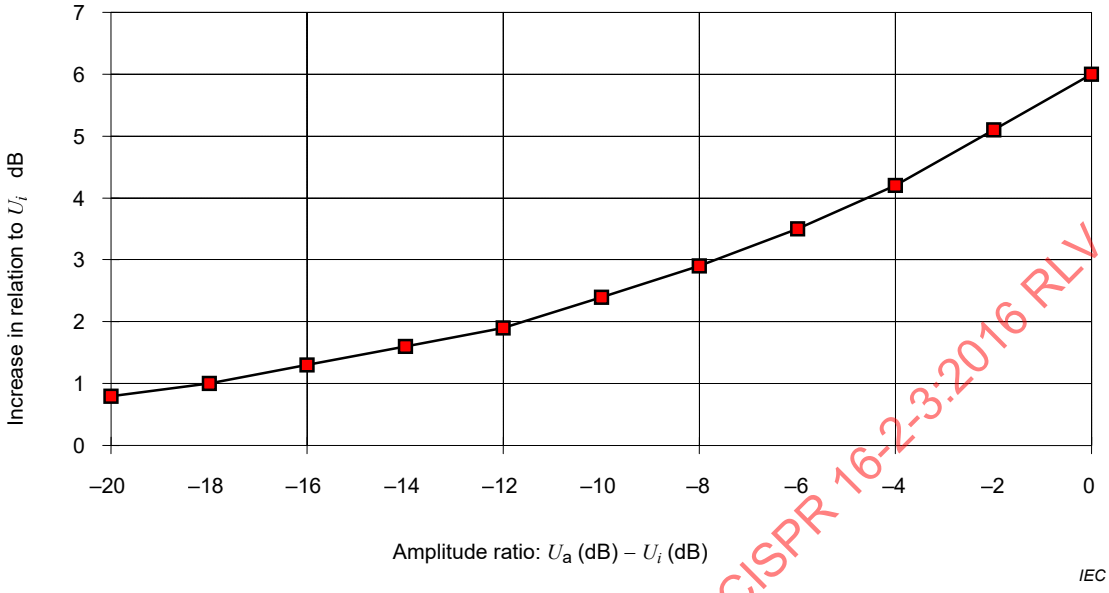
NOTE A scanning receiver or spectrum analyzer will show the spectra of two different broadband signals, unless the signal frequencies or pulse rates are harmonically related with each other, or the sweep rate of the measuring instrument is harmonically related with the measured pulse rates.

A.5 Determination of the EUT disturbance in case of superposition

If, as a result of the selection of the EUT disturbance and the ambient emission, the measured level to ambient emission ratio is lower than 20 dB, the superposition of ambient emission and EUT disturbance needs to be accounted for. For impulsive broadband voltage, the following calculation can be made.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

The received signal U_r is the sum of the EUT disturbance U_i and the ambient emission U_a. U_a can be measured only when the EUT is switched off. The superposition is linear for the peak detector (see Figure A.10).



Key:

U_a is level of ambient emission

U_i is level of EUT disturbance

Figure A.10 – Increase of peak value with superposition of two unmodulated signals

The following equation applies when using the peak detector:

$$U_r = U_i + U_a \tag{A.1}$$

The EUT disturbance can thus be calculated from

$$U_i = U_r - U_a \tag{A.2}$$

The amplitude ratio d of the received signal to the ambient emission can be measured easily.

$$D = \frac{U_r}{U_a}, \qquad d = 20 \lg D \tag{A.3}$$

The ambient emission U_a can be substituted in Equation (A.2):

$$U_i = U_r - \frac{U_r}{D} = U_r\left(1 - \frac{1}{D}\right) \tag{A.4}$$

or

$$U_{i,dB} = U_{r,dB} + 20 \lg\left(1 - \frac{1}{D}\right) \tag{A.5}$$

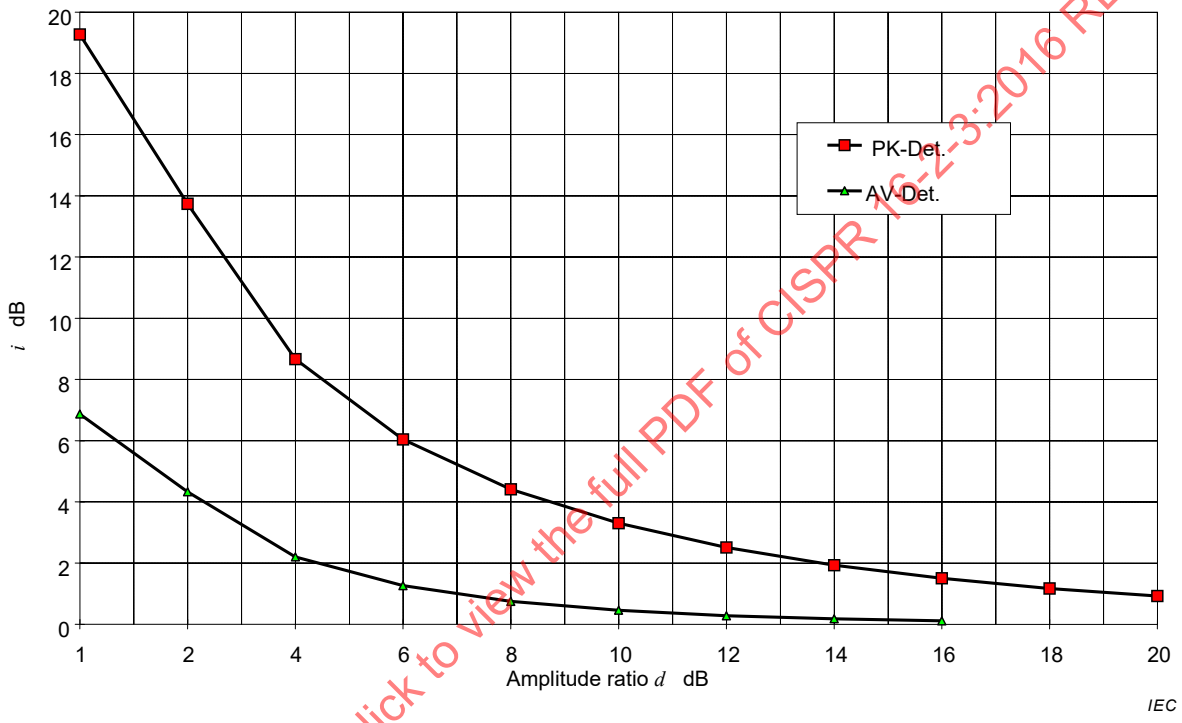
IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Defining i by Equation (A.6) as

$$i = -20 \lg\left(1 - \frac{1}{D}\right) \tag{A.6}$$

serves to determine the amplitude of the EUT disturbance. The factor i is illustrated in Figure A.11. Using i from Figure A.11, the amplitude of the EUT disturbance can be calculated as follows:

$$U_{i,\mathrm{dB}} = U_{\mathrm{r,dB}} - i \tag{A.7}$$



Key:

U_a is the ambient signal in dB

U_r is the resulting indication of received signal (by superposition) in dB

U_i is the disturbance signal in dB

$d = U_r - U_a$

$U_i = U_r - i$

$i = -20 \lg(1 - 1/D)$

Figure A.11 – Determination of the amplitude of the disturbance signal by means of the amplitude ratio d and the factor i (see Equation (A.3) and Equation (A.6))

Figure A.11 can be used as follows:

a) measure the ambient field strength U_a in dB(μV/m) (EUT off);

b) measure the resultant field strength U_r in dB(μV/m) (EUT on);

c) determine $d = U_r - U_a$;

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

d) find the value of i from Figure A.11;

e) determine U_i in dB(μV/m) using $U_i = U_r - i$.

If the received signal is measured with the average detector, Figure A.12 can be applied. Figure A.12 shows that in the case of unmodulated signals the following equation

$$U_r = \sqrt{U_i^2 + U_a^2} \tag{A.8}$$

can be used with an additional measurement error of up to about 1,5 dB. In case of modulation, the error decreases (see Figure A.12) but the errors in Table A.2 shall be accounted for.

By means of the average detector, the in-band disturbance can be estimated by applying Equation (A.7) if the curve of the average detector (Figure A.11) is used. In this case the factor i is defined as

$$i = -10 \lg\left(1 - \frac{1}{D^2}\right) \tag{A.9}$$

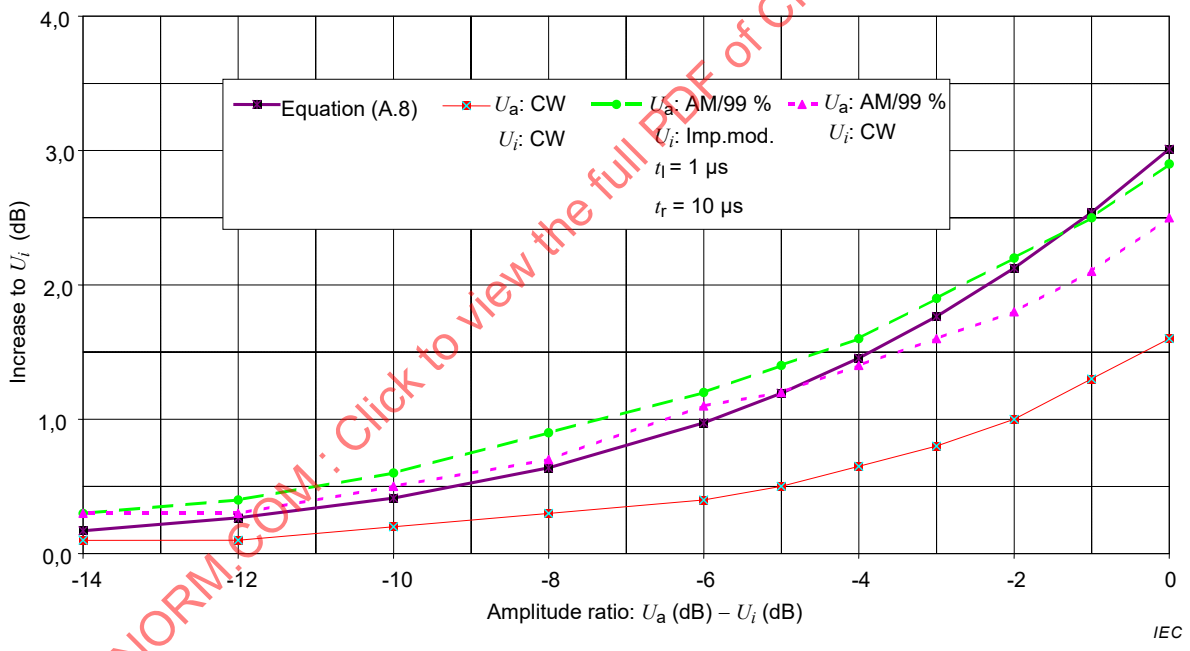


Figure A.12 – Increase of average indication measured with a real receiver and calculated from Equation (A.8)

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Table A.2 – Measurement error depending on the detector type and on the combination of ambient and disturbing signal spectra

Ambient emission	EUT disturbance			
	Unmodulated	**Amplitude-modulated**	**Pulse-modulated**	**Broadband disturbance**
Narrowband				
Steps taken to increase signal-to-noise ratio	Increased selectivity	Increased selectivity	Increased selectivity	Measurement outside ambient emission
Error of peak value $\left(\frac{PK}{QP}\right)$	0 dB	Less than or equal to +1,4 dB for bands C, D +3 dB for band B	Less than or equal to +1 dB $\left(\frac{U_{PK}}{U_{AV}} \leq 12...15 \text{ dB}\right)$	–
Error of average value $\left(\frac{AV}{QP}\right)$	0 dB	Less than or equal to –6 dB [a]	Greater than or equal to –6 dB [a]	–
Broadband				
Steps taken to increase signal-to-noise ratio	Selectivity	Selectivity	Selectivity	No measurement possible (superposition only)
Error of peak value $\left(\frac{PK}{QP}\right)$	$+X$ dB [a]	Less than or equal to $+X$ dB [a]	Greater than or equal to $+X$ dB [a]	–
Error of average value $\left(\frac{AV}{QP}\right)$	0 dB	Less than or equal to –6 dB [a]	Greater than or equal to –6 dB [a]	–

Key:

X is the error depending on the pulse character of the ambient emission.

PK is the peak value; QP is the quasi-peak value; AV is the average value.

Bands B, C, D are defined as in CISPR 16-1-1.

[a] Measurement procedure not recommended – not allowed for compliance measurements.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Annex B
(informative)

Use of spectrum analyzers and scanning receivers

B.1 General

When using spectrum analyzers and scanning receivers, the following characteristics should be addressed. See also Clause 6 of this standard for additional information.

B.2 Overload

Most spectrum analyzers have no RF preselection in the frequency range up to 2 000 MHz; that is, the input signal is directly fed to a broadband mixer. To avoid overload, to prevent damage and to operate a spectrum analyzer linearly, the signal amplitude at the mixer should typically be less than 150 mV peak. RF attenuation or additional RF preselection may be required to reduce the input signal to this level.

B.3 Linearity test

Linearity can be evaluated by measuring the level of the specific signal under investigation and repeating this measurement after an X dB attenuator has been inserted at the input of the receiver or, if used, the preamplifier ($X \geq 6$ dB). The new reading of the receiver display should differ by X dB up to ±0,5 dB from the first reading, if the measuring system is linear.

B.4 Selectivity

The spectrum analyzer and scanning receiver shall have the bandwidths specified in CISPR 16-1-1 to correctly measure broadband and impulsive signals, and narrowband disturbances with several spectrum components within the standardized bandwidth.

B.5 Normal response to pulses

The response of a spectrum analyzer and a scanning receiver with quasi-peak detection can be verified with the calibration test pulses specified in CISPR 16-1-1. The large peak voltage of the calibration test pulses typically requires insertion of an RF attenuation of 40 dB or more to satisfy the linearity requirements. This decreases the sensitivity and makes the measurement of low repetition rate and isolated calibration test pulses impossible for bands B, C and D. If a preselecting filter is used ahead of the receiver, then the RF attenuation can be decreased. The filter limits the spectrum width of the calibration test pulse as seen by the mixer.

B.6 Peak detection

The normal (peak) detection mode of spectrum analyzers provides a display indication that, in principal, is never less than the quasi-peak indication. It is convenient to measure emissions using peak-detection because it allows faster frequency scans than quasi-peak detection. Those signals that are close to the emission limits then need to be re-measured using quasi-peak detection to record quasi-peak amplitudes.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

B.7 Frequency scan rate

The scan rate of a spectrum analyzer or a scanning receiver should be adjusted for the CISPR frequency band and the detection mode used. The minimum sweep time/frequency is listed in the following table:

Band	Peak-detection	Quasi-peak detection
A	100 ms/kHz	20 s/kHz
B	100 ms/MHz	200 s/MHz
C and D	1 ms/MHz	20 s/MHz

For a spectrum analyzer or scanning receiver used in a fixed tuned non-scanning mode, the display sweep time may be adjusted independently of the detection mode and according to the needs for observing the behaviour of the emission. If the level of disturbance is not steady, the reading on the receiver must be observed for at least 15 s to determine the maximum (see 6.5.1).

B.8 Signal interception

The spectrum of intermittent emissions may be captured with peak-detection and digital display storage if provided. Multiple, fast frequency scans reduce the time to intercept an emission compared to a single, slow frequency scan. The starting time of the scans should be varied to avoid any synchronism with the emission and thereby hiding it. The total observation time for a given frequency range shall be longer than the time between the emissions. Depending upon the kind of disturbance being measured, the peak detection measurements can replace all or part of the measurements needed using quasi-peak detection. Re-tests using a quasi-peak detector should then be made at frequencies where emission maxima have been found.

B.9 Average detection

Average detection with a spectrum analyzer is obtained by reducing the video bandwidth until no further smoothing of the displayed signal is observed. The sweep time shall be increased with reductions in video bandwidth to maintain amplitude calibration. For such measurements, the receiver shall be used in the linear mode of the detector. After linear detection is made, the signal may be processed logarithmically for display, in which case the value is corrected even though it is the logarithm of the linearly detected signal.

A logarithmic amplitude display mode may be used, for example, to distinguish more easily between narrowband and broadband signals. The displayed value is the average of the logarithmically distorted IF signal envelope. It results in a larger attenuation of broadband signals than in the linear detection mode without affecting the display of narrowband signals. Video filtering in log-mode is, therefore, especially useful for estimating the narrowband component in a spectrum containing both.

B.10 Sensitivity

Sensitivity can be increased with low noise RF pre-amplification ahead of the spectrum analyzer. The input signal level to the amplifier should be adjustable with an attenuator to test the linearity of the overall system for the signal under examination.

The sensitivity to extremely broadband emissions that require large RF attenuation for system linearity is increased with RF preselecting filters ahead of the spectrum analyzer. The filters reduce the peak amplitude of the broadband emissions and less RF attenuation can be used.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Such filters may also be necessary to reject or attenuate strong out-of-band signals and the intermodulation products they cause. If such filters are used, they shall be calibrated with broadband signals.

B.11 Amplitude accuracy

The amplitude accuracy of a spectrum analyzer or a scanning receiver may be verified by using a signal generator, power meter and precision attenuator. The characteristics of these instruments, cable and mismatch losses have to be analysed to estimate the errors in the verification test.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Annex C
(informative)

Scan rates and measurement times for use with the average detector

C.1 Purpose

This annex is intended to give guidance on the selection of scan rates and measurement times when measuring impulsive disturbance with the average detector.

The average detector serves the following purposes:

a) to suppress impulsive noise and thus to enhance the measurement of CW components in disturbance signals to be measured;

b) to suppress amplitude modulation (AM) in order to measure the carrier level of amplitude modulated signals;

c) to show the weighted peak reading for intermittent, unsteady or drifting narrowband disturbances using a standardized meter time constant.

Clause 6 of this standard defines the average measuring receiver for the frequency range 9 kHz to 1 GHz.

In order to select the proper video bandwidth and the corresponding scan rate or measurement time, the following considerations apply.

C.2 Suppression of disturbances

C.2.1 Suppression of impulsive disturbance

The pulse duration T_p of an impulsive disturbance is often determined by the IF bandwidth, B_{res}, i.e. $T_p = 1/B_{res}$. For the suppression of such noise, the suppression factor a is then determined by the video bandwidth B_{video} relative to the IF bandwidth, i.e. $a = 20 \lg(B_{res}/B_{video})$. The bandwidth B_{video} is determined by the bandwidth of the low-pass filter following the envelope detector. For longer pulses, the suppression factor will be lower than a. The minimum scan time $T_{s\,min}$ (and maximum scan rate $R_{s\,max}$) is determined using:

$$T_{s\,min} = \frac{k\,\Delta f}{B_{res}\,B_{video}} \tag{C.1}$$

$$R_{s\,max} = \frac{\Delta f}{T_{s\,min}} = \frac{B_{res}\,B_{video}}{k} \tag{C.2}$$

where

Δf is the frequency span and

k is a proportionality factor that depends on the speed of the measuring receiver or spectrum analyzer.

For the longer scan times, k is very close to a factor of one (1). If a video bandwidth of 100 Hz is selected, the maximum scan rates and pulse suppression factors in Table C.1 are obtained.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Table C.1 – Pulse suppression factors and scan rates for a 100 Hz video bandwidth

	Band A	Band B	Bands C and D
Frequency range	9 kHz to 150 kHz	150 kHz to 30 MHz	30 MHz to 1 000 MHz
IF bandwidth B_{res}	200 Hz	9 kHz	120 kHz
Video bandwidth B_{video}	100 Hz	100 Hz	100 Hz
Maximum scan rate	17,4 kHz/s	0,9 MHz/s	12 MHz/s
Maximum suppression factor	6 dB	39 dB	61,5 dB

This can be applied for product standards calling out quasi-peak and average limits in bands B (and C) if short pulses are expected in the disturbance signal. Compliance of the EUT with both limits shall be demonstrated. If the pulse repetition frequency is greater than 100 Hz and the quasi-peak limit is not exceeded by the impulsive disturbance, then the short pulses are sufficiently suppressed for average detection with a video bandwidth of 100 Hz.

C.2.2 Suppression of impulsive disturbance by digital averaging

Average detection may be done by digital averaging of the signal amplitude. An equivalent suppression effect can be achieved if the averaging time is equal to the inverse of the video filter bandwidth. In this case, the suppression factor $a = 20 \cdot \lg(T_{av} B_{res})$, where T_{av} is the averaging (or measuring) time at a certain frequency. Consequently a measurement time of 10 ms will produce the same suppression factor as a video bandwidth of 100 Hz. Digital averaging has the advantage of zero delay time, when switching from one frequency to another. On the other hand, for averaging of a certain pulse repetition frequency f_p, the result may vary depending on whether n or $(n + 1)$ pulses are averaged. This has an effect of less than 1 dB, for $(T_{av} f_p) > 10$.

C.2.3 Suppression of amplitude modulation

In order to measure the carrier of a modulated signal, the modulation has to be suppressed by signal averaging over a sufficiently long time, or by using a video filter of sufficient attenuation at the lowest frequency. If f_m is the lowest modulation frequency, and assuming that the maximum measurement error due to a 100 % modulation is limited to 1 dB, then the measurement time T_m should be $T_m = 10/f_m$.

C.3 Measurement of slowly intermittent, unsteady or drifting narrowband disturbances

In CISPR 16-1-1, the response to intermittent, unsteady or drifting narrowband disturbances is defined using the peak reading with meter time constants of 160 ms (for Bands A and B) and 100 ms (for Bands C and D). These time constants correspond to second order video filter bandwidths of 0,64 Hz or 1 Hz respectively. For correct measurements, these bandwidths would require very long measurement times (see Table C.2).

Table C.2 – Meter time constants and the corresponding video bandwidths and minimum scan times

	Band A	Band B	Bands C and D
Frequency range	9 kHz to 150 kHz	150 kHz to 30 MHz	30 MHz to 1 000 MHz
IF bandwidth B_{res}	200 Hz	9 kHz	120 kHz
Meter time constant	160 ms	160 ms	100 ms
Video bandwidth B_{video}	0,64 Hz	0,64 Hz	1 Hz
Minimum scan time	8,9 s/kHz	172 s/MHz	8,3 s/MHz

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

This applies, however, only for pulse repetition frequencies of 5 Hz or less. For all higher pulse widths and modulation frequencies, higher video filter bandwidths may be used (see C.2.1). Figure C.1 and Figure C.2 show the weighting function of a pulse with 10 ms pulse duration versus pulse repetition frequency f_p with peak reading (CISPR AV) and with true averaging (AV) for meter time constants of 160 ms (Figure C.1) and 100 ms (Figure C.2).

