

BS EN 55016-2-3:2010+A2:2014

Incorporating corrigendum September 2013



BSI Standards Publication

Specification for radio disturbance and immunity measuring apparatus and methods

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

bsi.

...making excellence a habit.
AVA Documents™
Document Sharing Hub

National foreword

This British Standard is the UK implementation of EN 55016-2-3:2010+A2:2014. It is identical to CISPR 16-2-3:2010, incorporating amendments 1:2010 and 2:2014. It supersedes BS EN 55016-2-3:2010+A1:2010, which will be withdrawn on 18 April 2017.

BSI as a member of CENELEC, is obliged to publish the second amendment to EN 55016-2-3:2010+A2 as a British Standard. However, attention is drawn to the fact that during the development of this European Standard, the UK committee voted against its approval as a European Standard. The concern in amendment 2 clause 7.3.6.3 is that it does not provide a representative simulation of mains cabling. The UK will continue to work to improve this standard and its application to dependent standards.

Technical justification was presented at the Tokyo EMC conference in May 2014 in the paper: *"Measurement Method, Uncertainty and Cable Balance - with Implications for the CDNE-M"* by D M Lauder & R C Marshall, Paper 14A-A3, 2014 International Symposium on Electromagnetic Compatibility, May 12-16 2014, Tokyo, Japan. This academic paper is available from the British Library.

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

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

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

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© The British Standards Institution 2014.

Published by BSI Standards Limited 2014

ISBN 978 0 580 75017 5

ICS 33.100.10; 33.100.20

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 May 2011.

Amendments/corrigenda issued since publication

Date	Text affected
30 June 2011	Implementation of CISPR Amendment 1:2010 with CENELEC endorsement A1:2010
30 September 2013	Supersession information removed from EN title page
30 September 2014	Implementation of CISPR amendment 2:2014 with CENELEC endorsement A2:2014

**Specification for radio disturbance and immunity measuring apparatus
and methods -**

**Part 2-3: Methods of measurement of disturbances and immunity -
Radiated disturbance measurements
(CISPR 16-2-3:2010)**

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 -
Mesures des perturbations rayonnées
(CISPR 16-2-3:2010)

Anforderungen an Geräte
und Einrichtungen sowie Festlegung
der Verfahren zur Messung
der hochfrequenten Störaussendung
(Funkstörungen) und Störfestigkeit -
Teil 2-3: Verfahren zur Messung
der hochfrequenten Störaussendung
(Funkstörungen) und Störfestigkeit -
Messung der gestrahlten Störaussendung
(CISPR 16-2-3:2010)

This European Standard was approved by CENELEC on 2010-06-01. CENELEC members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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

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

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

CENELEC

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

Management Centre: Avenue Marnix 17, B - 1000 Brussels

Foreword

The text of document CISPR/A/886/FDIS, future edition 3 of CISPR 16-2-3, prepared by CISPR SC A, Radio-interference measurements and statistical methods, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 55016-2-3 on 2010-06-01.

This European Standard supersedes EN 55016-2-3:2006.

This EN 55016-2-3:2010 includes the following significant technical changes with respect to EN 55016-2-3:2006: addition of the measurand for radiated emissions measurements in an OATS and a SAC in the range of 30 MHz to 1 000 MHz, and addition of a new normative annex on the determination of suitability of spectrum analysers for compliance tests. Also, numerous maintenance items are addressed to make the standard current with respect to other parts of the EN 55016 series.

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

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

The following dates were fixed:

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

Annex ZA has been added by CENELEC.

Endorsement notice

The text of