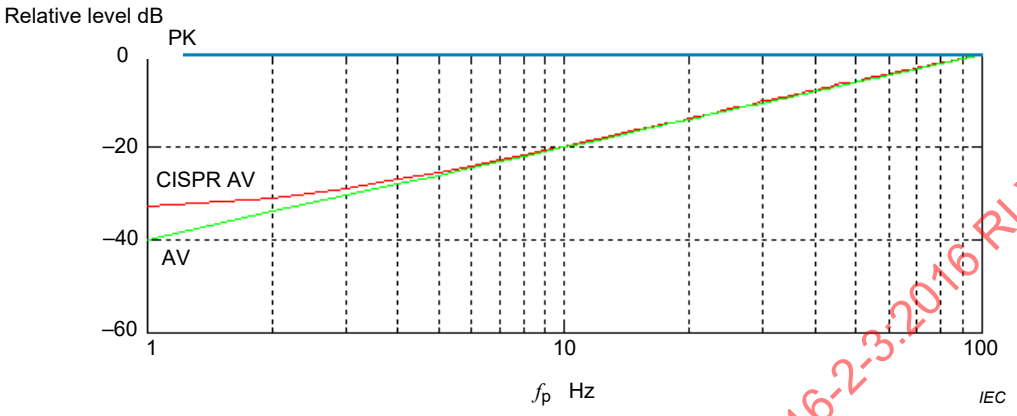


Figure C.1 – Weighting function of a 10 ms pulse for peak (PK) and average detections with (CISPR AV) and without (AV) peak reading: meter time constant 160 ms

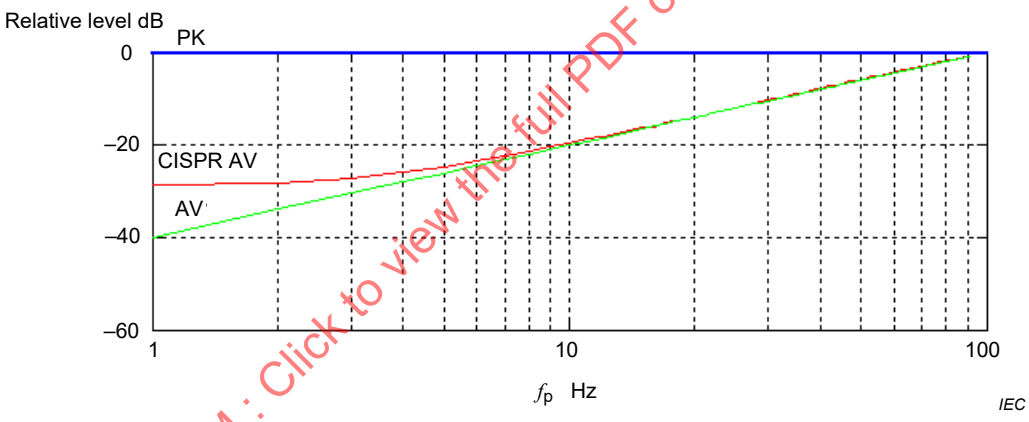


Figure C.2 – Weighting functions of a 10 ms pulse for peak (PK) and average detections with (CISPR AV) and without (AV) peak reading: meter time constant 100 ms

Figure C.1 and Figure C.2 imply that the difference between average with peak reading (CISPR AV) and without peak reading (AV) increases as the pulse repetition frequency f_p decreases. Figure C.3 and Figure C.4 show the difference for f_p = 1 Hz, as a function of pulse width.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

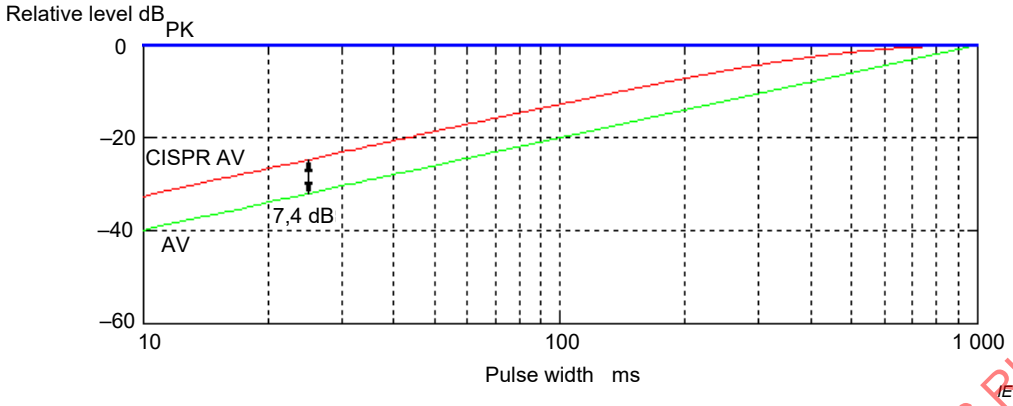


Figure C.3 – Example of weighting functions (of a 1 Hz pulse) for peak (PK) and average detections as a function of pulse width: meter time constant 160 ms

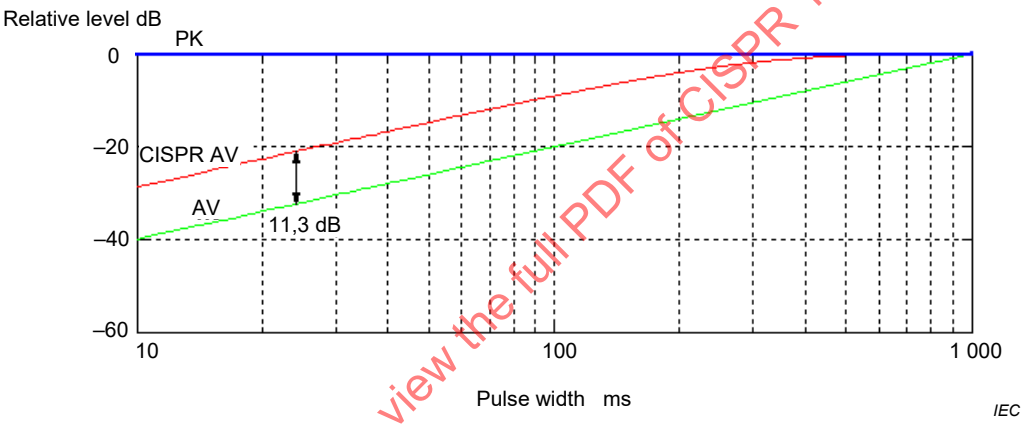


Figure C.4 – Example of weighting functions (of a 1 Hz pulse) for peak (PK) and average detections as a function of pulse width: meter time constant 100 ms

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

C.4 Recommended procedure for automated or semi-automated measurements

When measuring EUTs that do not emit slowly intermittent, unsteady or drifting narrowband disturbances, it is recommended to measure with the average detector using a video filter bandwidth of e.g. 100 Hz, i.e. a short averaging time during a pre-scan procedure. At frequencies where the emission is found to be close to the average limit, it is recommended to make a final measurement using a lower video filter bandwidth, i.e. a longer averaging time. (For the pre-scan/final measurement procedure, see also Clause 8).

For slowly intermittent, unsteady or drifting narrowband disturbances, manual measurements are the preferred method.

Annex D
(informative)

Explanation of the APD measurement method applying to the compliance test

One of the following two methods is used when the APD measurement is applied for a compliance test. Figure D.1 and Figure D.2 illustrate the specifics of the APD measurement methods, involving the measurement of the level of disturbance (i.e. Method 1, see 7.6.6.3.2) and the measurement of the probability (i.e. Method 2, see 7.6.6.3.3), respectively.

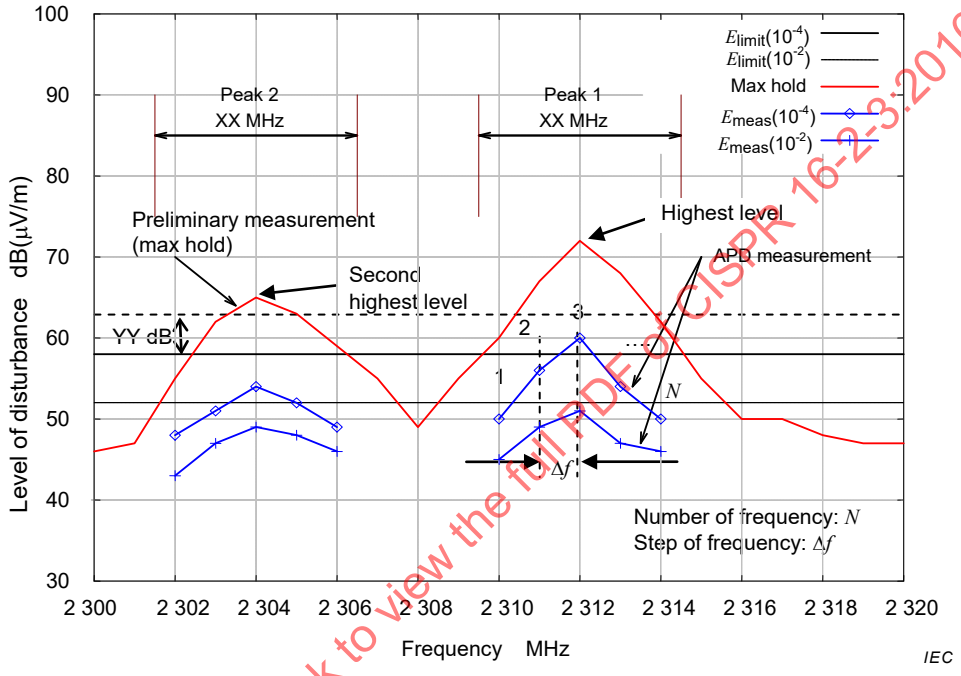


Figure D.1 – Example of APD measurement Method 1 for fluctuating disturbances

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

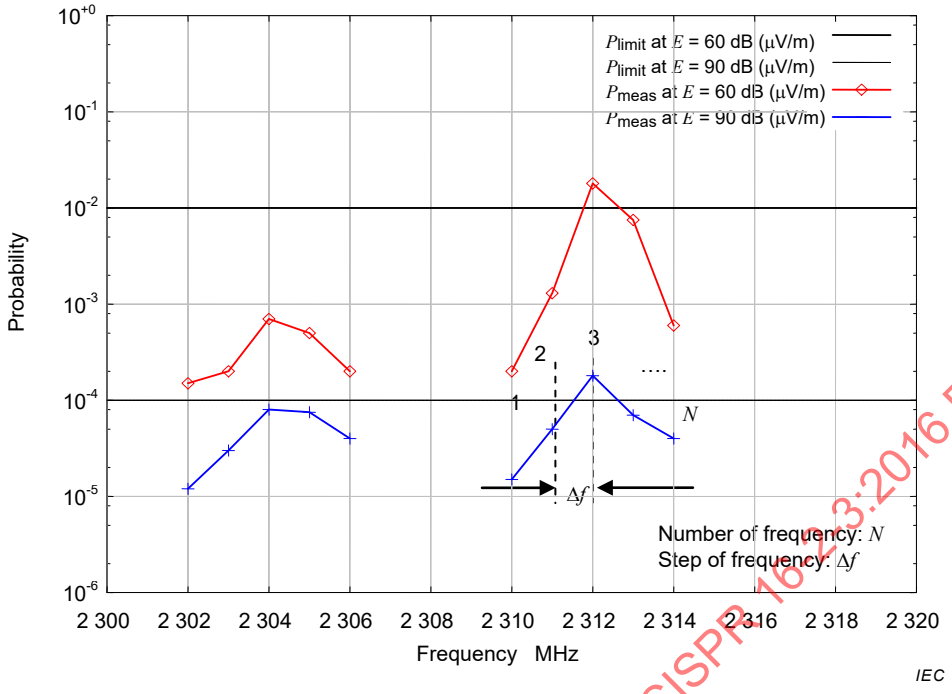


Figure D.2 – Example of APD measurement Method 2 for fluctuating disturbances

If the preliminary measurement results, obtained by using the maximum-hold display mode and peak detection, exceed the specified APD limit (the higher limit should be used if two APD limits apply) by YY dB at certain frequencies, then the APD measurement should be performed at these identified frequencies. The value YY dB is to be specified by the relevant product committee (e.g. YY = 5, 10, etc.).

In case of fluctuating disturbances, the product committee should specify the frequency range XX (= $\Delta f \times N$) MHz in which the APD measurements are to be performed, where Δf is the frequency step size and N is the number of frequencies. This frequency range should be specified according to the characteristics of the product.

As a first step, XX is determined by the preliminary measurement results. Then, Δf should be equal to the resolution bandwidth (RBW = 1 MHz for measurements above 1 GHz) of the spectrum analyzer. However, all frequencies that have an APD value within approximately 6 dB of the APD limit may require further investigation with a smaller frequency step size (i.e. $B_6/2$, where B_6 is the 6-dB bandwidth of the spectrum analyzer). RBW of the spectrum analyzer for measurements above 1 GHz is defined by the impulse bandwidth B_{imp} rather than the 6-dB bandwidth B_6. The relation between B_{imp} and B_6 is dependent upon the filter type, and cannot be generalized. If B_{imp} can be approximated to B_6, then the smaller frequency step size $B_6/2$ is recommended to be $B_{imp}/2$ (i.e. 0,5 MHz) for measurements above 1 GHz. Finally, N is determined from the values of XX and Δf.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Annex E
(normative)

Determination of suitability of spectrum analyzers for compliance tests

The user of a spectrum analyzer shall be able to demonstrate, either through specifications from the manufacturer or by measurement, that the analyzer meets the quasi-peak detection requirements for pulse-repetition frequencies greater than 20 Hz in the frequency range of use. For the average detector the response to pulses is called out in CISPR 16-1-1.

Since the measurement of the pulse repetition frequency of an emission may not always be possible, a simple method to verify the validity of the quasi-peak measurement shall be applied when a spectrum analyzer is used. This method is based on a comparison of measurement results with the peak and quasi-peak detectors. From the quasi-peak weighting functions, the amplitude differences shown in Table E.1 are the results of measurements for a signal with a pulse repetition frequency of 20 Hz.

Table E.1 – Maximum amplitude difference between peak and quasi-peak detected signals

Band A	Band B	Bands C and D
7 dB	13 dB	21 dB

The comparison measurement is to be made at signal frequencies that show an amplitude close to the applicable limit in quasi-peak detection. If the difference between the peak and quasi-peak detected amplitude is smaller than the value in Table E.1 the quasi-peak measurement is valid and the result obtained with a spectrum analyzer can be used to demonstrate compliance. If the amplitude difference is larger than the stated values in Table E.1 a measuring receiver that fully complies with the low-PRF requirements of CISPR 16-1-1 is to be used for the quasi-peak measurement instead of a spectrum analyzer. This comparison measurement requires an adequate signal-to-noise ratio to ensure proper results.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Bibliography

[1] CISPR 11:2015, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*

[2] CISPR 16-1-6:2014, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-6: Radio disturbance and immunity measuring apparatus – EMC antenna calibration*

[3] CISPR TR 16-3:2010, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 3: CISPR technical reports*
CISPR TR 16-3:2010/AMD1:2012
CISPR TR 16-3:2010/AMD2:2015

[4] CISPR 22:2008, *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement*

[5] IEC 61140:2016, *Protection against electric shock – Common aspects for installation and equipment*

[6] ISO/IEC Guide 2:2004, *Standardization and related activities – General vocabulary*

[7] ISO/IEC 17000:2004, *Conformity assessment – Vocabulary and general principles*

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

[9] ISO/IEC Guide 99:2007, *International vocabulary of metrology – Basic and general concepts and associated terms (VIM)*

[10] IEC 60050-151:2001, *International Electrotechnical Vocabulary – Part 151: Electrical and magnetic devices*
IEC 60050-151:2001/AMD1:2013
IEC 60050-151:2001/AMD2:2014

[11] Chen, Z., Foegelle, M.D. and Harrington, T., *Analysis of log periodic dipole array antennas for site validation and radiated emissions testing*, IEEE EMC Symposium, Seattle, 1999, p. 618-623

[12] Ryser, H., *Motivation for the use of CMAD in radiated emission measurements (CMAD: Common mode absorption devices)*, Report 2007-218-630, Federal Office of Metrology (METAS), Bern-Wabern, Switzerland, 11 September 2007, available as a downloaded PDF from http://www.metas.ch/2007-218-630

[13] IEC Guide 107, *Electromagnetic compatibility – Guide to the drafting of electromagnetic compatibility publications*

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

SOMMAIRE

AVANT-PROPOS 110
1 Domaine d'application 112
2 Références normatives 112
3 Termes, définitions et termes abrégés 113
3.1 Termes et définitons 113
3.2 Termes abrégés 119
4 Types de perturbations à mesurer 119
4.1 Généralités 119
4.2 Types de perturbations 119
4.3 Fonctions de détection 120
5 Connexion du matériel de mesure 120
6 Exigences et conditions générales de mesure 120
6.1 Généralités 120
6.2 Perturbation non produite par le matériel en essai 121
6.2.1 Généralités 121
6.2.2 Essais (d'évaluation) de conformité 121
6.3 Mesurage d'une perturbation continue 121
6.3.1 Perturbation continue à bande étroite 121
6.3.2 Perturbation continue à large bande 121
6.3.3 Utilisation d'analyseurs de spectre et de récepteurs à scrutation 121
6.4 Configuration et conditions de mesure de l'EUT 121
6.4.1 Configuration générale de l'EUT 122
6.4.2 Fonctionnement de l'EUT 124
6.4.3 Durée de fonctionnement de l'EUT 125
6.4.4 Durée de fonctionnement préalable de l'EUT 125
6.4.5 Alimentation de l'EUT 125
6.4.6 Mode de fonctionnement de l'EUT 125
6.4.7 Fonctionnement d'un matériel à fonctions multiples 125
6.4.8 Détermination de la ou des configurations provoquant des valeurs d'émission maximales 125
6.4.9 Enregistrement des mesurages 126
6.5 Interprétation des résultats de mesure 126
6.5.1 Perturbations continues 126
6.5.2 Perturbations discontinues 126
6.5.3 Mesurage de la durée d'une perturbation 126
6.6 Durées de mesure et vitesses de scrutation pour les perturbations continues 127
6.6.1 Généralités 127
6.6.2 Durées minimales de mesure 127
6.6.3 Vitesses de scrutation des récepteurs à scrutation et des analyseurs de spectre 128
6.6.4 Durées de balayage pour les récepteurs à accord par palier 129
6.6.5 Stratégies pour l'obtention d'une vue d'ensemble du spectre en utilisant le détecteur de crête 129
6.6.6 Considérations temporelles concernant l'utilisation d'appareils de mesure à FFT 133
7 Mesurage des perturbations rayonnées 136
7.1 Remarques introductives 136

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

7.2 Mesurages du système d'antenne-cadre (9 kHz à 30 MHz) 137
7.2.1 Généralités 137
7.2.2 Méthode générale de mesure 138
7.2.3 Environnement d'essai 139
7.2.4 Configuration du matériel en essai 139
7.2.5 Incertitude de mesure du système d'antenne-cadre 139
7.3 Mesurages sur emplacement d'essai en espace libre (OATS) ou en chambre semi-anéchoïque (SAC) (30 MHz à 1 GHz) 139
7.3.1 Mesurande 139
7.3.2 Exigences relatives à l'emplacement d'essai 143
7.3.3 Méthode générale de mesure 143
7.3.4 Distance de mesure 143
7.3.5 Variation de la hauteur d'antenne 144
7.3.6 Détails à fournir dans la spécification de produit 144
7.3.7 Instrumentation de mesure 146
7.3.8 Mesurages de l'amplitude de champ sur d'autres emplacements en extérieur 146
7.3.9 Incertitude de mesure pour les OATS et les SAC 146
7.4 Mesurages en enceinte complètement anéchoïque (30 MHz à 1 GHz) 147
7.4.1 Installation d'essai et géométrie de l'emplacement 147
7.4.2 Position de l'EUT 150
7.4.3 Disposition et terminaison des câbles 151
7.4.4 Incertitude de mesure de l'enceinte complètement anéchoïque 152
7.5 Méthode de mesure des émissions rayonnées (de 30 MHz à 1 GHz) et méthode d'essai d'immunité aux rayonnements (de 80 MHz à 1 GHz) avec une installation d'essai commune en chambre semi-anéchoïque 152
7.5.1 Applicabilité 152
7.5.2 Définition du périmètre de l'EUT et distance de séparation antenne-EUT 153
7.5.3 Volume d'essai uniforme 154
7.5.4 Spécifications pour les installations d'essai communs pour les essais d'émissions/immunité de l'EUT 155
7.5.5 Incertitude de mesure pour une installation et une méthode d'émission/immunité communes 161
7.6 Mesurages en enceinte complètement anéchoïque et mesurages en OATS/SAC à revêtement absorbant (1 GHz à 18 GHz) 161
7.6.1 Grandeur à mesurer 161
7.6.2 Distance de mesure 162
7.6.3 Installation et conditions de fonctionnement du matériel en essai (EUT) 162
7.6.4 Emplacement de mesure 163
7.6.5 Instrumentation de mesure 163
7.6.6 Mode opératoire de mesure 163
7.6.7 Incertitude de mesure de l'enceinte complètement anéchoïque 171
7.7 Mesurages *in situ* (9 kHz à 18 GHz) 171
7.7.1 Applicabilité et préparation à des mesurages *in situ* 171
7.7.2 Mesurages *in situ* d'amplitude du champ dans la plage de fréquences de 9 kHz à 30 MHz 172
7.7.3 Mesurages *in situ* d'amplitude du champ dans la plage de fréquences supérieures à 30 MHz 173

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

7.7.4 Mesurage *in situ* de la puissance perturbatrice apparente rayonnée avec la méthode de substitution 174
7.7.5 Documentation des résultats de mesure 178
7.7.6 Incertitude de mesure pour la méthode *in situ* 178
7.8 Mesurages de substitution (30 MHz à 18 GHz) 178
7.8.1 Généralités 178
7.8.2 Emplacement d'essai 179
7.8.3 Antennes d'essai 179
7.8.4 Configuration de l'EUT 180
7.8.5 Procédure d'essai 180
7.8.6 Incertitude de mesure pour la méthode de substitution 181
7.9 Mesurages en chambre réverbérante (80 MHz à 18 GHz) 181
7.10 Mesurages avec des guides d'ondes TEM (30 MHz à 18 GHz) 181
8 Mesurage automatisé des émissions 181
8.1 Introduction – Précautions à prendre pour les mesurages automatisés 181
8.2 Procédure générale de mesure 181
8.3 Mesurages par prescrutation 182
8.3.1 Généralités 182
8.3.2 Détermination de la durée de mesure exigée 182
8.3.3 Exigences relatives à la prescrutation pour différents types de mesurages 183
8.4 Réduction des données 184
8.5 Maximisation des émissions et mesurage final 185
8.6 Post-traitement et rapport d'essai 186
8.7 Stratégies de mesure d'émissions avec des appareils de mesure à FFT 186
Annexe A (informative) Mesurage des perturbations en présence d'émissions ambiantes 187
A.1 Généralités 187
A.2 Termes et définitions 187
A.3 Description du problème 187
A.4 Solution proposée 188
A.4.1 Vue d'ensemble 188
A.4.2 Prémesurage de l'EUT dans une chambre blindée 191
A.4.3 Méthode de mesure des perturbations de l'EUT en présence d'émissions ambiantes en bande étroite 192
A.4.4 Méthode de mesure de la perturbation de l'EUT en présence d'émissions ambiantes à large bande 196
A.5 Détermination de la perturbation de l'EUT dans le cas d'une superposition 198
Annexe B (informative) Utilisation d'analyseurs de spectre et de récepteurs à scrutation 203
B.1 Généralités 203
B.2 Surcharge 203
B.3 Essai de linéarité 203
B.4 Sélectivité 203
B.5 Réponse normale aux impulsions 203
B.6 Détection de crête 203
B.7 Vitesse de scrutation en fréquence 204
B.8 Interception du signal 204
B.9 Détection de la valeur moyenne 204

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

B.10 Sensibilité 205
B.11 Exactitude en amplitude 205
Annexe C (informative) Vitesses de scrutation et durées de mesure utilisables avec le détecteur de valeur moyenne 206
C.1 Objet 206
C.2 Suppression des perturbations 206
C.2.1 Suppression des perturbations impulsives 206
C.2.2 Suppression de la perturbation impulsive par moyennage numérique 207
C.2.3 Suppression de la modulation d'amplitude 207
C.3 Mesurage des perturbations à bande étroite faiblement intermittentes, instables ou variables 207
C.4 Procédure recommandée pour les mesurages automatiques ou semi-automatiques 209
Annexe D (informative) Explication de la méthode de mesure de distribution de probabilité des amplitudes (DPA) appliquée à l'essai de conformité 210
Annexe E (normative) Détermination de l'aptitude à l'emploi des analyseurs de spectre pour les essais de conformité 212
Bibliographie 213

Figure 1 – Mesurage d'une combinaison d'un signal en onde entretenue à bande étroite et d'un signal impulsif à large bande en utilisant des balayages multiples avec maintien du maximum 130
Figure 2 – Exemple d'analyse temporelle 131
Figure 3 – Spectre à large bande mesuré avec un récepteur à accord par palier 132
Figure 4 – Perturbations intermittentes à bande étroite mesurées en utilisant des balayages courts, rapides et répétitifs avec la fonction «maintien du maximum» pour obtenir une vue d'ensemble du spectre d'émission 133
Figure 5 – Scrutation par FFT en segments 135
Figure 6 – Résolution en fréquence améliorée au moyen d'un appareil de mesure à FFT 136
Figure 7 – Concept des mesurages des courants induits par un champ magnétique avec le système d'antenne-cadre 138
Figure 8 – Distance de mesure 141
Figure 9 – Distance de séparation par rapport au centre de phase d'une antenne LPDA 142
Figure 10 – Concept des mesurages de l'amplitude de champ électrique effectués sur un emplacement d'essai en espace libre (OATS) ou dans une chambre semi-anéchoïque (SAC) représentant les rayons directs et réfléchis arrivant sur l'antenne de réception 143
Figure 11 – Position d'un CMAD pour un matériel posé sur table sur un emplacement d'essai en espace libre (OATS) ou dans une chambre semi-anéchoïque (SAC) 146
Figure 12 – Géométrie type d'une enceinte complètement anéchoïque, où a, b, c, e dépendent des performances de l'enceinte 148
Figure 13 – Installation type d'essai pour un matériel posé sur table dans le volume d'essai d'une enceinte complètement anéchoïque 149
Figure 14 – Installation type d'essai pour un matériel posé au sol dans le volume d'essai d'une enceinte complètement anéchoïque 150
Figure 15 – Positions des plans de référence pour l'étalonnage du champ uniforme (vue de dessus) 154
Figure 16 – Installation d'essai pour un matériel posé sur table 158
Figure 17 – Installation d'essai pour un matériel posé sur table – Vue de dessus 159

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Figure 18 – Installation d'essai pour un matériel posé au sol 160
Figure 19 – Installation d'essai pour un matériel posé au sol – Vue de dessus 161
Figure 20 – Méthode de mesure au-dessus de 1 GHz, antenne de réception en polarisation verticale 164
Figure 21 – Présentation des exigences relatives à la scrutation en hauteur pour deux catégories différentes de matériels en essai 166
Figure 22 – Détermination de la distance de transition 177
Figure 23 – Géométries d'installation d'essai dans le cas de la méthode de substitution pour: a) mesurage, b) étalonnage 180
Figure 24 – Processus de réduction de la durée de mesure 182
Figure A.1 – Organigramme de sélection des largeurs de bande et des détecteurs, et estimation des erreurs de mesure qui en résultent 190
Figure A.2 – Différence relative des amplitudes des émissions adjacentes lors des essais préliminaires 192
Figure A.3 – Perturbation par un signal non modulé (ligne en pointillés) 193
Figure A.4 – Perturbation par un signal modulé en amplitude (ligne en pointillés) 193
Figure A.5 – Indication d'un signal modulé en amplitude en fonction de la fréquence de modulation avec le détecteur de quasi-crête dans les bandes B, C et D CISPR 194
Figure A.6 – Indication d'un signal modulé en impulsions (largeur d'impulsion 50 µs) en fonction de la fréquence de répétition d'impulsions avec des détecteurs de crête, de quasi-crête et de valeur moyenne 195
Figure A.7 – Perturbation par un signal à large bande (ligne en pointillés) 195
Figure A.8 – Perturbation du matériel en essai non modulée (ligne en pointillés) 196
Figure A.9 – Perturbation modulée en amplitude du matériel en essai (ligne en pointillés) 197
Figure A.10 – Augmentation de la valeur de crête avec la superposition de deux signaux non modulés 198
Figure A.11 – Détermination de l'amplitude du signal de perturbation au moyen du rapport d'amplitude d et du facteur i (voir Équation (A.3) et Équation (A.6)) 200
Figure A.12 – Augmentation de l'indication moyenne mesurée avec un récepteur réel et calculée d'après l'Équation (A.8) 201
Figure C.1 – Fonction de pondération d'une impulsion de 10 ms pour des détections de valeurs de crête (PK) et de valeurs moyennes avec lecture de crête (CISPR AV) et sans lecture de crête (AV): constante de temps de l'indicateur de 160 ms 208
Figure C.2 – Fonctions de pondération d'une impulsion de 10 ms pour des détections de valeurs de crête (PK) et de valeurs moyennes avec lecture de crête (CISPR AV) et sans lecture de crête (AV): constante de temps de l'indicateur de 100 ms 208
Figure C.3 – Exemple de fonctions de pondération (d'une impulsion de 1 Hz) pour des détections de valeurs de crête (PK) et de valeurs moyennes, en fonction de la largeur d'impulsion: constante de temps de l'indicateur de 160 ms 209
Figure C.4 – Exemple de fonctions de pondération (d'une impulsion de 1 Hz) pour des détections de valeurs de crête (PK) et de valeurs moyennes, en fonction de la largeur d'impulsion: constante de temps de l'indicateur de 100 ms 209
Figure D.1 – Exemple de mesurage de DPA par la Méthode 1 pour des perturbations fluctuantes 210
Figure D.2 – Exemple de mesurage de DPA par la Méthode 2 pour des perturbations fluctuantes 211

Tableau 1 – Durées minimales de mesure pour les quatre bandes CISPR 127

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Tableau 2 – Durées minimales de scrutation pour les trois bandes CISPR avec détecteurs de crête et de quasi-crête 127
Tableau 3 – Plages de fréquences applicables et références de documents pour les emplacements et les méthodes d'essai d'émissions rayonnées CISPR 137
Tableau 4 – Dimension minimale de w (w_{min}) 165
Tableau 5 – Exemples de valeurs de w pour trois types d'antennes 166
Tableau 6 – Facteurs de correction en polarisation horizontale en fonction de la fréquence 177
Tableau 7 – Hauteurs d'antenne recommandées pour garantir l'interception du signal (pour la préscrutation) dans la plage de fréquences de 30 MHz à 1 000 MHz 184
Tableau A.1 – Combinaisons des perturbations du matériel en essai et des émissions ambiantes 188
Tableau A.2 – Erreur de mesure en fonction du type de détecteur et de la combinaison des spectres du signal ambiant et du signal perturbateur 202
Tableau C.1 – Facteurs de suppression d'impulsion et vitesses de scrutation pour une largeur de bande vidéo de 100 Hz 207
Tableau C.2 – Constantes de temps de l'indicateur et largeurs de bande vidéo et durées de scrutation minimales correspondantes 208
Tableau E.1 – Différence d'amplitude maximale entre les signaux de crête et de quasi-crête détectés 212

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE

COMITÉ INTERNATIONAL SPÉCIAL DES PERTURBATIONS RADIOÉLECTRIQUES

_____

SPÉCIFICATIONS DES MÉTHODES ET DES APPAREILS DE MESURE DES PERTURBATIONS RADIOÉLECTRIQUES ET DE L'IMMUNITÉ AUX PERTURBATIONS RADIOÉLECTRIQUES –

Partie 2-3: Méthodes de mesure des perturbations et de l'immunité – Mesurages des perturbations rayonnées

AVANT-PROPOS

1) La Commission Electrotechnique Internationale (IEC) est une organisation mondiale de normalisation composée de l'ensemble des comités électrotechniques nationaux (Comités nationaux de l'IEC). L'IEC a pour objet de favoriser la coopération internationale pour toutes les questions de normalisation dans les domaines de l'électricité et de l'électronique. À cet effet, l'IEC – entre autres activités – publie des Normes internationales, des Spécifications techniques, des Rapports techniques, des Spécifications accessibles au public (PAS) et des Guides (ci-après dénommés "Publication(s) de l'IEC"). Leur élaboration est confiée à des comités d'études, aux travaux desquels tout Comité national intéressé par le sujet traité peut participer. Les organisations internationales, gouvernementales et non gouvernementales, en liaison avec l'IEC, participent également aux travaux. L'IEC collabore étroitement avec l'Organisation Internationale de Normalisation (ISO), selon des conditions fixées par accord entre les deux organisations.
2) Les décisions ou accords officiels de l'IEC concernant les questions techniques représentent, dans la mesure du possible, un accord international sur les sujets étudiés, étant donné que les Comités nationaux de l'IEC intéressés sont représentés dans chaque comité d'études.
3) Les Publications de l'IEC se présentent sous la forme de recommandations internationales et sont agréées comme telles par les Comités nationaux de l'IEC. Tous les efforts raisonnables sont entrepris afin que l'IEC s'assure de l'exactitude du contenu technique de ses publications; l'IEC ne peut pas être tenue responsable de l'éventuelle mauvaise utilisation ou interprétation qui en est faite par un quelconque utilisateur final.
4) Dans le but d'encourager l'uniformité internationale, les Comités nationaux de l'IEC s'engagent, dans toute la mesure possible, à appliquer de façon transparente les Publications de l'IEC dans leurs publications nationales et régionales. Toutes divergences entre toutes Publications de l'IEC et toutes publications nationales ou régionales correspondantes doivent être indiquées en termes clairs dans ces dernières.
5) L'IEC elle-même ne fournit aucune attestation de conformité. Des organismes de certification indépendants fournissent des services d'évaluation de conformité et, dans certains secteurs, accèdent aux marques de conformité de l'IEC. L'IEC n'est responsable d'aucun des services effectués par les organismes de certification indépendants.
6) Tous les utilisateurs doivent s'assurer qu'ils sont en possession de la dernière édition de cette publication.
7) Aucune responsabilité ne doit être imputée à l'IEC, à ses administrateurs, employés, auxiliaires ou mandataires, y compris ses experts particuliers et les membres de ses comités d'études et des Comités nationaux de l'IEC, pour tout préjudice causé en cas de dommages corporels et matériels, ou de tout autre dommage de quelque nature que ce soit, directe ou indirecte, ou pour supporter les coûts (y compris les frais de justice) et les dépenses découlant de la publication ou de l'utilisation de cette Publication de l'IEC ou de toute autre Publication de l'IEC, ou au crédit qui lui est accordé.
8) L'attention est attirée sur les références normatives citées dans cette publication. L'utilisation de publications référencées est obligatoire pour une application correcte de la présente publication.
9) L'attention est attirée sur le fait que certains des éléments de la présente Publication de l'IEC peuvent faire l'objet de droits de brevet. L'IEC ne saurait être tenue pour responsable de ne pas avoir identifié de tels droits de brevets et de ne pas avoir signalé leur existence.

La Norme internationale CISPR 16-2-3 a été établie par le sous-comité A du CISPR: Mesures des perturbations radioélectriques et méthodes statistiques.

Cette quatrième édition annule et remplace la troisième édition parue en 2010, l'Amendement 1:2010 et l'Amendement 2:2014. Cette édition constitue une révision technique.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Cette édition inclut la modification technique majeure suivante par rapport à l'édition précédente: ajout de contenu relatif à la correction de l'amplitude de champ électrique pour prendre en compte le centre de phase des réseaux de dipôles log-périodiques.

Elle a le statut de publication fondamentale en CEM conformément au Guide 107 de l'IEC, *Compatibilité électromagnétique – Guide pour la rédaction des publications sur la compatibilité électromagnétique.*

Le texte de cette norme est issu des documents suivants:

FDIS	Rapport de vote
CISPR/A/1176A/FDIS	CISPR/A/1182/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette norme.

Cette publication a été rédigée selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série CISPR 16, publiées sous le titre général *Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques,* peut être consultée sur le site web de l'IEC.

Le comité a décidé que le contenu de cette publication ne sera pas modifié avant la date de stabilité indiquée sur le site web de l'IEC sous "http://webstore.iec.ch" dans les données relatives à la publication recherchée. A cette date, la publication sera

- reconduite,
- supprimée,
- remplacée par une édition révisée, ou
- amendée.

IMPORTANT – Le logo *"colour inside"* qui se trouve sur la page de couverture de cette publication indique qu'elle contient des couleurs qui sont considérées comme utiles à une bonne compréhension de son contenu. Les utilisateurs devraient, par conséquent, imprimer cette publication en utilisant une imprimante couleur.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

SPÉCIFICATIONS DES MÉTHODES ET DES APPAREILS DE MESURE DES PERTURBATIONS RADIOÉLECTRIQUES ET DE L'IMMUNITÉ AUX PERTURBATIONS RADIOÉLECTRIQUES –

Partie 2-3: Méthodes de mesure des perturbations et de l'immunité – Mesurages des perturbations rayonnées

1 Domaine d'application

La présente partie de la CISPR 16 spécifie les méthodes de mesure de phénomènes perturbateurs rayonnés, dans la plage de fréquences de 9 kHz à 18 GHz. Les aspects de l'incertitude de mesure sont spécifiés dans les normes CISPR 16-4-1 et CISPR 16-4-2.

NOTE Selon le Guide 107 de l'IEC, la CISPR 16-2-3 est une publication fondamentale en CEM destinée à l'usage des comités de produits de l'IEC. Comme mentionné dans le Guide 107 [13][1], les comités de produits sont responsables de la détermination de l'applicabilité de la norme CEM. Le CISPR et ses sous-comités sont prêts à coopérer avec les comités de produits pour l'évaluation de la pertinence des essais particuliers de CEM pour des produits spécifiques.

2 Références normatives

Les documents suivants sont cités en référence de manière normative, en intégralité ou en partie, dans le présent document et sont indispensables pour son application. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

CISPR 14-1:2016, *Compatibilité électromagnétique – Exigences pour les appareils électrodomestiques, outillages électriques et appareils analogues – Partie 1: Emission*

CISPR 16-1-1, *Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Partie 1-1: Appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Appareils de mesure*

CISPR 16-1-2:2014, *Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Partie 1-2: Appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Dispositifs de couplage pour la mesure des perturbations conduites*

CISPR 16-1-4:2010, *Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Partie 1-4: Appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Antennes et emplacements d'essai pour les mesures des perturbations rayonnées*
CISPR 16-1-4:2010/AMD1:2012

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

[1] Les chiffres entre crochets se réfèrent à la Bibliographie.

CISPR 16-2-1:2014, *Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Partie 2-1: Méthodes de mesure des perturbations et de l'immunité – Mesures des perturbations conduites*

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* (disponible en anglais seulement)

CISPR 16-4-2, *Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Partie 4-2: Incertitudes, statistiques et modélisation des limites – Incertitudes de mesure de l'instrumentation*

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* (disponible en anglais seulement)

IEC 60050-161, *Vocabulaire électrotechnique international – Chapitre 161: Compatibilité électromagnétique*

IEC 61000-4-3:2006, *Compatibilité électromagnétique (CEM) – Partie 4-3: Techniques d'essai et de mesure – Essai d'immunité aux champs électromagnétiques rayonnés aux fréquences radioélectriques*
IEC 61000-4-3:2006/AMD1:2007
IEC 61000-4-3:2006/AMD2:2010

IEC 61000-4-20, *Compatibilité électromagnétique (CEM) – Partie 4-20: Techniques d'essai et de mesure – Essais d'émission et d'immunité dans les guides d'onde TEM*

3 Termes, définitions et termes abrégés

3.1 Termes et définitons

Pour les besoins du présent document, les termes et définitions donnés de l'IEC 60050-161, ainsi que les suivants, s'appliquent.

3.1.1
OATS/SAC à revêtement absorbant
emplacement d'essai en espace libre (OATS) ou chambre semi-anéchoïque (SAC) dont le plan de masse est partiellement recouvert d'un matériau absorbant de l'énergie aux fréquences radioélectriques

3.1.2
matériel d'appoint
transducteurs (par exemple, sondes de courant et de tension et réseaux fictifs) connectés à un récepteur de mesure ou à un générateur de signal (d'essai) et utilisés dans la transmission du signal perturbateur entre le matériel en essai (EUT – equipment under test) et le matériel de mesure ou d'essai

3.1.3
faisceau de l'antenne
lobe principal du diagramme d'antenne (diagramme de gain) de l'antenne de réception (généralement la direction avec la sensibilité maximale ou le facteur d'antenne le plus faible) dirigé vers l'EUT

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

3.1.4
largeur de faisceau de l'antenne
angle entre les points de demi-puissance (3 dB) du lobe principal du faisceau de l'antenne, lorsqu'il est rapporté à la puissance maximale dudit lobe

Note 1 à l'article: Il peut être exprimé pour le plan H ou pour le plan E de l'antenne.

Note 2 à l'article: La largeur de faisceau de l'antenne est exprimée en degrés.

3.1.5
matériel associé
AE
appareil ne faisant pas partie du système en essai, mais nécessaire au bon fonctionnement du matériel en essai (EUT)

Note 1 à l'article: L'abréviation «AE» est dérivée du terme anglais développé correspondant «associated equipment».

3.1.6
matériel auxiliaire
AuxEq
périphérique faisant partie du système en essai

Note 1 à l'article: L'abréviation «AuxEq» est dérivée du terme anglais développé correspondant «auxiliary equipment».

3.1.7
norme de base
norme de portée générale ou qui comporte des dispositions d'ensemble pour un domaine particulier

Note 1 à l'article: Une norme de base peut être utilisée comme une norme d'application directe ou servir de base à d'autres normes.

[SOURCE: ISO/IEC Guide 2:2004, définition 5.1 [6]]

3.1.8
câble coaxial
câble comportant une ou plusieurs lignes coaxiales, généralement utilisé pour réaliser une connexion adaptée entre un matériel d'appoint et le matériel de mesure ou le générateur de signal (d'essai) et fournissant une impédance caractéristique spécifiée et une impédance de transfert de câble maximale admissible spécifiée

3.1.9
dispositif d'absorption en mode commun
CMAD
dispositif qui peut être appliqué sur des câbles à leur sortie du volume d'essai au cours des mesures d'émissions rayonnées pour réduire l'incertitude de conformité

Note 1 à l'article: L'abréviation «CMAD» est dérivée du terme anglais développé correspondant «common-mode absorption device».

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

3.1.10
évaluation de la conformité
démonstration que des exigences spécifiées relatives à un produit, processus, système, personne ou organisme sont respectées

Note 1 à l'article: Le domaine de l'évaluation de la conformité comprend des activités définies ailleurs dans l'ISO/IEC 17000:2004 [7] telles que les essais, l'inspection et la certification, de même que l'accréditation des organismes d'évaluation de la conformité.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

[SOURCE: ISO/IEC 17000:2004, 2.1, modifiée – La note 2 a été supprimée.]

3.1.11
perturbation continue
perturbation RF de durée supérieure à 200 ms à la sortie en fréquence intermédiaire d'un récepteur de mesure, qui provoque une déviation sur l'indicateur du récepteur de mesure, en mode de détection de quasi-crête, et qui ne décroît pas immédiatement

[SOURCE: IEC 60050-161:1990, 161-02-11, modifiée – La définition a été modifiée.]

3.1.12
émission
<électromagnétique> processus par lequel une source fournit de l'énergie électromagnétique vers l'extérieur

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

3.1.13
limite d'émission
<d'une source perturbatrice> valeur maximale spécifiée du niveau d'émission d'une source de perturbation électromagnétique

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

3.1.14
matériel en essai
EUT
matériel (dispositifs, appareils et systèmes) soumis aux essais de conformité pour la CEM (émission et évaluation de la conformité)

Note 1 à l'article: L'abréviation «EUT» est dérivée du terme anglais développé correspondant «equipment under test».

3.1.15
enceinte complètement anéchoïque
FAR
enceinte dont les six surfaces intérieures sont revêtues d'un matériau absorbant les fréquences radioélectriques (c'est-à-dire un absorbeur RF) qui atténue l'énergie électromagnétique dans la plage de fréquences considérée

Note 1 à l'article: L'abréviation «FAR» est dérivée du terme anglais développé correspondant «fully-anechoic room».

3.1.16
système d'antenne-cadre
LAS
système d'antenne consistant en trois antennes-cadres à orientation orthogonale utilisées pour mesurer les trois moments magnétiques coulombiens orthogonaux d'un EUT situé au centre des trois antennes-cadres

Note 1 à l'article: L'abréviation «LAS» est dérivée du terme anglais développé correspondant «loop-antenna system».

3.1.17
durées de mesure, de scrutation et de balayage

3.1.17.1
durée de mesure
T_m
durée effective et cohérente pour obtenir un résultat de mesure à une fréquence unique

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

– pour le détecteur de crête, la durée effective pour détecter le maximum de l'enveloppe du signal,

– pour le détecteur de quasi-crête, la durée effective pour mesurer le maximum de l'enveloppe pondérée,

– pour le détecteur de valeur moyenne, la durée effective pour effectuer la moyenne de l'enveloppe du signal,

– pour le détecteur de valeur efficace, la durée effective pour déterminer la valeur efficace de l'enveloppe du signal

Note 1 à l'article: Dans certains domaines, la "durée de mesure" est également appelée temps de palier.

3.1.17.2
scrutation
variation continue ou par pas de la fréquence dans un intervalle de fréquence donné

3.1.17.3
intervalle
Δf
différence entre la fréquence de départ et la fréquence d'arrivée d'un balayage ou d'une scrutation

3.1.17.4
balayage
variation continue de la fréquence dans un intervalle de fréquence donné

3.1.17.5
vitesse de balayage ou de scrutation
intervalle de fréquence divisé par la durée de balayage ou de scrutation

3.1.17.6
durée de balayage ou de scrutation
T_s
durée comprise entre la fréquence de départ et la fréquence d'arrivée d'un balayage ou d'une scrutation

3.1.17.7
durée d'observation
T_o
somme des durées de mesure T_m à une certaine fréquence dans le cas de balayages multiples

Note 1 à l'article: Si n est le nombre de balayages ou de scrutations, alors $T_o = n \times T_m$.

3.1.17.8
durée totale d'observation
T_{tot}
durée effective pour une vue d'ensemble du spectre (soit en balayage simple soit en balayages multiples)

Note 1 à l'article: Si c est le nombre de canaux dans une scrutation ou un balayage, alors $T_{tot} = c \times n \times T_m$.

3.1.18
récepteur de mesure
appareil de mesure tel qu'un voltmètre accordable, un récepteur de brouillage électromagnétique, un analyseur de spectre ou un appareil de mesure à FFT, avec ou sans présélection, qui est conforme à la CISPR 16-1-1

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

3.1.19
nombre de balayages par unité de temps
n_S
inverse de la somme de la durée de balayage et de la durée du retour, c'est-à-dire 1/(durée de balayage + durée du retour)

Note 1 à l'article: Balayages par seconde, par exemple.

3.1.20
emplacement d'essai en espace libre
OATS
installation pour effectuer des mesurages et des étalonnages dans laquelle la réflexion sur le sol est reproductible par un plan de masse de référence électriquement conducteur plat et de grande dimension

Note 1 à l'article: Un OATS peut être utilisé pour les mesurages des perturbations rayonnées, cas dans lequel il est également appelé COMTS. Un OATS peut également être utilisé pour les étalonnages d'antennes, cas dans lequel il est appelé CALTS.

Note 2 à l'article: Un OATS est un site en extérieur non protégé, suffisamment éloigné des bâtiments, lignes électriques, clôtures, arbres, câbles enterrés, canalisations et autres objets réfléchissants potentiels, de sorte que les effets dus à ce type d'objets soient négligeables. Voir la CISPR 16-1-4 pour des lignes directrices concernant la construction d'un OATS.

Note 3 à l'article: L'abréviation «OATS» est dérivée du terme anglais développé correspondant «open-area test site».

3.1.21
norme de produit
norme qui spécifie les exigences auxquelles doit satisfaire un produit ou un groupe de produits pour assurer son/leur aptitude à l'emploi

Note 1 à l'article: Une norme de produit peut comporter, outre les exigences d'aptitude à l'emploi, soit directement, soit par référence, les éléments relatifs à la terminologie, à l'échantillonnage, à l'essai, à l'emballage, à l'étiquetage et parfois des exigences de procédé.

Note 2 à l'article: Une norme de produit peut être complète ou non, selon qu'elle spécifie les exigences nécessaires en totalité ou en partie. En l'occurrence, on peut établir une distinction entre les normes telles que les normes dimensionnelles, les normes relatives aux matériaux ou les normes techniques de livraison.

[SOURCE: ISO/IEC Guide 2, définition 5.4]

3.1.22
chambre semi-anéchoïque
SAC
enceinte blindée dans laquelle cinq des six surfaces internes sont revêtues d'un matériau absorbant les fréquences radioélectriques (c'est-à-dire un absorbeur RF) qui atténue l'énergie électromagnétique dans la plage de fréquences considérée et dont la surface horizontale inférieure est un plan de masse de référence conducteur destiné à être utilisé avec les montages d'essai dans les emplacements d'essai en espace libre (OATS)

Note 1 à l'article: L'abréviation «SAC» est dérivée du terme anglais développé correspondant «semi-anechoic chamber».

3.1.23
configuration d'essai
combinaison permettant d'obtenir la disposition de mesure spécifiée pour le matériel en essai permettant la mesure d'un niveau d'émission

3.1.24
pondération
conversion (principalement réduction) dépendant de la fréquence de répétition d'impulsions (PRF – pulse repetition frequency) d'un niveau de détection d'impulsions de crête en une indication correspondant à l'effet des perturbations sur la réception radio

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Note 1 à l'article: Pour le récepteur analogique, la gêne psychophysique des perturbations est une grandeur subjective (habituellement acoustique ou visuelle), et non un certain nombre d'incompréhensions d'un texte parlé.

Note 2 à l'article: Pour le récepteur numérique, l'effet des perturbations est une grandeur objective qui peut être définie soit par le taux d'erreur critique sur les bits (BER – bit error ratio) ou la probabilité d'erreur sur les bits (BEP – bit error probability) pour lesquels une correction d'erreur parfaite peut encore apparaître, soit par un autre paramètre objectif et reproductible.

Note 3 à l'article: Pondération de perturbations impulsives, par example.

3.1.24.1
mesurage pondéré d'une perturbation
mesurage d'une perturbation à l'aide d'un détecteur à pondération

3.1.24.2
caractéristique de pondération
niveau de tension de crête en fonction de la PRF ayant un effet constant sur un système de radiocommunication spécifique, c'est-à-dire que la perturbation est pondérée par le système de radiocommunication lui-même

3.1.24.3
détecteur à pondération
détecteur fournissant une fonction de pondération approuvée

3.1.24.4
facteur de pondération
valeur de la fonction de pondération par rapport à une PRF de référence ou par rapport à la valeur de crête

Note 1 à l'article: Le facteur de pondération est exprimé en dB.

3.1.24.5
fonction de pondération ou courbe de pondération
relation entre le niveau de tension d'entrée de crête et la PRF pour l'indication de niveau constant d'un récepteur de mesure avec un détecteur à pondération, c'est-à-dire la courbe de réponse d'un récepteur de mesure pour des impulsions répétées

3.1.25
mesurage
processus consistant à obtenir expérimentalement une ou plusieurs valeurs que l'on peut raisonnablement attribuer à une grandeur

[SOURCE: ISO/IEC Guide 99:2007, 2.1 [9][2], modifiée – Les notes 1 à 3 ont été supprimées.]

3.1.26
essai
opération technique qui consiste à déterminer une ou plusieurs caractéristiques d'un produit, processus ou service donné, selon un mode opératoire spécifié

Note 1 à l'article: Un essai est destiné à mesurer ou à classer une caractéristique ou une propriété d'une entité en appliquant à celle-ci un ensemble d'exigences et de conditions d'environnement et de fonctionnement.

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

3.1.27
fréquence interne la plus haute
fréquence la plus haute générée ou utilisée avec le matériel en essai (EUT) ou fréquence la plus haute à laquelle l'EUT fonctionne ou s'accorde

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

2 Les chiffres entre crochets font référence à la Bibliographie.

3.1.28
module
partie d'un matériel en essai (EUT) remplissant une fonction et pouvant contenir des sources de fréquences radioélectriques

3.2 Termes abrégés

Les abréviations suivantes, ne figurant pas déjà en 3.1, sont utilisées dans la présente norme.

AM	Amplitude modulation (Modulation d'amplitude)
AV	Average (Moyenne)
BB	Broadband (Large bande)
CW	Continuous wave (Émission à ondes entretenues)
DPA	Distribution de probabilité des amplitudes
FFT	Fast-Fourier transform (Transformée de Fourier rapide)
FI	Fréquence intermédiaire
FM	Frequency modulation (Modulation de fréquence)
ISM	Industriel, scientifique et médical
LPDA	Log-periodic dipole array (Réseau de dipôles log-périodiques)
NB	Narrowband (Bande étroite)
NSA	Normalized site attenuation (Affaiblissement normalisé de l'emplacement)
PRF	Pulse repetition frequency (Fréquence de répétition d'impulsions)
RBW	Resolution bandwidth (Largeur de bande de résolution)
RF	Radiofréquence – fréquence radioélectrique
RGP	Reference ground plane (Plan de masse de référence)
QP	Quasi-peak (Quasi-crête)
TEM	Transverse electromagnetic (Électromagnétique transverse)
UFA	Uniform field area (Zone de champ uniforme)
VBW	Video bandwidth (Largeur de bande vidéo)

4 Types de perturbations à mesurer

4.1 Généralités

Le présent article décrit la classification des différents types de perturbations et les détecteurs adaptés à leur mesurage.

4.2 Types de perturbations

Pour des raisons physiques et psychophysiques[3] dépendant de la répartition spectrale, de la largeur de bande du récepteur de mesure, de la durée, du rythme d'apparition et du degré de nuisance lors de l'évaluation et du mesurage des perturbations radioélectriques, les types de perturbations suivants sont distingués:

a) *perturbations continues à bande étroite,* c'est-à-dire sur des fréquences discrètes, par exemple les composantes fondamentales et les harmoniques produits intentionnellement pour générer l'énergie RF dans les matériels ISM (Industriels, scientifiques et médicaux), constituant un spectre de fréquences composé uniquement de raies spectrales

3 Psychophysique signifie relation psychologique entre un stimulus physique et une réponse sensorielle.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

individuelles dont la séparation est supérieure à la largeur de bande du récepteur de mesure de manière à ce qu'une seule raie s'inscrive dans la largeur de bande au cours du mesurage, par opposition à b);

b) *perturbations continues à large bande,* normalement produites non intentionnellement par les impulsions répétées, par exemple de moteurs à collecteur, et présentant une fréquence de répétition inférieure à la largeur de bande du récepteur de mesure de manière que deux raies spectrales ou plus s'inscrivent dans la largeur de bande au cours du mesurage; et

c) *perturbations discontinues à large bande* produites également non intentionnellement par des commutations mécaniques ou électroniques, par exemple les thermostats ou programmateurs avec une fréquence de répétition inférieure à 1 Hz (cadence des claquements inférieure à 30/min).

Les spectres de fréquences de b) et c) se caractérisent par un spectre continu, dans le cas d'impulsions individuelles (uniques), et par un spectre discontinu, dans le cas d'impulsions répétées, les deux spectres étant caractérisés par une plage de fréquences plus large que la largeur de bande du récepteur de mesure spécifié dans la CISPR 16-1-1.

4.3 Fonctions de détection

En fonction des types de perturbations, les mesurages peuvent être effectués au moyen d'un récepteur de mesure équipé:

a) d'un détecteur de valeur moyenne utilisé généralement pour le mesurage des perturbations à bande étroite et des signaux, et plus particulièrement pour différencier les perturbations à bande étroite des perturbations à large bande;

b) d'un détecteur de quasi-crête utilisé pour le mesurage pondéré des perturbations à large bande permettant l'évaluation des nuisances audibles pour un auditeur radiophonique, mais également des perturbations à bande étroite;

c) d'un détecteur quadratique moyen utilisé pour le mesurage pondéré des perturbations à large bande permettant l'évaluation de l'effet des perturbations impulsives sur les services de radiocommunication numérique, mais également des perturbations à bande étroite;

d) d'un détecteur de crête pouvant être utilisé pour le mesurage des perturbations soit à large bande, soit à bande étroite.

Les récepteurs de mesure comportant ces détecteurs sont spécifiés dans la CISPR 16-1-1.

5 Connexion du matériel de mesure

Pour ce qui concerne la connexion de matériel de mesure, de récepteurs de mesure et de matériel d'appoint, par exemple des antennes, le câble de connexion entre le récepteur de mesure et le matériel d'appoint doit être blindé et son impédance caractéristique doit être adaptée à l'impédance d'entrée du récepteur de mesure. La sortie du matériel d'appoint doit être terminée par l'impédance spécifiée.

6 Exigences et conditions générales de mesure

6.1 Généralités

Les mesurages des perturbations radioélectriques doivent être:

- reproductibles, c'est-à-dire indépendants de l'emplacement de mesure et de l'environnement, plus particulièrement du bruit ambiant; et
- sans interactions, c'est-à-dire que la connexion de l'EUT au matériel de mesure ne doit influencer ni le fonctionnement de l'EUT ni l'exactitude du matériel de mesure.

Ces exigences peuvent être satisfaites en respectant les conditions suivantes:

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

a) existence d'un rapport signal sur bruit suffisant au niveau de mesure souhaité, par exemple au niveau de la limite de perturbation appropriée;

b) existence d'installation de mesure, des conditions de raccordement et de fonctionnement de l'EUT définies.

6.2 Perturbation non produite par le matériel en essai

6.2.1 Généralités

Le rapport signal sur bruit de mesure, eu égard au bruit ambiant, doit satisfaire aux exigences suivantes. Si le bruit ambiant dépasse le niveau exigé, cela doit être consigné dans le rapport d'essai.

6.2.2 Essais (d'évaluation) de conformité

Un emplacement d'essai doit permettre de distinguer les émissions de l'EUT du bruit ambiant. Il convient que le niveau de bruit ambiant soit de préférence de 20 dB inférieur au niveau de mesure souhaité, mais au moins de 6 dB inférieur à ce niveau. Pour la condition de 6 dB, le niveau de perturbation apparent venant de l'EUT est augmenté d'une valeur pouvant atteindre 3,5 dB. L'aptitude de l'emplacement pour le niveau ambiant exigé peut être déterminée en mesurant le niveau de bruit ambiant avec le matériel d'essai en place, mais hors fonctionnement.

Lors de l'évaluation de la conformité par rapport à une limite, il est admis que le niveau de bruit ambiant dépasse le niveau préférentiel de −6 dB, à condition que les niveaux combinés de bruit ambiant et d'émission de la source ne dépassent pas la limite spécifiée. L'EUT est alors considéré comme satisfaisant à la limite. Des recommandations complémentaires concernant le mesurage des perturbations en présence d'émissions ambiantes sont données à l'Annexe A.

6.3 Mesurage d'une perturbation continue

6.3.1 Perturbation continue à bande étroite

Le réglage du récepteur doit être maintenu sur la fréquence discrète examinée et modifié si la fréquence fluctue.

6.3.2 Perturbation continue à large bande

Pour évaluer une perturbation continue à large bande dont le niveau n'est pas stable, la valeur maximale reproductible de mesure doit être déterminée. Voir 6.5.1 pour de plus amples informations.

6.3.3 Utilisation d'analyseurs de spectre et de récepteurs à scrutation

Les analyseurs de spectre et les récepteurs à scrutation sont utiles pour mesurer les perturbations, particulièrement afin de réduire la durée de mesure. Une attention toute particulière doit cependant être accordée à certaines caractéristiques de ces instruments, notamment: la surcharge, la linéarité, la sélectivité, la réponse normale aux impulsions, la vitesse de scrutation en fréquence, l'interception du signal, la sensibilité, l'exactitude en amplitude et la détection de crête, de valeur moyenne et de quasi-crête. Ces caractéristiques sont examinées à l'Annexe B.

6.4 Configuration et conditions de mesure de l'EUT

L'EUT doit fonctionner dans les conditions suivantes.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

6.4.1 Configuration générale de l'EUT

6.4.1.1 Généralités

Lorsque ce n'est pas spécifié dans la norme de produit, l'EUT doit être configuré comme décrit ci-dessous.

L'EUT doit être installé, disposé et doit fonctionner d'une façon compatible avec ses applications types. Lorsque le fabricant a spécifié ou recommandé une pratique d'installation, cette pratique doit être utilisée si possible dans la configuration d'essai. Cette configuration doit être le type de pratique normale d'installation. Les câbles, charges et dispositifs d'interface doivent être raccordés à au moins un accès d'interface de chaque type de l'EUT et, lorsque la pratique le permet, chaque câble doit être raccordé à un dispositif caractéristique d'une utilisation réelle.

Lorsqu'il y a plusieurs accès d'interface du même type, des câbles d'interconnexion, des charges et des dispositifs supplémentaires peuvent devoir être ajoutés à l'EUT, en fonction des résultats des essais préliminaires. Le raccordement d'un câble ou d'un conducteur à un seul accès de ce type d'accès peut être suffisant. Le nombre réel de câbles ou de conducteurs supplémentaires peut être limité aux cas où l'ajout d'un autre câble ou conducteur n'influe pas significativement sur le niveau d'émission, c'est-à-dire qu'il varie de moins de 2 dB, à condition que l'EUT reste conforme. La justification du choix de la configuration et du chargement des accès doit être incluse dans le rapport d'essai.

Il convient que les câbles d'interconnexion soient du type et de la longueur spécifiés dans les exigences concernant le matériel individuel. Si la longueur peut être modifiée, celle-ci doit être choisie de manière à produire un maximum de perturbation.

Si des câbles blindés ou particuliers sont utilisés pendant les essais pour obtenir la conformité, une note doit alors être incluse dans le manuel d'instructions, informant de la nécessité d'utiliser de tels câbles.

Les longueurs de câbles en excès doivent être disposées en faisceau, approximativement au milieu du câble, la longueur des faisceaux allant de 30 cm à 40 cm. S'il s'avère impossible d'y parvenir en raison de l'encombrement ou de la rigidité des câbles, la disposition du câble en excès doit être notée précisément dans le rapport d'essai.

Les résultats d'une évaluation d'EUT comportant un module de chaque type peuvent être appliqués à des configurations comportant plusieurs de ces modules. Ceci est admis, car il s'est avéré que des perturbations provenant de modules identiques ne sont généralement pas additives dans la pratique. Toutefois, le critère de 2 dB défini dans le présent article doit être appliqué.

Tout ensemble de résultats doit être accompagné d'une description complète du câblage et de l'orientation du matériel de façon à pouvoir reproduire les résultats. Si des conditions d'utilisation spécifiques sont exigées pour satisfaire aux limites, ces conditions doivent être spécifiées et documentées, par exemple, la longueur de câble, le type, le blindage et la mise à la masse des câbles. Ces conditions doivent être incluses dans les instructions destinées à l'utilisateur.

Un matériel contenant plusieurs modules (tiroir, carte enfichable, plaque, etc.) doit être soumis aux essais avec un mélange et un nombre représentatifs de ce qui est utilisé dans une installation type. Le nombre réel de plaques ou de cartes enfichables du même type peut être limité aux cas où l'ajout d'une autre plaque ou carte enfichable n'influe pas significativement sur le niveau d'émission, c'est-à-dire qu'il varie de moins de 2 dB, à condition que l'EUT reste conforme. La justification utilisée pour choisir le nombre et le type de modules doit être mentionnée dans le rapport d'essai.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Un système constitué d'un certain nombre d'unités séparées doit être configuré de manière à former une configuration représentative minimale. Le nombre et le mélange d'unités incluses dans la configuration d'essai doivent être représentatifs de ce qui est utilisé dans une installation type. La justification utilisée pour choisir les unités doit être mentionnée dans le rapport d'essai.

Au minimum un module de chaque type doit être fonctionnel dans chaque matériel évalué d'un EUT. Pour un EUT faisant partie d'un système, au minimum un matériel de chaque type pouvant être inclus dans la configuration possible du système doit être inclus dans l'EUT.

La position de l'EUT par rapport au plan de masse de référence (RGP) doit être équivalente à ce qui existe dans la pratique. En conséquence, le matériel posé au sol est placé sur un RGP, mais isolé de celui-ci, et le matériel posé sur une table est placé sur une table non conductrice.

Le matériel conçu pour fonctionner monté sur un mur ou monté au plafond doit être soumis aux essais comme l'EUT posé sur une table. L'orientation du matériel doit être cohérente avec la pratique d'installation normale.

Les combinaisons de types de matériels identifiés ci-dessus doivent également être disposées d'une manière cohérente avec la pratique d'installation normale. Le matériel conçu à la fois pour fonctionner posé sur une table et posé au sol doit être soumis aux essais comme un matériel posé sur une table, sauf si l'installation habituelle est posée au sol, auquel cas cette configuration doit être utilisée.

Les extrémités des câbles de signaux reliés à l'EUT qui ne sont pas raccordées à une autre unité ou à un autre matériel auxiliaire doivent être terminées en utilisant l'impédance de fermeture correcte définie dans la norme de produit.

Les câbles ou autres connexions à du matériel associé situé en dehors de la zone d'essai doivent pendre jusqu'au sol, puis être acheminés jusqu'à l'emplacement où ils quittent le volume d'essai.

Le matériel auxiliaire doit être installé conformément à la pratique d'installation normale. Lorsque ceci signifie que le matériel auxiliaire est situé sur l'emplacement d'essai, il doit être configuré en utilisant les mêmes conditions que celles qui sont applicables pour l'EUT (par exemple, distance par rapport au plan de masse et isolation par rapport au plan de masse s'il est posé au sol, et disposition du câblage).

6.4.1.2 Configuration posée sur une table

Le matériel destiné à être utilisé posé sur une table doit être placé sur une table non conductrice. Les dimensions nominales de la table sont de 1,5 m sur 1,0 m, mais elles peuvent finalement dépendre des dimensions horizontales de l'EUT.

Toutes les unités constituant le système en essai (incluant l'EUT, les périphériques et les matériels ou dispositifs auxiliaires connectés) doivent être disposées conformément à une utilisation normale. Lorsqu'elle n'est pas définie dans l'utilisation normale, une distance de séparation nominale de 0,1 m entre les unités voisines doit être définie pour la configuration d'essai.

Les câbles intra-unités doivent pendre à l'arrière de la table. Si un câble pend jusqu'à moins de 0,4 m du plan de masse horizontal (ou du sol), la partie en excès doit être repliée au centre du câble en formant un faisceau dont la longueur ne dépasse pas 0,4 m, de façon que le faisceau se trouve au moins à 0,4 m au-dessus du RGP horizontal.

Les câbles doivent être positionnés comme pour une utilisation normale.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Si la longueur du câble d'entrée de la prise d'alimentation électrique est inférieure à 0,8 m (y compris les alimentations intégrées dans la prise d'alimentation électrique), un câble prolongateur doit être utilisé de sorte que l'unité d'alimentation extérieure soit placée sur la table. Le câble prolongateur doit avoir des caractéristiques similaires au câble d'alimentation électrique (y compris le nombre de conducteurs et la présence d'une mise à la masse). Le câble prolongateur doit être traité comme une partie du câble d'alimentation électrique.

Dans les configurations ci-dessus, le câble situé entre l'EUT et l'alimentation doit être disposé sur la table de la même manière que les autres câbles reliant les composants de l'EUT.

6.4.1.3 Configuration posée au sol

L'EUT doit être placé sur le RGP horizontal, orienté pour une utilisation normale, mais séparé de tout contact métallique avec le RGP par une isolation allant jusqu'à 15 cm.

Les câbles doivent être isolés (jusqu'à 15 cm) du RGP horizontal. Si le matériel exige une mise à la masse dédiée, celle-ci doit alors être prévue et reliée au plan de masse horizontal.

Les câbles intra-unité (entre des unités constituant l'EUT ou entre l'EUT et un matériel auxiliaire) doivent pendre du RGP horizontal, mais rester isolés de celui-ci. Toute partie en excès doit être, soit repliée au centre du câble en un faisceau dont la longueur ne dépasse pas 0,4 m, soit disposée en serpentin. Si la longueur d'un câble intra-unité n'est pas suffisante pour pendre jusqu'au RGP horizontal, mais pend à moins de 0,4 m, la longueur en excès doit alors être repliée au centre du câble en un faisceau dont la longueur ne dépasse pas 0,4 m. Le faisceau doit être positionné de façon à se trouver à 0,4 m au-dessus du RGP horizontal ou à la hauteur de l'entrée du câble ou du point de connexion si celui-ci se trouve à moins de 0,4 m du RGP horizontal.

Pour un matériel avec une montée verticale de câbles, le nombre de montées doit être celui de la pratique d'installation type. Lorsque la montée est réalisée dans un matériau non conducteur, un espacement minimal d'au moins 0,2 m doit être maintenu entre la partie la plus proche du matériel et le câble vertical le plus proche. Lorsque la structure de la montée est conductrice, l'espacement minimal de 0,2 m doit être celui qui existe entre les parties les plus proches du matériel et la structure de la montée.

6.4.1.4 Combinaisons de configurations de matériel posé sur une table et posé au sol

La partie en excès des câbles intra-unités entre une unité posée sur une table et une unité posée au sol doit être repliée en un faisceau dont la longueur est inférieure ou égale à 0,4 m. Le faisceau doit être positionné de façon à se trouver à 0,4 m au-dessus du RGP horizontal ou à la hauteur de l'entrée du câble ou du point de connexion si celui-ci se trouve à moins de 0,4 m du RGP horizontal.

6.4.2 Fonctionnement de l'EUT

Les conditions de fonctionnement de l'EUT doivent être déterminées par le fabricant conformément à l'utilisation type de l'EUT vis-à-vis du niveau d'émission le plus élevé attendu. Le mode de fonctionnement déterminé et la justification du choix des conditions de fonctionnement doivent être mentionnés dans le rapport d'essai.

L'EUT doit être utilisé avec la plage de tensions de fonctionnement assignées (nominales) et les conditions de charge type (mécanique ou électrique) pour lesquelles il est conçu. Il convient d'utiliser des charges réelles chaque fois que possible. Si un simulateur est utilisé, celui-ci doit représenter la charge réelle vis-à-vis de sa fréquence radio et de ses caractéristiques fonctionnelles.

Il convient que les programmes d'essai ou les autres moyens de vérification du matériel garantissent que les diverses parties d'un système sont vérifiées d'une manière permettant la détection de toutes les perturbations du système.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

6.4.3 Durée de fonctionnement de l'EUT

La durée de fonctionnement, dans le cas d'EUT avec une durée de fonctionnement assignée donnée, doit être conforme au marquage. Dans tous les autres cas, l'EUT doit être en fonctionnement continu au cours de l'essai.

6.4.4 Durée de fonctionnement préalable de l'EUT

Aucune durée de fonctionnement préalable particulière n'est spécifiée, mais, avant d'effectuer les essais, l'EUT doit avoir fonctionné pendant une durée suffisante pour que ses modes et conditions de fonctionnement soient représentatifs de ceux qui se présentent au cours de la vie normale du matériel. Pour certains EUT, certaines conditions particulières d'essai peuvent être spécifiées dans les normes de produits applicables.

6.4.5 Alimentation de l'EUT

L'EUT doit être alimenté à sa tension assignée. Si le niveau de perturbation varie considérablement avec la tension d'alimentation, les mesurages doivent être répétés pour des tensions d'alimentation sur la plage comprise entre 0,9 et 1,1 fois la tension assignée. Les EUT prévus pour plusieurs tensions assignées doivent être soumis aux essais à la tension assignée qui provoque la perturbation maximale.

6.4.6 Mode de fonctionnement de l'EUT

L'EUT doit fonctionner dans les conditions pratiques qui provoquent la perturbation maximale à la fréquence de mesure.

6.4.7 Fonctionnement d'un matériel à fonctions multiples

Un matériel à fonctions multiples, qui est soumis simultanément à différents articles d'une norme de produit et/ou de normes différentes, doit être soumis à des essais, chaque fonction étant mise en fonctionnement seule, si cela peut être obtenu sans modification interne du matériel. Le matériel ainsi soumis aux essais doit être considéré comme satisfaisant aux exigences de tous les articles et/ou normes lorsque chacune de ses fonctions a satisfait aux exigences de l'article et/ou de la norme applicable(s).

Pour un matériel dont l'essai de chaque fonction mise en fonctionnement seule n'est pas réalisable, ou lorsque l'essai séparé d'une fonction particulière rendrait le matériel inapte à remplir sa fonction primaire, ou lorsque le fonctionnement simultané de plusieurs fonctions produirait une économie de durée de mesure, le matériel doit être considéré comme satisfaisant s'il répond aux dispositions des articles et/ou normes pertinent(e)s, lorsque les fonctions nécessaires sont mises en fonctionnement.

6.4.8 Détermination de la ou des configurations provoquant des valeurs d'émission maximales

Un essai initial doit identifier la fréquence ayant la plus forte perturbation par rapport à la limite. Cette identification doit être effectuée pendant le fonctionnement de l'EUT dans les modes de fonctionnement types et avec les positions des câbles dans une configuration d'essai représentative d'une pratique d'installation type.

La fréquence de plus forte perturbation par rapport à la limite doit être déterminée en étudiant les perturbations à plusieurs fréquences significatives. Ceci permet d'assurer que la fréquence probable de perturbation maximale a été déterminée et que le câble associé, la configuration et le mode de fonctionnement de l'EUT ont été identifiés.

Pour l'essai initial, il convient de configurer l'EUT conformément aux normes de produits, selon le cas.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

6.4.9 Enregistrement des mesurages

Parmi les perturbations ci-dessus (L – 20 dB), où L est le niveau limite en unités logarithmiques, les niveaux de perturbation et les fréquences au minimum des six perturbations les plus fortes doivent être enregistrés.

Pour les perturbations rayonnées, la polarisation de l'antenne et la hauteur pour chaque perturbation consignée doivent être enregistrées.

6.5 Interprétation des résultats de mesure

6.5.1 Perturbations continues

a) Si le niveau de perturbation n'est pas stable, la lecture sur le récepteur de mesure est observée pendant au moins 15 s pour chaque mesurage. Les indications les plus élevées doivent être enregistrées, à l'exception de tout claquement isolé, qui doit être ignoré (voir 4.4 de la CISPR 14-1:2016).

b) Si le niveau général de perturbation n'est pas stable, mais présente une augmentation ou une diminution continue supérieure à 2 dB pendant une période de 15 s, alors les niveaux de tension perturbatrice doivent être observés pendant une période plus longue et doivent être interprétés en fonction des conditions normales d'utilisation de l'EUT, comme suit:

   1) si l'EUT peut être allumé ou éteint fréquemment ou si son sens de rotation peut être inversé, il convient alors, pour chaque fréquence de mesure, d'allumer ou d'inverser le sens de rotation du matériel en essai juste avant chaque mesurage, puis de l'éteindre juste après. Le niveau maximal obtenu durant la première minute, pour chaque fréquence de mesure, doit être enregistré;

   2) si l'EUT fonctionne habituellement pendant de plus longues durées, il convient alors de le laisser allumé pendant toute la durée de l'essai. Le niveau de perturbation doit être enregistré pour chaque fréquence, mais uniquement après avoir obtenu une lecture stable (sous réserve de la satisfaction du point a)).

c) Si la nature des perturbations de l'EUT passe d'un caractère stable à un caractère aléatoire au cours d'un essai, l'EUT doit alors être soumis à l'essai conformément au point b).

d) Les mesurages sont effectués sur le spectre complet et enregistrés au moins à la fréquence qui offre la valeur lue la plus élevée, comme exigé dans la publication CISPR applicable.

6.5.2 Perturbations discontinues

Il n'existe actuellement aucune exigence pour le mesurage des perturbations discontinues rayonnées.

6.5.3 Mesurage de la durée d'une perturbation

La durée d'une perturbation doit être connue pour pouvoir la mesurer correctement et pour déterminer si elle est discontinue. La durée d'une perturbation peut être mesurée selon l'une des manières suivantes:

- en connectant un oscilloscope à la sortie FI (fréquence intermédiaire) d'un récepteur de mesure pour pouvoir surveiller la perturbation dans le domaine temporel;
- en accordant un récepteur de brouillage électromagnétique ou un analyseur de spectre sur la fréquence de la perturbation sans scrutation en fréquence (c'est-à-dire, en mode «intervalle nul») pour pouvoir surveiller la perturbation dans le domaine temporel; ou
- en utilisant la sortie du domaine temporel d'un récepteur de mesure à FFT.

Des recommandations concernant la détermination de la durée appropriée de mesure peuvent être consultées en 8.3.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

6.6 Durées de mesure et vitesses de scrutation pour les perturbations continues

6.6.1 Généralités

Pour les mesurages manuels et pour les mesurages automatiques ou semi-automatiques, les durées de mesure et les vitesses de scrutation des récepteurs de mesure et des récepteurs à scrutation doivent être réglées afin de mesurer l'émission maximale. Plus particulièrement, lorsqu'un détecteur de crête est utilisé pour une préscrutation, les durées de mesure et les vitesses de scrutation doivent prendre en compte le rythme de l'émission en essai. Des recommandations plus détaillées sur l'exécution des mesurages automatiques peuvent être consultées à l'Article 8.

6.6.2 Durées minimales de mesure

Les durées (temps de palier) de mesure minimales sont données au Tableau 1. Les durées minimales de scrutation des mesurages pour chaque bande CISPR dans son intégralité ont été déduites à partir du Tableau 1 et elles figurent dans le Tableau 2. Ces durées minimales (temps de palier) de mesure pour les récepteurs à scrutation et les instruments de mesure à FFT du Tableau 1 et les durées de scrutation pour les analyseurs de spectre du Tableau 2 s'appliquent à des signaux en ondes entretenues (CW).

En outre, le rapport d'essai doit comprendre la valeur de l'incertitude de l'instrument de mesure, correspondant à l'installation d'essai utilisée, calculée selon les exigences de la CISPR 16-4-2.

Tableau 1 – Durées minimales de mesure pour les quatre bandes CISPR

Bande de fréquences		Durées minimales de mesure T_m
A	9 kHz à 150 kHz	10,00 ms
B	0,15 MHz à 30 MHz	0,50 ms
C et D	30 MHz à 1 000 MHz	0,06 ms
E	1 GHz à 18 GHz	0,01 ms

Tableau 2 – Durées minimales de scrutation pour les trois bandes CISPR avec détecteurs de crête et de quasi-crête

Bande de fréquence		Durée de scrutation T_S pour une détection de crête	Durée de scrutation T_S pour une détection de quasi-crête
A	9 kHz à 150 kHz	14,1 s	2 820 s = 47 min
B	0,15 MHz à 30 MHz	2,985 s	5 970 s = 99,5 min = 1 h 39 min
C et D	30 MHz à 1 000 MHz	0,97 s	19 400 s = 323,3 min = 5 h 23 min

En fonction du type de perturbation, la durée de scrutation peut devoir être augmentée, même pour des mesurages de quasi-crête. Dans des cas extrêmes, la durée de mesure T_m à une certaine fréquence peut devoir être augmentée à 15 s, si le niveau de l'émission observée n'est pas stable (voir 6.5.1). Toutefois, les claquements isolés sont exclus.

Les durées de mesure et les vitesses de scrutation utilisables avec un détecteur de valeur moyenne sont données à l'Annexe C.

La plupart des normes de produits font appel à la détection de quasi-crête pour les mesurages de conformité, ce qui peut prendre beaucoup de temps si aucune procédure de réduction de la durée de mesure n'est appliquée (voir Article 8). Avant de pouvoir appliquer une procédure de réduction de la durée de mesure, l'émission doit être détectée par une préscrutation. Afin de s'assurer que, par exemple, des signaux intermittents ne sont pas

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

oubliés pendant une scrutation automatique, les considérations de 6.6.3 à 6.6.5 doivent être prises en compte.

6.6.3 Vitesses de scrutation des récepteurs à scrutation et des analyseurs de spectre

Il est nécessaire de remplir l'une des deux conditions suivantes pour s'assurer que des signaux ne sont pas oubliés pendant des scrutations automatiques sur les intervalles de fréquences:

- pour un balayage unique: la durée de mesure pour chaque fréquence doit être supérieure aux intervalles entre impulsions pour les signaux intermittents;
- pour des balayages multiples avec maintien du maximum: il convient que la durée d'observation pour chaque fréquence soit suffisante pour intercepter des signaux intermittents.

La vitesse de scrutation en fréquence est limitée par la largeur de bande de résolution de l'instrument et le réglage de la largeur de bande vidéo. Si la vitesse de scrutation choisie est trop rapide pour un état donné de l'instrument, des résultats de mesure erronés sont obtenus. En conséquence, il est nécessaire de choisir une durée de balayage suffisamment longue pour l'intervalle de fréquence considéré. Les signaux intermittents peuvent être interceptés soit par un simple balayage avec une durée d'observation suffisamment longue à chaque fréquence, soit par des balayages multiples avec maintien du maximum. Généralement, pour une vue d'ensemble d'émissions inconnues, la deuxième solution est particulièrement efficace: tant que l'affichage du spectre se modifie, il peut exister encore des signaux intermittents à découvrir. La durée d'observation doit être choisie en fonction de la périodicité avec laquelle les signaux brouilleurs apparaissent. Dans certains cas, une modification de la vitesse de balayage peut devoir être effectuée pour éviter des effets de synchronisation.

Lors de la détermination de la durée minimale de balayage pour les mesurages avec un analyseur de spectre ou un récepteur de brouillage électromagnétique à scrutation, sur la base d'un réglage donné de l'instrument et en utilisant une détection de crête, deux cas différents doivent être distingués. Si la largeur de bande vidéo choisie est **plus large** que la largeur de bande de résolution, l'expression suivante peut être utilisée pour calculer la durée minimale de balayage:

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

où

$T_{\mathrm{s\,min}}$ est la durée minimale de balayage,

Δf est l'intervalle de fréquence,

B_{res} est la largeur de bande de résolution, et

k est la constante de proportionnalité, relative à la forme du filtre de résolution; cette constante a une valeur estimée entre 2 et 3 pour des filtres à accord synchrone, pratiquement gaussiens. Pour des filtres pratiquement rectangulaires, à accord décalé, k a une valeur comprise entre 10 et 15.

Si la largeur de bande vidéo choisie est inférieure ou égale à la largeur de bande de résolution, l'expression suivante peut être utilisée pour calculer la durée minimale de balayage:

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

où B_{video} est la largeur de bande vidéo.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

La plupart des analyseurs de spectre et des récepteurs de brouillage électromagnétique à scrutation règlent automatiquement la durée de balayage en fonction de l'intervalle de fréquence choisi et des réglages de largeur de bande. La durée de balayage est réglée pour maintenir un affichage étalonné. La sélection automatique de la durée de balayage peut être annulée si des durées d'observation plus longues sont exigées, par exemple pour intercepter des signaux à variation lente.

De plus, pour les balayages répétitifs, le nombre de balayages par seconde est déterminé par la durée de balayage $T_{s\ min}$ et le temps de retour (durée nécessaire pour réajuster l'oscillateur local et pour enregistrer les résultats de mesure, etc.).

6.6.4 Durées de balayage pour les récepteurs à accord par palier

Les récepteurs de brouillage électromagnétique à accord par palier sont accordés successivement sur des fréquences ponctuelles en utilisant des largeurs de pas prédéfinies. Tout en couvrant la plage de fréquences concernée par des pas discrets de fréquence, un temps minimal de palier à chaque fréquence est exigé pour que l'instrument mesure de façon précise le signal d'entrée.

Pour le mesurage réel, l'utilisation d'un pas de fréquence d'environ 50 % de la largeur de bande de résolution utilisée, ou moins (en fonction de la forme du filtre de résolution) est exigée pour réduire l'incertitude de mesure due à la largeur du pas pour les signaux à bande étroite. Avec ces hypothèses, la durée de scrutation $T_{s\ min}$ pour un récepteur à accord par palier peut être calculée en utilisant l'équation suivante:

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

où $T_{m\ min}$ est la durée minimale de mesure (temps de palier) à chaque fréquence.

En plus de la durée de mesure, une certaine période de temps doit être prise en considération pour que le synthétiseur passe à la fréquence suivante et pour que le micrologiciel enregistre le résultat de mesure, ce qui est réalisé automatiquement dans la plupart des récepteurs, de telle sorte que la durée de mesure choisie est la durée réelle pour obtenir le résultat de mesure. De plus, le détecteur choisi, par exemple de crête ou de quasi-crête, détermine également cette durée.

Pour des émissions purement à large bande, le pas de fréquence peut être augmenté. Dans ce cas, l'objectif consiste à déterminer uniquement les valeurs maximales du spectre d'émission.

6.6.5 Stratégies pour l'obtention d'une vue d'ensemble du spectre en utilisant le détecteur de crête

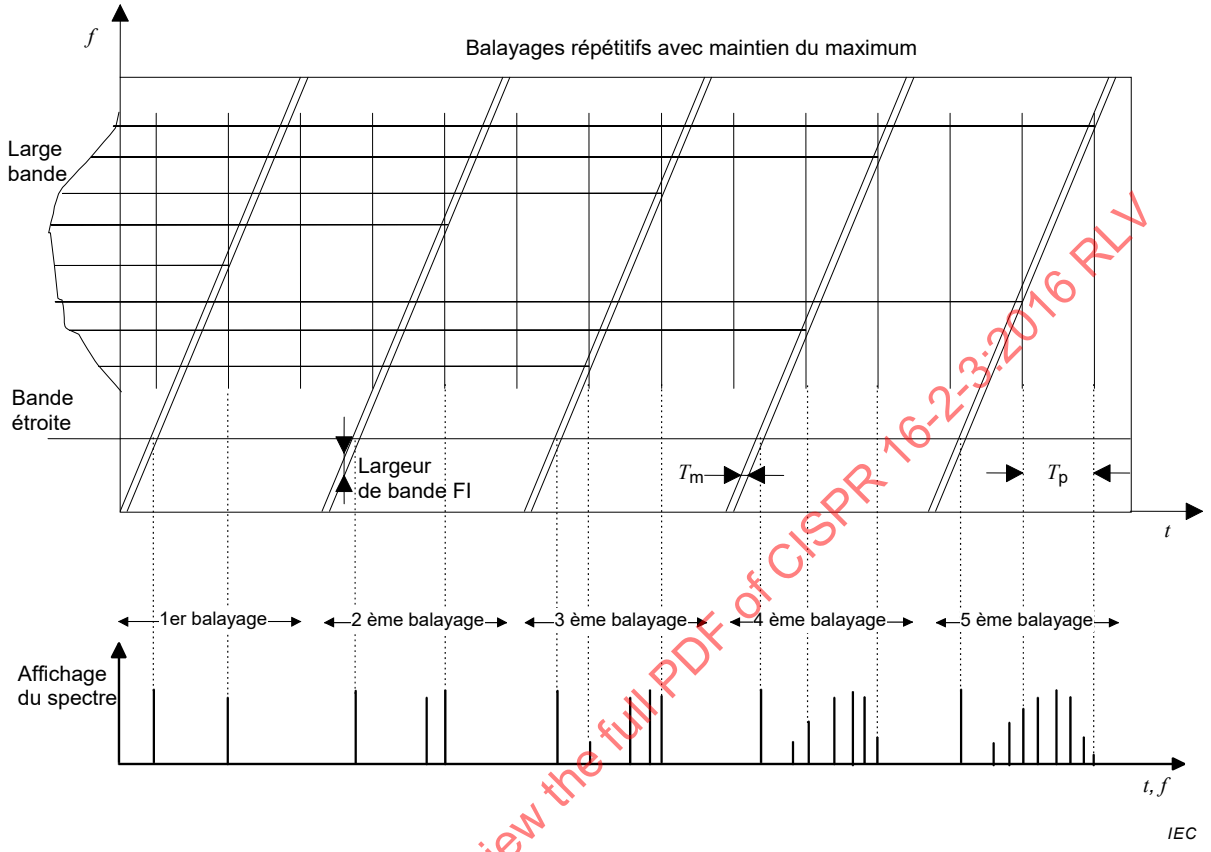
Pour chaque mesurage par préscrutation, la probabilité d'intercepter toutes les composantes spectrales critiques du spectre de l'EUT doit être de 100 % ou aussi proche que possible de 100 %. En fonction du type de récepteur de mesure et des caractéristiques de la perturbation pouvant contenir des composantes à bande étroite et à large bande, deux approches générales sont proposées:

– scrutation par pas: la durée de mesure (temps de palier) doit être assez longue pour chaque fréquence pour mesurer la crête du signal, par exemple, pour un signal impulsif, il convient que la durée de mesure (temps de palier) soit supérieure à l'inverse de la fréquence de répétition du signal.

– scrutation continue: la durée de mesure doit être supérieure aux intervalles entre les signaux intermittents (balayage unique) et il convient de maximiser le nombre de scrutations en fréquence pendant la durée d'observation pour augmenter la probabilité d'interception du signal.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

La Figure 1, la Figure 2 et la Figure 3 donnent des exemples de la relation entre différents spectres d'émission variant dans le temps et les affichages correspondants sur le récepteur de mesure. Dans chaque cas, la partie supérieure de la Figure représente la position de la largeur de bande du récepteur selon qu'il balaye le spectre en continu ou par pas.



Légende:

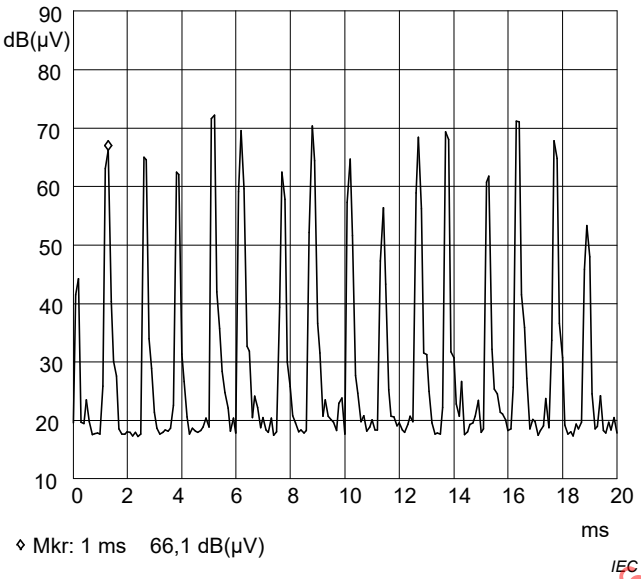
T_o est l'intervalle de répétition des impulsions du signal impulsif. Une impulsion se produit à chaque ligne verticale du spectre en fonction de l'échelle de temps de l'affichage (partie supérieure de la Figure).

Figure 1 – Mesurage d'une combinaison d'un signal en onde entretenue à bande étroite et d'un signal impulsif à large bande en utilisant des balayages multiples avec maintien du maximum

Si le type d'émission est inconnu, des balayages multiples avec une durée de balayage aussi courte que possible et une détection de crête permettent de déterminer l'enveloppe du spectre. Un balayage unique court est suffisant pour mesurer le contenu d'un signal continu à bande étroite dans le spectre d'un matériel en essai. Pour les signaux continus à large bande et les signaux intermittents à bande étroite, des balayages multiples à différentes vitesses de scrutation en utilisant la fonction «maintien du maximum» peuvent être nécessaires pour déterminer l'enveloppe du spectre. Pour des signaux impulsifs à faible répétition, il est nécessaire d'effectuer de nombreux balayages pour remplir l'enveloppe du spectre de la composante à large bande.

La réduction de la durée de mesure exige une analyse temporelle des signaux à mesurer. Ceci peut être effectué soit avec un récepteur de mesure qui fournit un affichage graphique du signal, utilisé en mode «intervalle nul» ou en utilisant un oscilloscope raccordé à la sortie FI ou vidéo du récepteur, comme représenté à la Figure 2.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



NOTE Perturbation d'un moteur à collecteur à courant continu: en raison du nombre de segments du collecteur, la fréquence de répétition d'impulsions est élevée (environ 800 Hz) et l'amplitude des impulsions varie fortement. En conséquence, pour cet exemple, la durée de mesure (temps de palier) recommandée avec un détecteur de crête est supérieure à 10 ms.

Figure 2 – Exemple d'analyse temporelle

À partir d'une telle analyse temporelle, les durées des impulsions et leurs fréquences de répétition peuvent être déterminées, et les vitesses de scrutation ou les temps de palier peuvent être sélectionnés en conséquence, dans les conditions suivantes:

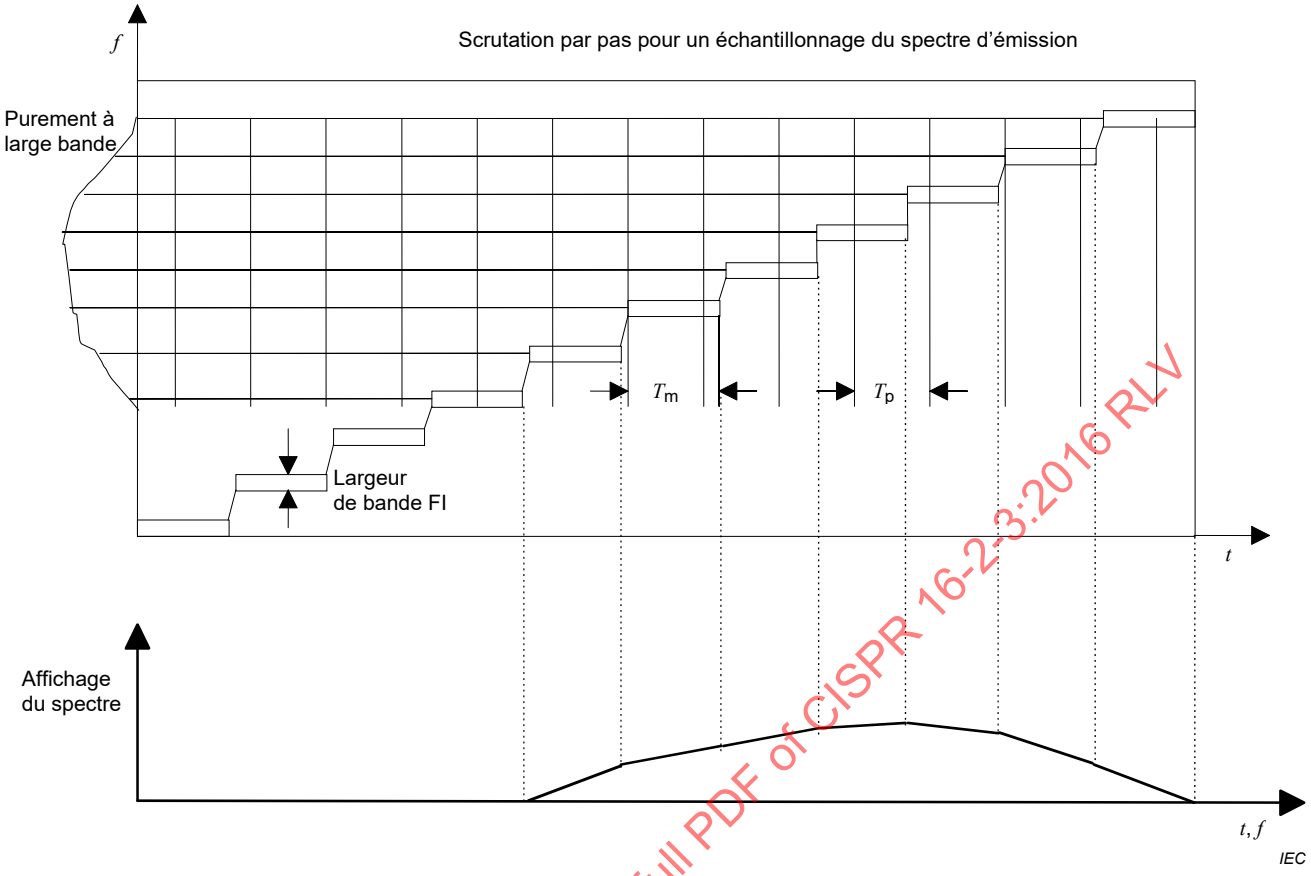
– pour les perturbations **continues non modulées à bande étroite**, la durée de scrutation la plus courte possible pour les réglages choisis de l'instrument peut être utilisée;

– pour les perturbations **purement continues à large bande**, par exemple dues à des moteurs à allumage, des appareils de soudage à l'arc et des moteurs à collecteur, une scrutation par pas (avec une détection de crête ou même de quasi-crête) peut être utilisée pour un échantillonnage du spectre d'émission. Dans ce cas, la connaissance du type de perturbation permet de dessiner une courbe en lignes brisées représentant l'enveloppe du spectre (voir Figure 3). La largeur du pas doit être choisie de sorte qu'aucune variation significative de l'enveloppe du spectre ne soit oubliée. Un mesurage par balayage unique, s'il est effectué suffisamment lentement, génère également l'enveloppe du spectre;

– pour les perturbations **intermittentes à bande étroite** de fréquences inconnues, des balayages courts et rapides avec la fonction «maintien du maximum» (voir Figure 4) ou un balayage lent peuvent être utilisés. Une analyse temporelle peut être exigée avant le mesurage réel pour s'assurer d'une interception correcte du signal;

– les perturbations **intermittentes à large bande** doivent être mesurées avec les procédures d'analyse des perturbations discontinues, comme décrites dans la CISPR 16-1-1.

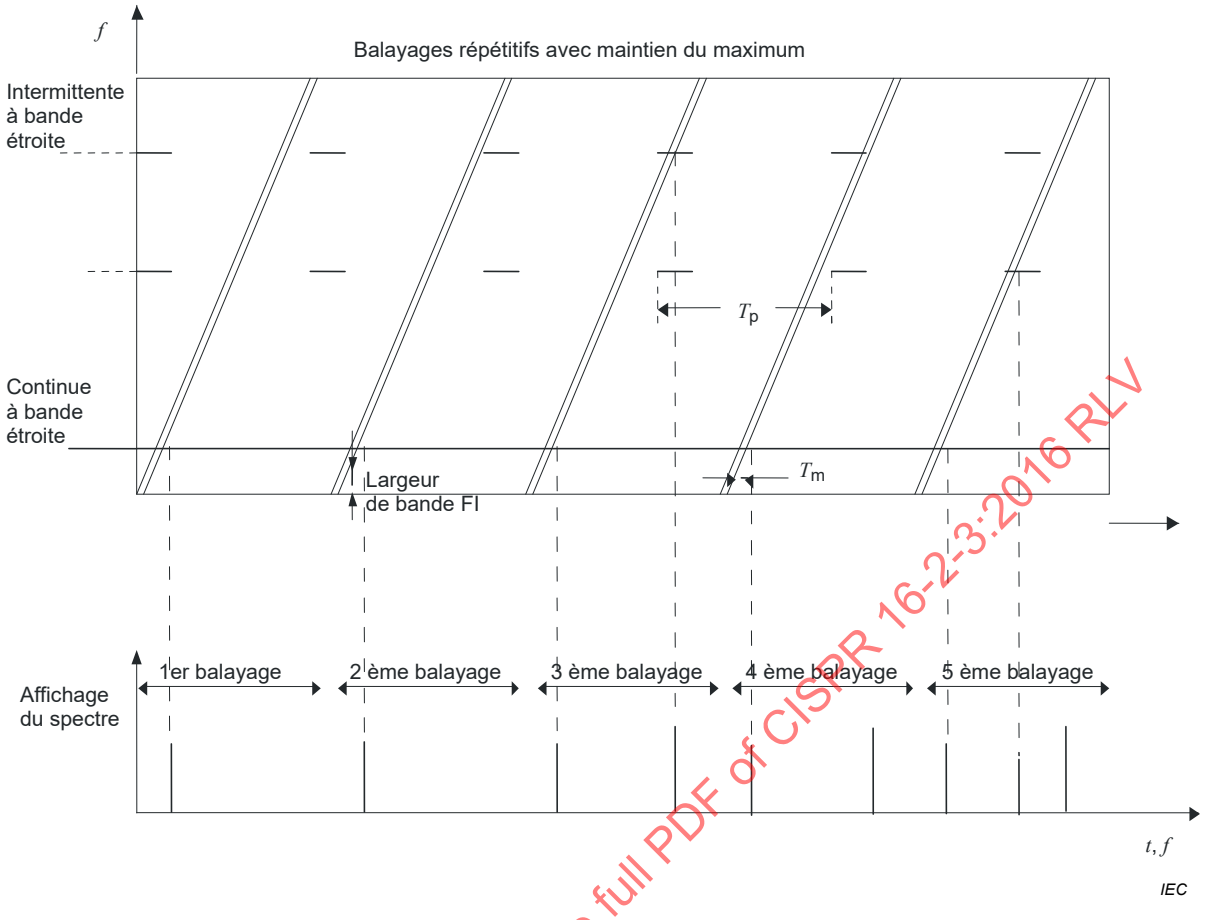
IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



La durée de mesure (temps de palier) T_m doit être supérieure à l'intervalle de répétition des impulsions T_p, qui est l'inverse de la fréquence de répétition d'impulsions.

Figure 3 – Spectre à large bande mesuré avec un récepteur à accord par palier

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



NOTE 1 Le nombre de balayages exigés ou la durée de balayage peuvent devoir être augmentés, en fonction de la durée des impulsions ou de leur intervalle de répétition.

NOTE 2 Dans cet exemple, cinq balayages sont exigés pour intercepter toutes les composantes spectrales.

Figure 4 – Perturbations intermittentes à bande étroite mesurées en utilisant des balayages courts, rapides et répétitifs avec la fonction «maintien du maximum» pour obtenir une vue d'ensemble du spectre d'émission

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

6.6.6 Considérations temporelles concernant l'utilisation d'appareils de mesure à FFT

Les appareils de mesure à FFT peuvent associer le calcul en parallèle à N fréquences et une scrutation par pas. Dans ce but, la plage de fréquences concernée est subdivisée en un certain nombre de segments N_{seg} qui sont scrutés en séquence. Le mode opératoire est présenté à la Figure 5 pour trois segments. La durée totale de scrutation pour la plage de fréquences concernée $T_{scrutation}$ est calculée de la manière suivante:

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

où

T_m est la durée de mesure pour chaque segment, et

N_{seg} est le nombre de segments.

Les appareils de mesure à FFT peuvent également fournir des méthodes pour améliorer la résolution en fréquence sur une plage de fréquences donnée. Un appareil de mesure à FFT a

généralement un pas de fréquence fixe $f_{\text{pas,FFT}}$ qui est déterminé par le nombre de fréquences de la FFT. Une résolution de fréquence accrue est obtenue en effectuant des calculs répétés sur une plage de fréquences donnée. Pour chaque calcul répété, la fréquence la plus basse est incrémentée d'un pas de fréquence $f_{\text{pas final}}$.

Ainsi, le premier calcul sur la plage de fréquences donnée prend en compte les fréquences suivantes:

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

Le deuxième calcul sur la plage de fréquences donnée prend en compte les fréquences suivantes:

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

Ce mode opératoire, appliqué à un rapport de pas de 3, est présenté à la Figure 6.

La durée de scrutation $T_{\text{scrutation}}$ est calculée de la manière suivante:

$$T_{\text{scrutation}} = T_{\text{m}} \frac{f_{\text{pas FFT}}}{f_{\text{pas final}}} \tag{5}$$

où

T_{m} est la durée de mesure, et

$\frac{f_{\text{pas FFT}}}{f_{\text{pas final}}}$ est le rapport de pas.

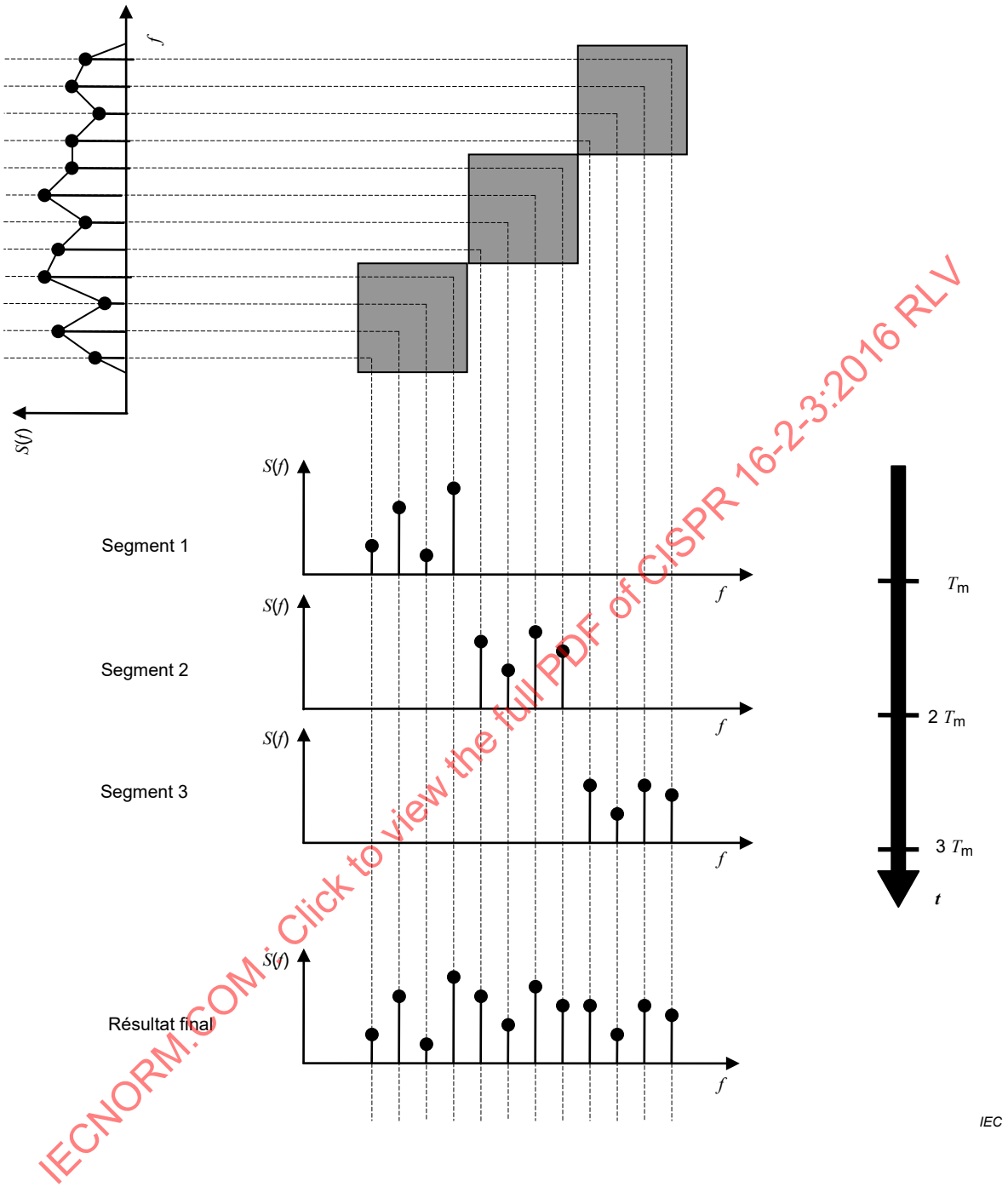
Pour un système associant les deux méthodes, la durée de scrutation $T_{\text{scrutation}}$ est calculée de la manière suivante:

$$T_{\text{scrutation}} = T_{\text{m}} N_{\text{seg}} \frac{f_{\text{pasFFT}}}{f_{\text{pas final}}} \tag{6}$$

NOTE 1 Les appareils de mesure à FFT peuvent combiner les deux méthodes, la scrutation par pas ainsi qu'une méthode d'amélioration de la résolution en fréquence.

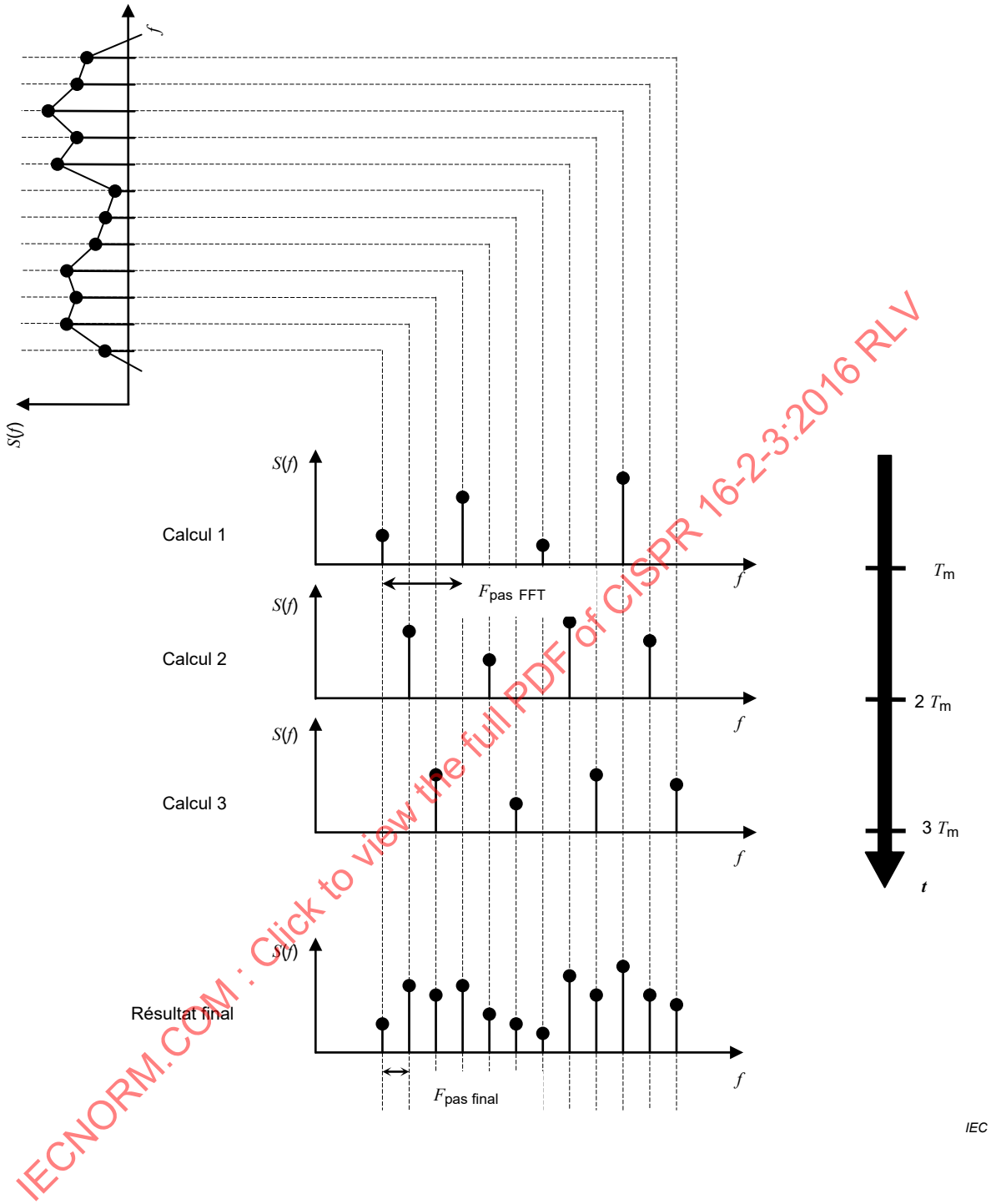
NOTE 2 Des informations contextuelles supplémentaires sur la définition du récepteur de mesure à FFT peuvent être consultées dans la CISPR TR 16-3 [3].

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Figure 5 – Scrutation par FFT en segments



IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Figure 6 – Résolution en fréquence améliorée au moyen d'un appareil de mesure à FFT

7 Mesurage des perturbations rayonnées

7.1 Remarques introductives

Le présent article établit les procédures générales de mesure de l'amplitude du champ de perturbation radioélectrique produit par des dispositifs et des systèmes. L'expérience en matière de mesurage de perturbations rayonnées est moins étendue que celle relative aux mesurages de la tension. Les procédures de mesure de perturbations rayonnées sont donc susceptibles de faire l'objet de révisions et d'extensions, à mesure de l'avancée des connaissances et de l'expérience. Une attention toute particulière doit être accordée à l'effet des conducteurs et des câbles associés à l'EUT. Le Tableau 3 fournit une liste récapitulative

des emplacements et des méthodes d'essai d'émissions rayonnées CISPR, ainsi que des références croisées associées aux paragraphes du présent document ou à d'autres documents.

Pour certains produits, des mesurages des composantes électriques, magnétiques, ou les deux, de la perturbation rayonnée peuvent être exigés. Parfois, il est plus approprié de mesurer une grandeur liée à la puissance rayonnée. Il convient normalement de mesurer à la fois les composantes verticale et horizontale de la perturbation, par rapport au plan de masse de référence. Les résultats de mesure des composantes électriques ou magnétiques peuvent être exprimés en valeurs de crête, de quasi-crête, moyennes ou efficaces.

La composante magnétique de la perturbation est normalement mesurée à des fréquences ne dépassant pas 30 MHz. Lors du mesurage du champ magnétique, seule la composante horizontale du champ à l'emplacement de l'antenne de réception est mesurée lorsque la procédure de l'antenne à distance est appliquée. Si le système d'antenne-cadre (LAS – loop antenna system) est utilisé, les trois moments magnétiques coulombiens orthogonaux de l'EUT sont mesurés. (Noter que dans la méthode à antenne unique, la composante horizontale du champ à l'emplacement de l'antenne est déterminée par les moments coulombiens horizontaux et verticaux de l'EUT, en raison du rôle joué par la réflexion).

Tableau 3 – Plages de fréquences applicables et références de documents pour les emplacements et les méthodes d'essai d'émissions rayonnées CISPR

Emplacement / méthode	9 kHz à 30 MHz	30 MHz à 1 000 MHz	1 GHz à 18 GHz
Emplacement en extérieur	tbd	7.3.8	n/a
LAS	7.2	n/a	n/a
OATS ou SAC	tbd	7.3	n/a
FAR	n/a	7.4	7.6
Méthode commune d'émission rayonnée/Immunité rayonnée	n/a	7.5 (Démarrage de l'immunité rayonnée à 80 MHz)	n/a
OATS à revêtement absorbant	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
Remplacement	n/a	7.8	7.8
Chambre réverbérante	n/a	7.9 (Démarrage à 80 MHz)	7.9
Guide d'onde TEM	IEC 61000-4-20	7.10	7.10
n/a = non applicable; tbd = à déterminer ou à l'étude			

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

7.2 Mesurages du système d'antenne-cadre (9 kHz à 30 MHz)

7.2.1 Généralités

Le système d'antenne-cadre (LAS) étudié dans le présent paragraphe est adapté au mesurage en intérieur de l'amplitude du champ magnétique émis par un seul EUT dans la plage de fréquences comprises entre 9 kHz et 30 MHz. L'amplitude du champ magnétique se mesure en termes de courants induits dans le LAS par le champ magnétique perturbateur de l'EUT. Le LAS doit être validé régulièrement en appliquant la méthode décrite dans la CISPR 16-1-4. La CISPR 16-1-4 fournit également une description complète du LAS et une relation entre les résultats de mesure obtenus avec le LAS et ceux obtenus conformément à la description du présent paragraphe.

7.2.2 Méthode générale de mesure

La Figure 7 présente le concept général sur lequel reposent les mesurages réalisés avec le LAS. L'EUT est installé au centre du LAS. Le courant induit par le champ magnétique de l'EUT dans chacune des trois grandes antennes-cadres du LAS est mesuré en connectant la sonde de courant de la grande antenne-cadre au récepteur de mesure (ou équivalent). Au cours des mesurages, l'EUT reste en position fixe.

Les courants dans les trois grandes antennes-cadres, issus des trois composantes de champ magnétique mutuellement orthogonales, sont mesurés en séquence. Chaque niveau de courant mesuré doit respecter la limite d'émission, exprimée en dB(μA), comme spécifié dans la norme de produit. La limite d'émission doit s'appliquer à un LAS comportant de grandes antennes-cadres de diamètre normalisé égal à 2 m.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

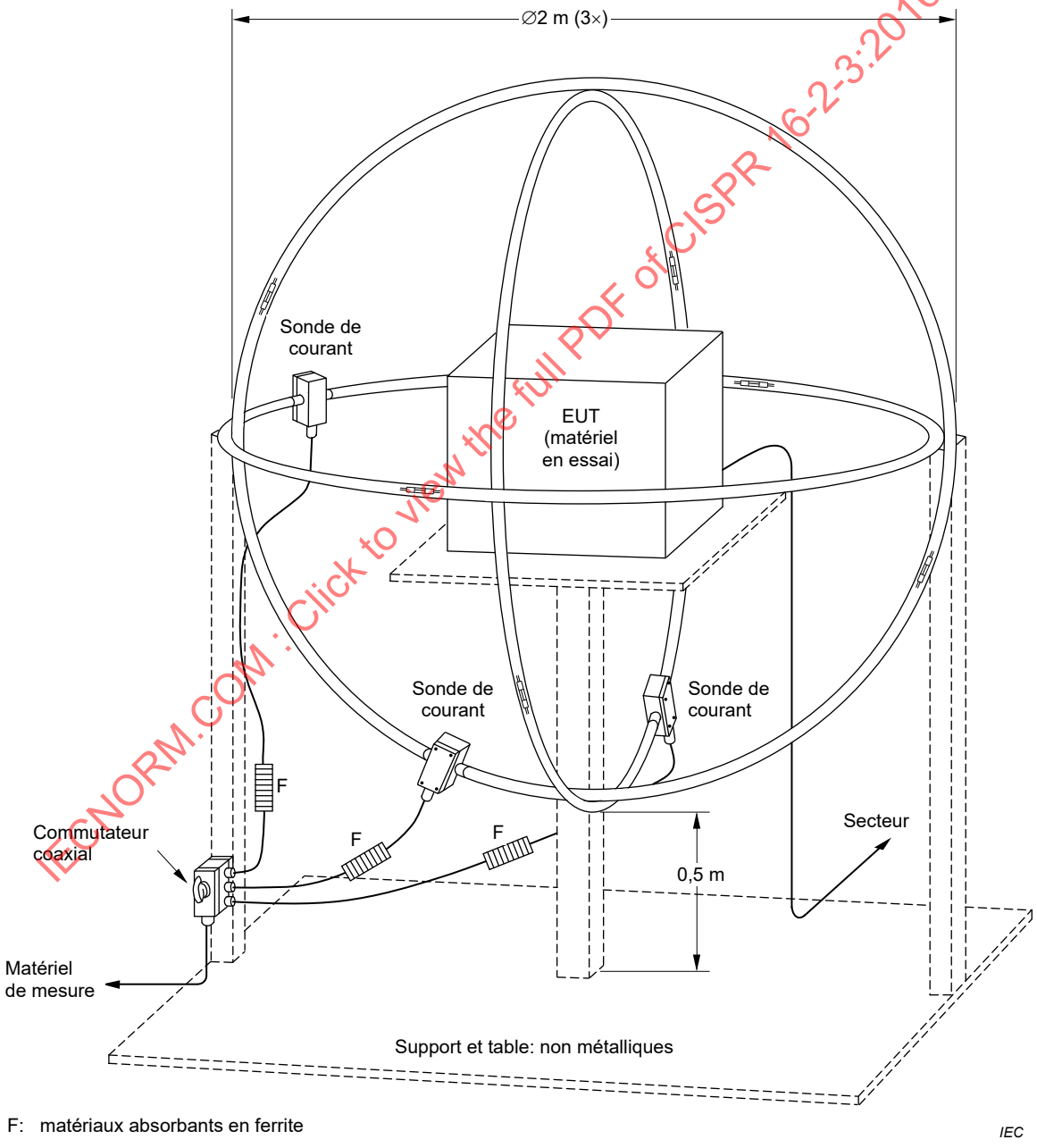


Figure 7 – Concept des mesurages des courants induits par un champ magnétique avec le système d'antenne-cadre

7.2.3 Environnement d'essai

La distance entre le périmètre extérieur du LAS et les objets environnants, tels que le sol et les murs, doit être au moins égale à 0,5 m. Les courants induits dans le LAS par un champ RF ambiant doivent être évalués conformément à la CISPR 16-1-4.

7.2.4 Configuration du matériel en essai

Afin d'éviter un couplage capacitif indésirable entre l'EUT et le LAS, les dimensions maximales de l'EUT doivent laisser une distance minimale de 0,20 m entre ce dernier et les grandes antennes-cadres de 2 m normalisées du LAS.

La position du cordon d'alimentation doit être optimisée pour permettre une induction maximale du courant. En général, cette position n'est pas critique lorsque l'EUT respecte la limite d'émission conduite.

Dans le cas d'un EUT de taille importante, le diamètre des antennes-cadres du LAS peut être augmenté jusqu'à 4 m. Dans ce cas:

a) les valeurs du courant mesurées doivent être corrigées conformément à l'Article B.6 de la CISPR 16-1-2; et

b) les dimensions maximales de l'EUT doivent laisser, entre l'EUT et les grands cadres, une distance minimale de $(0{,}1 \times D)$ m, D représentant le diamètre du cadre non normalisé.

7.2.5 Incertitude de mesure du système d'antenne-cadre

Les éléments généraux et fondamentaux à prendre en compte concernant les incertitudes de mesure des émissions sont mentionnés dans la CISPR 16-4-1.

7.3 Mesurages sur emplacement d'essai en espace libre (OATS) ou en chambre semi-anéchoïque (SAC) (30 MHz à 1 GHz)

7.3.1 Mesurande

La grandeur à mesurer est l'amplitude de champ électrique maximale émise par l'EUT en fonction de la polarisation horizontale et verticale et à des hauteurs comprises entre 1 m et 4 m, et avec une distance horizontale de 10 m par rapport à l'EUT, sur tous les angles dans le plan d'azimut. Cette grandeur doit être déterminée compte tenu des dispositions suivantes:

a) la plage de fréquences concernée est comprise entre 30 MHz et 1 000 MHz;

b) la grandeur doit être exprimée en termes d'unités d'amplitude de champ qui correspondent aux unités utilisées pour exprimer les niveaux limites relatifs à cette grandeur;

c) un emplacement de mesure et une table de positionnement propres au SAC/OATS et conformes aux exigences de validation CISPR applicables doivent être utilisés;

d) un récepteur de mesure conforme à la CISPR 16-1-1 doit être utilisé;

e) l'application de distances de mesure alternatives, telles que 3 m ou 30 m en lieu et place de 10 m, doit être considérée comme une méthode de mesure alternative;

f) la distance de mesure est la projection horizontale de la distance entre la limite de l'EUT et le point de référence de l'antenne par rapport au plan de masse;

g) la configuration et le fonctionnement de l'EUT sont conformes aux spécifications CISPR;

h) des facteurs d'antenne en espace libre doivent être utilisés.

Le mesurande E est déduit de la lecture de tension maximale V_{r} en utilisant le facteur d'antenne en espace libre F_{a}:

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

$$E = V_r + A_c + F_a \quad (7)$$

où

E est l'amplitude de champ exprimée en dB(μV/m) comme dans la description du mesurande;

V_r est la tension maximale de réception exprimée en dB(μV), en appliquant la procédure définie dans la description du mesurande;

A_c est la perte en dB du câble de mesure entre l'antenne et le récepteur;

F_a est le facteur d'antenne en espace libre de l'antenne de réception, exprimé en dB(m^{-1}).

Les facteurs d'antenne en espace libre sont utilisés comme facteur de qualité de l'antenne. Il convient de noter que l'amplitude du champ est mesurée au-dessus d'un plan de masse et non dans un environnement en espace libre.

Pour un mesurage de perturbation électromagnétique, l'amplitude du champ électrique est exigée à une distance donnée à partir de la limite de l'EUT. La distance d'essai est mesurée à partir du point de référence de l'antenne jusqu'à la limite de l'EUT (voir Figure 8). Dans le cas d'une différence entre le point de référence sur une antenne et le centre de phase, un facteur de correction peut être appliqué pour obtenir l'amplitude du champ à la distance d'essai.

NOTE 1 Voir aussi 7.5.2.2 et A.6.2 de la CISPR 16-1-6:2014 [2] concernant les corrections portant sur les résultats d'amplitude de champ pour les variations de centre de phase d'antenne.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

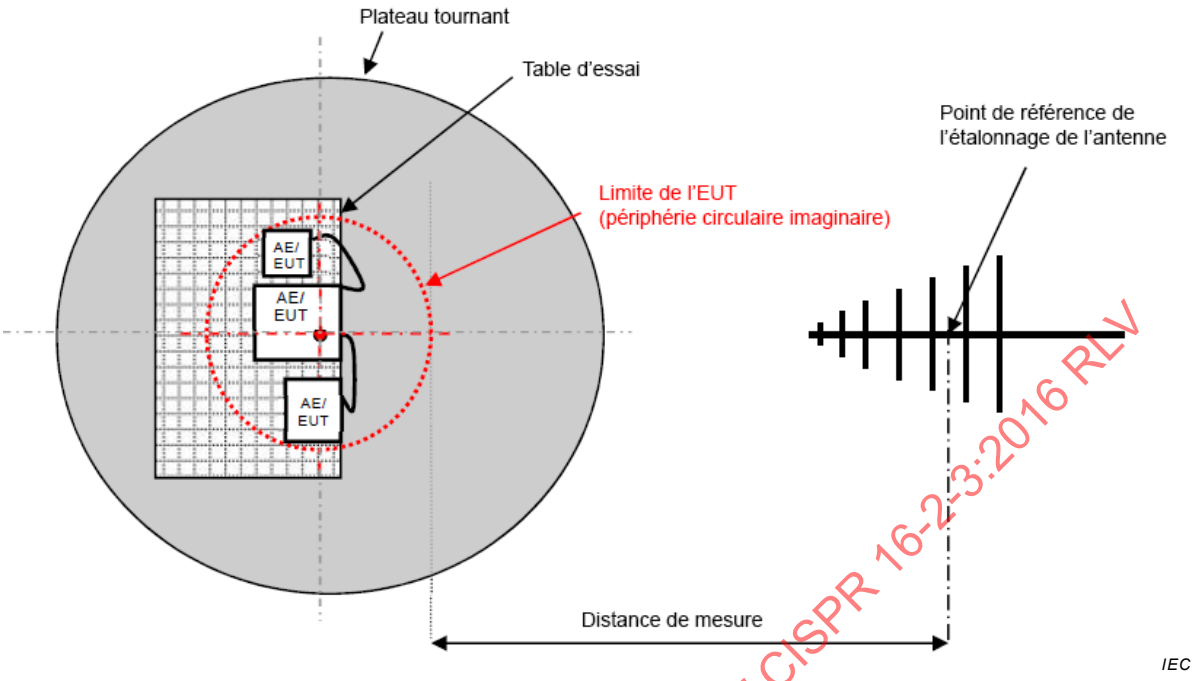


Figure 8 – Distance de mesure

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

À titre d'exemple, soit une antenne de réseau de dipôles log-périodiques (LPDA – log-periodic dipole array) type, présentant une séparation d'environ 0,6 m entre le doublet qui est sensible au champ à 200 MHz et le doublet qui est sensible à 1 000 MHz. Pour le mesurage de l'émission à une distance d = 3 m de l'EUT, à une fréquence de 200 MHz, l'amplitude du champ électrique est mesurée à une distance d'environ 3,3 m de P2 dans la Figure 9, selon la valeur de d_{phase} de l'Équation (11), où P2 est la limite de l'EUT.

Pour une fréquence donnée, la correction suivante, ΔE en dB, doit être ajoutée à l'amplitude du champ électrique mesurée:

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

Selon la Figure 9, la distance entre P2 et l'élément résonnant à une fréquence donnée est d_{phase}, indiquée par l'Équation (9). Le point P1 est la marque du fabricant ou le centre de l'antenne, $d_{1\text{P}}$ est la distance entre la terminaison de l'antenne et P1, et d_{1f} est la distance entre la terminaison de l'antenne et la position du centre de phase à la fréquence f.

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

où

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

l_f est la longueur de l'élément du doublet qui est résonnant nominalement à la fréquence f en MHz et égal à 0,9 × 150/f en m, où 0,9 est un facteur de raccourcissement général en raison du rayon fini du doublet [11];

l_{min} et l_{max} sont les longueurs des doublets présentant des longueurs minimales et maximales (c'est-à-dire que les doublets sont résonnants approximativement aux fréquences de fonctionnement supérieure et inférieure, respectivement);

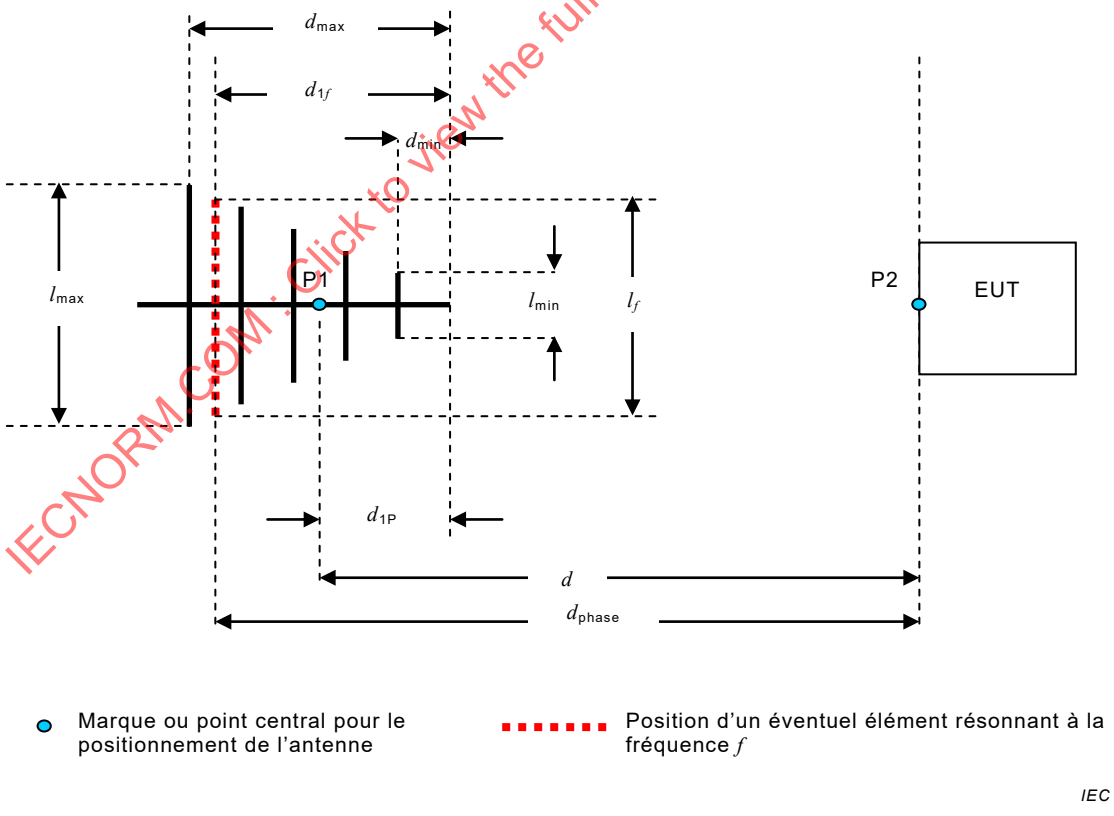
d_{min} et d_{max} sont les distances entre les doublets des longueurs minimale et maximale et la terminaison de l'antenne, respectivement.

Pour les antennes hybrides, la position du centre de phase d_{phase} est déterminée à l'aide des informations fournies par le fabricant de l'antenne. Dans le cas où les informations sont fournies sous forme de tableau, le fabricant de l'antenne doit fournir d_{1f} pour la plage de fréquences de 100 MHz à 300 MHz avec un pas de fréquence maximal de 20 MHz.

Il est pris pour hypothèse dans l'Équation (8) que le point du champ est dans le champ lointain de l'antenne. Dans une situation de champ proche, généralement pour moins d'une demi-longueur d'onde, la mesure pour A_{APR} (voir l'Équation (35) de la CISPR 16-1-4:2010/AMD1:2012) prend en compte les effets du champ proche. Pour de plus amples informations, y compris les corrections pour les sections de LPDA coniques des antennes hybrides, voir 7.5.2.2 de la CISPR 16-1-6:2014 [2]. L'interpolation linéaire est utilisée pour estimer la position de centre de phase pour les fréquences entre les fréquences de résonance des éléments aux extrémités de la plage de fréquences de fonctionnement.

Si une correction de centre de phase n'est pas appliquée, elle doit être prise en compte dans le budget d'incertitude de l'instrumentation de mesure, conformément à la CISPR 16-4-2.

NOTE 2 Le laboratoire d'étalonnage de l'antenne peut fournir la correction d'amplitude de champ électrique pour des distances de mesure spécifiques (par exemple 3 m et 10 m) par des corrections équivalentes du facteur d'antenne pour ces distances.



IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Figure 9 – Distance de séparation par rapport au centre de phase d'une antenne LPDA

7.3.2 Exigences relatives à l'emplacement d'essai

L'emplacement d'essai doit être conforme aux spécifications pertinentes de la CISPR 16-1-4 concernant ses propriétés physiques et électriques, ainsi que sa validation.

7.3.3 Méthode générale de mesure

La Figure 10 représente le concept des mesurages effectués sur un emplacement d'essai en espace libre (OATS) ou dans une chambre semi-anéchoïque (SAC) avec des rayons directs et réfléchis par le sol arrivant sur l'antenne de réception.

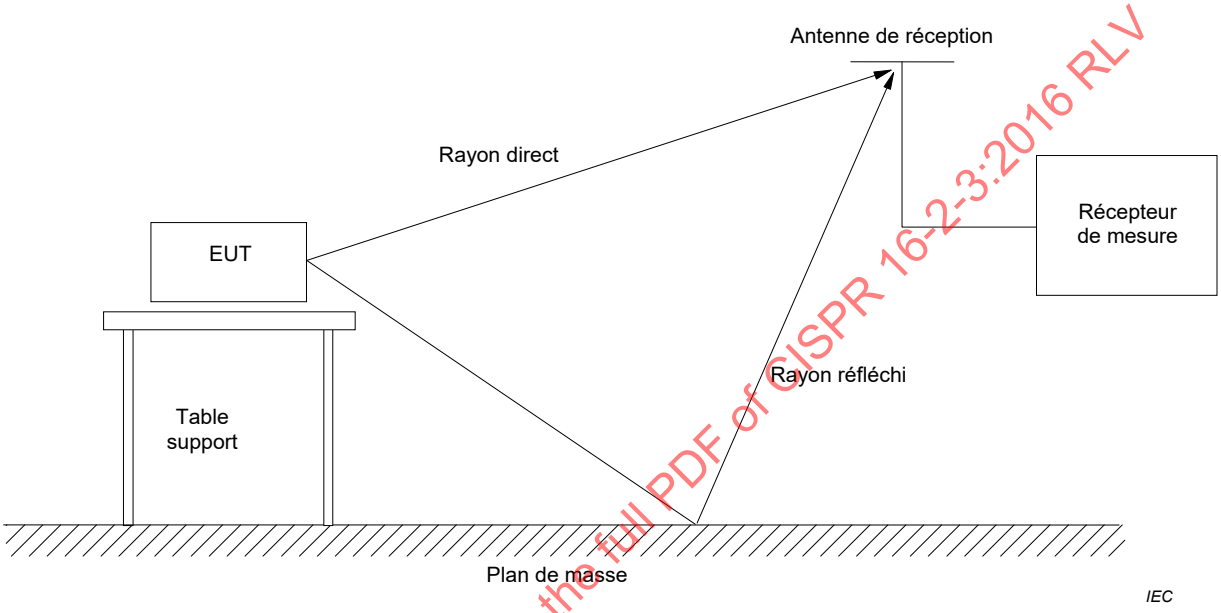


Figure 10 – Concept des mesurages de l'amplitude de champ électrique effectués sur un emplacement d'essai en espace libre (OATS) ou dans une chambre semi-anéchoïque (SAC) représentant les rayons directs et réfléchis arrivant sur l'antenne de réception

L'EUT est installé à une hauteur spécifiée au-dessus du plan de masse. Il est configuré pour représenter des conditions normales de fonctionnement. L'antenne est placée à la distance de séparation spécifiée. Une rotation de l'EUT est effectuée dans le plan horizontal et la lecture maximale est consignée. La hauteur de l'antenne est réglée de manière que les rayons directs et réfléchis soient en phase ou approximativement en phase. Les étapes de la procédure sont interchangeables et peuvent nécessiter d'être répétées afin de déterminer la perturbation maximale. Pour des raisons d'ordre pratique, la variation de la hauteur est limitée; une parfaite addition en phase peut, par conséquent, ne pas être atteinte.

7.3.4 Distance de mesure

Il convient de mesurer un EUT soumis à une limite de perturbation rayonnée à une distance spécifiée à cette distance, à moins d'une impossibilité due à la taille du matériel, etc. La distance de mesure est la longueur de la projection entre le point de l'EUT le plus proche de l'antenne et le point de référence d'étalonnage de l'antenne sur le plan de masse. Si le point de référence de l'antenne n'est pas spécifié dans le rapport d'étalonnage de cette dernière, le point de référence pour les antennes log-périodiques est un point situé le long de la perche horizontale de l'antenne, à mi-chemin entre les éléments de l'antenne doublet, qui correspondent à une demi-longueur d'onde à la fréquence centrale de la plage de fréquences des antennes.

NOTE La fréquence centrale est définie par: $\lg(f_{centre}) = (\lg f_{min} + \lg f_{max})/2$; $f_{centre} = 10^{\lg(f\,centre)}$

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Une distance de 10 m est préférable pour la plupart des emplacements en extérieur, dans la mesure où, à cette distance, le niveau attendu des perturbations mesurées est suffisamment supérieur au niveau général de bruit ambiant pour permettre une réalisation des essais qui soit efficace. Des distances inférieures à 3 m ou supérieures à 30 m ne sont généralement pas utilisées. Si une distance de mesure autre que la distance spécifiée est nécessaire, il convient d'extrapoler les résultats à l'aide des procédures spécifiées dans les normes de produits. Si aucune ligne directrice n'est donnée, une justification convenable pour l'extrapolation doit être fournie. En général, l'extrapolation ne suit pas une loi simple de fonction inverse de la distance.

Il convient, dans toute la mesure du possible, d'effectuer les mesurages en champ lointain. La région de champ lointain peut être définie par les conditions ci-dessous. La distance de mesure d est choisie de telle sorte que:

a) $d \geq \lambda/6$. À cette distance, $E/H = Z_0 = 120\ \pi = 377\ \Omega$, c'est-à-dire que les composantes d'amplitude de champs électrique et magnétique sont perpendiculaires les unes par rapport aux autres, et l'erreur de mesure est de l'ordre de 3 dB si l'EUT est considéré comme une antenne doublet accordée; ou

b) $d \geq \lambda$, condition pour une onde plane, pour laquelle l'erreur est de l'ordre de 0,5 dB si l'EUT est considéré comme une antenne doublet accordée; ou

c) $d \geq 2D^2 / \lambda$, où D est la plus grande dimension de l'EUT ou de l'antenne, qui détermine l'ouverture minimale pour l'illumination de l'EUT, qui s'applique aux cas dans lesquels $D >> \lambda$.

7.3.5 Variation de la hauteur d'antenne

Pour mesurer l'amplitude du champ électrique, la hauteur d'antenne doit varier au-dessus du plan de masse à l'intérieur d'une plage spécifiée afin d'obtenir une lecture maximale lorsque les rayons directs et réfléchis sont en phase. En règle générale, pour des distances de mesure inférieures ou égales à 10 m, la hauteur d'antenne, pour mesurer l'amplitude du champ électrique, doit varier entre 1 m et 4 m. À des distances supérieures jusqu'à 30 m, la hauteur doit varier de préférence entre 2 m et 6 m. Il peut s'avérer nécessaire d'ajuster la hauteur minimale de l'antenne au-dessus du sol à 1 m, afin de maximiser la lecture. Ces scrutations de la hauteur s'appliquent à la fois aux polarisations horizontale et verticale. Cependant, pour la polarisation verticale, la hauteur minimale doit être augmentée de sorte que le point le plus bas de l'antenne soit à au moins 25 cm de la surface au sol de l'emplacement d'essai.

7.3.6 Détails à fournir dans la spécification de produit

7.3.6.1 Généralités

Outre la spécification de la méthode de mesure détaillée et des paramètres de perturbation à mesurer, les normes de produits doivent inclure d'autres détails pertinents, exposés ci-dessous.

7.3.6.2 Environnement d'essai

L'influence de l'environnement d'essai doit être prise en compte afin d'assurer un fonctionnement correct de l'EUT. Les paramètres importants de l'environnement physique doivent être spécifiés, par exemple la température et l'humidité.

L'environnement électromagnétique nécessite une considération toute particulière afin d'assurer l'exactitude des mesurages de perturbation. Il convient que le bruit radioélectrique ambiant et les niveaux de signaux mesurés sur l'emplacement d'essai avec l'EUT hors tension soient au moins de 6 dB inférieurs à la limite. Il est admis que ceci n'est pas toujours réalisable à toutes les fréquences. Cependant, dans le cas où les niveaux mesurés des émissions de bruit radioélectrique ambiant plus celles de l'EUT ne sont pas supérieurs à la limite, l'EUT doit être considéré comme étant conforme à cette dernière. Pour des lignes

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

directrices supplémentaires concernant les niveaux de bruit ambiant et les erreurs de mesure résultantes, se reporter à 6.2.2 et à l'Annexe A.

Si le niveau d'amplitude du champ ambiant à des fréquences s'inscrivant dans les plages de mesure spécifiées, à la distance de mesure spécifiée, dépasse la ou les limites, les solutions suivantes peuvent être appliquées pour démontrer la conformité de l'EUT:

a) Effectuer les mesurages à une distance plus courte et extrapoler les résultats à la distance pour laquelle la limite est spécifiée. Extrapoler les résultats en utilisant l'une des méthodes suivantes:

   1) déterminer L_2 correspondant à la distance de fermeture d_2 en appliquant la relation $L_2 = L_1(d_1/d_2)$, où L_1 est la limite spécifiée en µV/m à la distance d_1;

      NOTE Cette méthode d'extrapolation peut seulement être utilisée lorsque les deux valeurs d_1 et d_2 se situent dans la zone du champ lointain de l'EUT à toutes les fréquences de mesure.

   2) utiliser la formule comme recommandé par la norme de produit;

   3) déterminer la limite L_2 à une distance d_2 en appliquant une formule d'extrapolation vérifiée par des mesurages à au moins trois distances différentes.

b) Dans les bandes de fréquences où les valeurs du bruit ambiant sont dépassées (valeurs mesurées supérieures à 6 dB au-dessous de la limite), les valeurs de perturbation de l'EUT peuvent être interpolées d'après les valeurs de perturbation adjacentes. La valeur obtenue par interpolation doit être sur la courbe représentant une fonction continue des valeurs de perturbation aux fréquences adjacentes au bruit ambiant.

c) Effectuer les mesurages dans les bandes de fréquences critiques pendant les heures où les stations de radiodiffusion n'émettent pas et où les conditions ambiantes dues aux matériels industriels sont plus faibles.

d) Comparer l'amplitude de la perturbation de l'EUT à la fréquence étudiée et l'amplitude de la perturbation sur des fréquences adjacentes, à l'intérieur d'une chambre blindée ou d'une chambre blindée à revêtement absorbant. L'amplitude de la perturbation du matériel en essai à la fréquence étudiée peut être estimée en mesurant l'amplitude de la perturbation de fréquence adjacente et en établissant une comparaison.

e) Lors de l'orientation de l'axe d'un emplacement d'essai en espace libre, il est souhaitable de considérer les directions des signaux ambiants forts pour que l'orientation de l'antenne de réception sur l'emplacement discrimine ces signaux, dans la mesure du possible.

f) Utiliser un appareil de mesure avec une bande plus étroite pour les perturbations à bande étroite de l'EUT proches d'un environnement électromagnétique RF, qui sont tous deux situés dans la largeur de bande normalisée.

7.3.6.3 Configuration du matériel en essai

Les conditions de fonctionnement et la configuration du matériel en essai (EUT) sont détaillées en 6.4.

Des dispositifs d'absorption en mode commun (CMAD – common-mode absorption device) de type à pinces ferrites sont utilisés pour réduire l'influence des câbles à l'extérieur du volume d'essai sur les résultats de mesure des perturbations rayonnées. Si des CMAD sont utilisés, le câble quittant le volume d'essai doit entrer dans le CMAD au point où il atteint le plan de masse, comme présenté à la Figure 11. Le CMAD doit toujours être placé à plat sur le plan de masse. La partie du câble située entre le point de sortie du CMAD et le point de sortie du plateau tournant doit être conservée aussi petite que possible. Chaque câble doit être traité avec un CMAD distinct. Les câbles de diamètres supérieurs aux ouvertures des câbles des CMAD disponibles dans le commerce ne doivent pas être traités avec des CMAD.

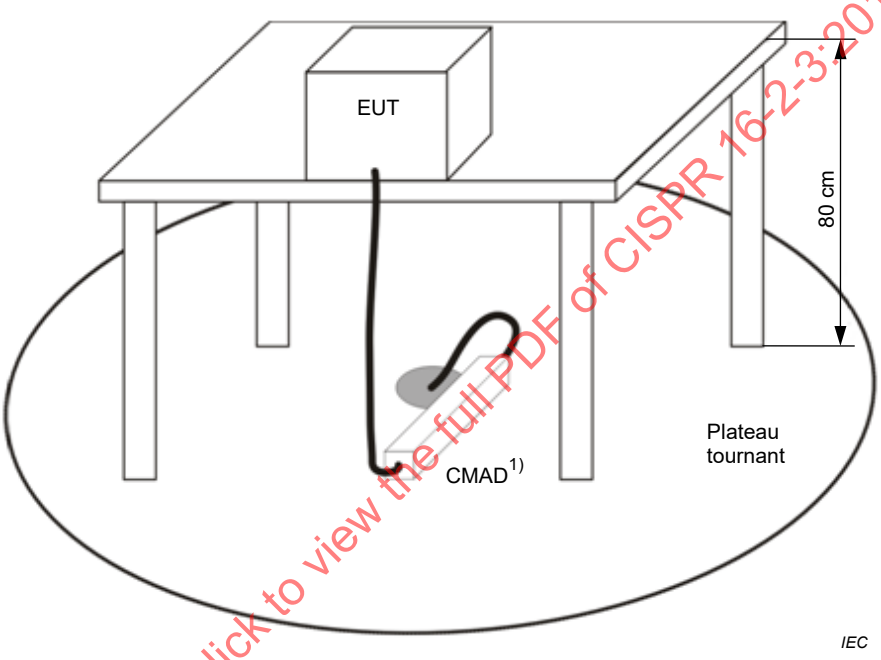
Pour éviter une saturation, il convient de ne pas traiter les câbles de puissance pour courants en mode commun élevés (par exemple le port de sortie d'inverseurs) avec des CMAD, sauf si ces CMAD sont conçus spécifiquement pour des courants en mode commun élevés.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

Pour des EUT comportant jusqu'à trois câbles quittant le volume d'essai, chaque câble doit être traité avec un CMAD pendant les mesurages des perturbations rayonnées. Cette exigence s'applique à n'importe quel type de câble (par exemple, des câbles de puissance, de télécommunication ou de commande). Pour une installation d'essai comportant plus de trois câbles quittant le volume d'essai, seuls les trois câbles sur lesquels l'émission la plus forte est prévue nécessitent d'être équipés de CMAD. Les câbles sur lesquels des CMAD ont été appliqués doivent figurer dans le rapport d'essai.

NOTE La limite du nombre de CMAD est examinée en [12]. Lors de la comparaison d'EUT de grande taille et de petite taille, ainsi que celle des EUT à un câble et à deux câbles, l'auteur en a conclu qu'un petit EUT comportant un seul câble quittant le volume d'essai constituait le cas le plus défavorable. L'étude de cet auteur a couvert l'application des CMAD aux matériels posés sur table comportant trois câbles ou moins.

Des informations générales sur le but et l'application des CMAD de type à ferrite figurent en 4.9.1 de la CISPR TR 16-3:2010 [3].



1) Les CMAD doivent être conformes aux spécifications applicables de la CISPR 16-1-4. Leur utilisation doit être documentée dans le rapport d'essai.

Figure 11 – Position d'un CMAD pour un matériel posé sur table sur un emplacement d'essai en espace libre (OATS) ou dans une chambre semi-anéchoïque (SAC)

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

7.3.7 Instrumentation de mesure

L'instrumentation de mesure, antennes comprises, doit être conforme aux exigences applicables de la CISPR 16-1-1 et de la CISPR 16-1-4.

7.3.8 Mesurages de l'amplitude de champ sur d'autres emplacements en extérieur

Les emplacements d'essai en extérieur similaires à l'emplacement d'essai en espace libre, mais sans plan de masse en métal peuvent être spécifiés pour certains produits, et ce, pour des raisons d'ordre pratique, par exemple les appareils ISM et les véhicules à moteur. Les dispositions de 7.3.4 à 7.3.7 doivent rester applicables.

7.3.9 Incertitude de mesure pour les OATS et les SAC

Les éléments généraux et fondamentaux à prendre en compte concernant les incertitudes de mesure des émissions sont mentionnés dans la CISPR 16-4-1. Les aspects liés à

l'incertitude, spécifiques aux mesurages des émissions rayonnées sur un OATS ou une SAC (30 MHz à 1 GHz), sont mentionnés dans la CISPR 16-4-2.

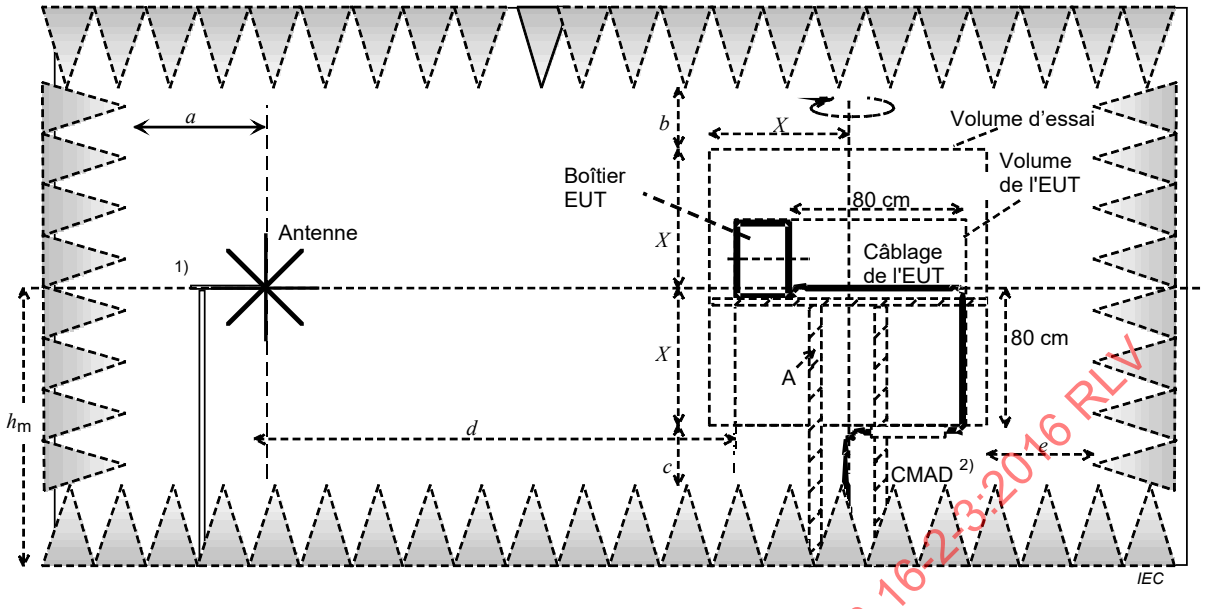
7.4 Mesurages en enceinte complètement anéchoïque (30 MHz à 1 GHz)

7.4.1 Installation d'essai et géométrie de l'emplacement

Le type d'antenne utilisé pour les essais d'émission de l'EUT doit être le même que celui de l'antenne de réception utilisée pour les essais de validation de l'enceinte complètement anéchoïque (FAR). La hauteur de l'antenne est fixée au milieu géométrique de la hauteur du volume d'essai. Les mesurages sont effectués avec les polarisations horizontale et verticale de l'antenne de réception. Il convient de mesurer l'émission pendant la rotation du plateau tournant dans au moins trois positions successives en azimut (0°, 45°, 90°) de l'EUT, lorsqu'une rotation continue n'est pas exigée. La Figure 12 présente la géométrie type d'une FAR, avec les dimensions correspondantes.

L'EUT doit être placé sur un plateau tournant. Les Figures 12, 13 et 14 expliquent les différentes dimensions à l'intérieur de la FAR. Le plateau tournant, le mât d'antenne et le plancher d'appui doivent être en place pendant la procédure de validation de l'emplacement, et sont constitués en grande partie de matériau transparent aux ondes électromagnétiques. Les distances a, b, c et e peuvent être limitées par les dimensions du volume d'essai. Le niveau du plan inférieur (hauteur de l'absorbeur plus c) est le niveau pour les matériels posés au sol (la hauteur de la palette de transport n'est pas comprise dans le volume d'essai).

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



Légende:

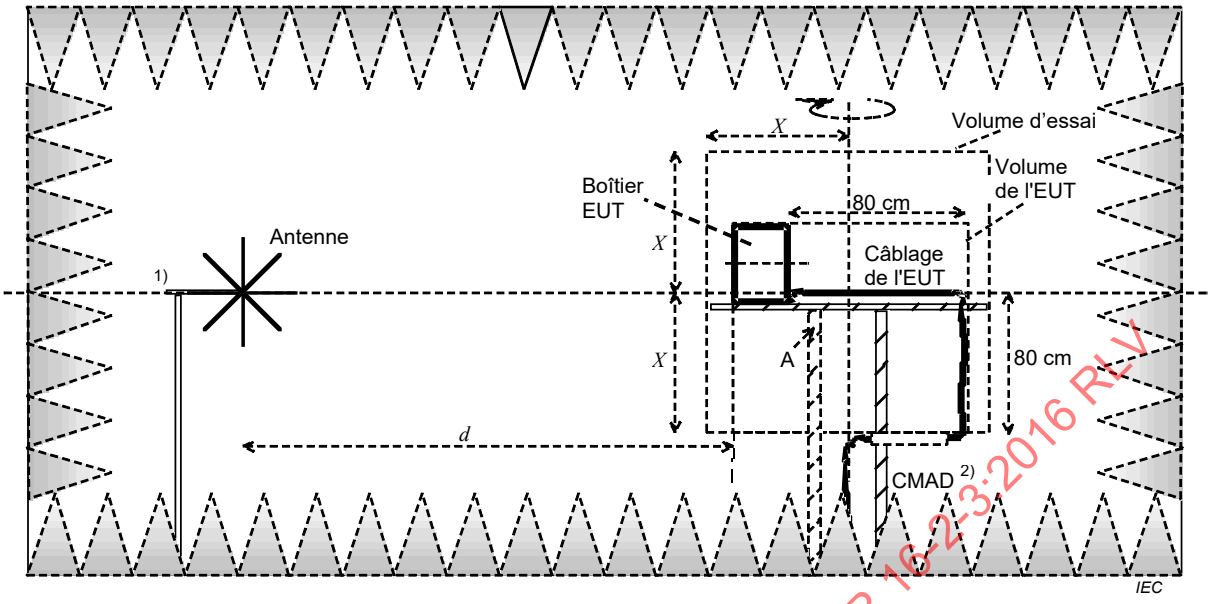
A	plateau tournant et fixation du support de l'EUT;
2X	1,5 m, 2,5 m, 5 m – correspond à la distance d'essai utilisée (3 m, 5 m ou 10 m, respectivement);
h_m	milieu du volume d'essai;
a, b, c, e	≥ 0,5 m recommandé (≥ 1 m est plus pratique), la valeur réelle est cohérente avec la procédure de validation de la FAR, définie dans la CISPR 16-1-4;
d	3 m, 5 m, ou 10 m.

1) Les dispositions de l'antenne et du câble doivent être validées ensemble et utilisées dans la même configuration pendant l'essai de l'EUT. L'antenne ainsi que le câble peuvent devoir être déplacés pour être conformes à la distance d'essai exigée au cours de l'essai de l'EUT.

2) Les CMAD doivent être conformes aux spécifications applicables de la CISPR 16-1-4. Leur utilisation doit être documentée dans le rapport d'essai.

Figure 12 – Géométrie type d'une enceinte complètement anéchoïque, où a, b, c, e dépendent des performances de l'enceinte

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



Légende:

A plateau tournant et fixation du support de l'EUT;

2X 1,5 m, 2,5 m, ou 5 m;

d 3 m, 5 m ou 10 m (pour une distance d'essai de 3 m, 5 m ou 10 m, respectivement).

1) La disposition du câble d'antenne doit être la même que pendant la procédure de validation de l'emplacement (voir Figure 12).

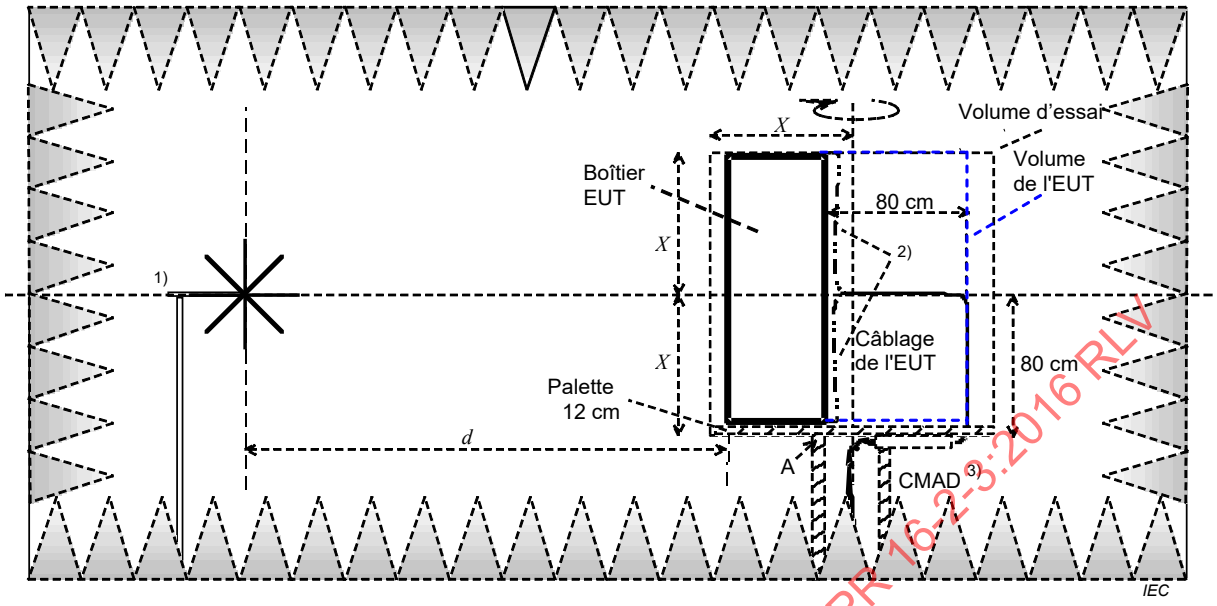
2) Les CMAD doivent être conformes aux spécifications applicables de la CISPR 16-1-4. Leur utilisation doit être documentée dans le rapport d'essai.

Figure 13 – Installation type d'essai pour un matériel posé sur table dans le volume d'essai d'une enceinte complètement anéchoïque

La distance d'essai est mesurée à partir du point de référence de l'antenne jusqu'à la limite de l'EUT. S'il existe une différence entre le point de référence sur une antenne et le centre de phase, un facteur de correction peut être appliqué pour obtenir l'amplitude du champ à la distance d'essai.

Pour une fréquence donnée, la correction ΔE en dB dans l'Équation (8) doit être ajoutée à l'amplitude du champ électrique mesurée afin de réduire son incertitude. La correction de l'amplitude du champ électrique est appliquée pour tenir compte de la correction du centre de phase des antennes LPDA et de la partie log-périodique des antennes hybrides.

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV



Légende:

A plateau tournant et fixation du support de l'EUT

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

d 3 m, 5 m ou 10 m pour une distance d'essai de 3 m, 5 m ou 10 m, respectivement

La palette de 12 cm (10 cm à 14 cm) est un compromis entre un plan de masse métallique et un plan de masse en bois.

1) La disposition du câble d'antenne doit être la même que pendant la procédure de validation (voir Figure 12).

2) La disposition des câbles dépend de la position de leurs prises de sortie et doit être proche de la surface du boîtier.

3) Les CMAD doivent être conformes aux spécifications applicables de la CISPR 16-1-4. Leur utilisation doit être documentée dans le rapport d'essai.

Figure 14 – Installation type d'essai pour un matériel posé au sol dans le volume d'essai d'une enceinte complètement anéchoïque

7.4.2 Position de l'EUT

La Figure 13 et la Figure 14 présentent respectivement les installations d'essai dans une FAR pour des EUT types posés sur table et posés au sol. L'EUT doit être configuré, installé, disposé et doit fonctionner d'une façon compatible avec ses applications types. L'ensemble de l'EUT doit être compris dans le volume d'essai. Le matériel associé, qui est exigé pour le bon fonctionnement de l'EUT sans toutefois en faire partie, doit être placé à l'extérieur de la chambre blindée.

Les câbles d'interface doivent être reliés à chaque type d'accès d'interface de l'EUT. Si l'EUT est constitué de dispositifs séparés, l'espacement entre les dispositifs doit être celui de la configuration normale, mais si possible de 10 cm. Les câbles d'interconnexion doivent être repliés en faisceau. Le faisceau doit avoir une longueur de 30 cm à 40 cm et doit être longitudinal au câble.

Pour améliorer la répétitivité de mesure, les lignes directrices suivantes doivent être prises en compte:

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV

a) L'EUT (y compris la disposition des câbles conformément à 7.4.3) doit être placé de sorte que son centre soit à la même hauteur que le centre du volume d'essai. Un support non conducteur de hauteur appropriée peut être utilisé dans ce but.

b) Lorsqu'il n'est pas physiquement possible de surélever un EUT de grande dimension jusqu'au centre du volume d'essai (Figure 12 et Figure 13), l'EUT peut rester sur une palette de transport non conductrice pendant l'essai (Figure 14). La hauteur de la palette doit être consignée dans le rapport d'essai.

Les spécifications d'installation pour certains matériels posés au sol exigent que l'unité soit installée et fixée directement sur un sol conducteur. Les éléments suivants s'appliquent aux essais des matériels posés au sol dans une FAR: si des résultats d'essai obtenus dans une FAR avec des matériels posés au sol destinés à être installés et fixés directement sur un sol conducteur révèlent une non-conformité avec une limite d'émission applicable aux emplacements d'essai dans une FAR, les émissions réelles peuvent être inférieures si l'EUT est mesuré sur un plan de masse qui simule mieux l'environnement de l'installation finale. Ceci est particulièrement vrai pour des émissions dont la fréquence est inférieure à 200 MHz, en polarisation horizontale et si la source d'émissions se situe en un point du matériel qui correspondrait à une hauteur au-dessus du sol de 0,4 m ou moins dans une installation type. Il est recommandé au lecteur de procéder à une investigation supplémentaire dans un environnement d'essai avec plan de masse (c'est-à-dire un emplacement d'essai en espace libre ou une chambre semi-anéchoïque) simulant mieux les conditions prévues pour l'installation finale du matériel, avant de déterminer une non-conformité sur la base de mesurages dans une FAR.

7.4.3 Disposition et terminaison des câbles

Dans les essais de CEM, la reproductibilité des résultats de mesure est souvent mauvaise à cause des différences de disposition et de terminaison des câbles, lorsqu'un même EUT est mesuré sur des emplacements d'essai différents. Les points suivants constituent des conditions générales pour l'installation d'essai afin de fournir une bonne reproductibilité (voir Figure 13 et Figure 14). De façon idéale, il convient que tous les rayonnements à mesurer proviennent du seul volume d'essai. Les câbles utilisés pendant l'essai doivent être conformes aux spécifications du fabricant. L'EUT peut utiliser des câbles sans terminaison si les câbles avec terminaisons ne sont pas disponibles. Les spécifications des câbles et des terminaisons utilisés pendant les essais doivent être clairement décrites dans le rapport d'essai.

a) Les câbles connectés à l'EUT et aux matériels auxiliaires ou à l'alimentation doivent comporter un trajet horizontal de 0,8 m et un trajet vertical de 0,8 m (sans aucun faisceau) à l'intérieur du volume d'essai (voir Figure 8 et Figure 14). Toute longueur de câble supérieure à 1,6 m, avec une tolérance relative de ±5 %, doit être acheminée à l'extérieur du volume d'essai.

b) Si le fabricant spécifie une longueur de câble inférieure à 1,6 m, alors, et dans toute la mesure du possible, le câble doit être orienté de telle sorte que la moitié de sa longueur soit horizontale et l'autre moitié verticale, dans le volume d'essai.

c) Les câbles qui ne sont pas utilisés pendant l'essai, par l'intermédiaire d'un matériel associé, doivent comporter une terminaison appropriée:

   1) les câbles coaxiaux (blindés) avec une terminaison coaxiale d'impédance correcte (50 Ω ou 75 Ω);

   2) les câbles blindés avec plus d'un conducteur intérieur doivent avoir des terminaisons en mode commun (entre phase et masse ou terre de référence) et en mode différentiel (entre phases), conformément aux spécifications du fabricant;

   3) les câbles non blindés doivent avoir des terminaisons en mode différentiel et en mode commun, conformément aux spécifications du fabricant.

d) Si l'EUT nécessite un matériel associé pour fonctionner correctement, une attention particulière doit être portée afin qu'aucune émission de ce matériel ne puisse influencer le mesurage de rayonnement. Le matériel associé doit être placé dans toute la mesure du

IECNORM.COM : Click to view the full PDF of CISPR 16-2-3:2016 RLV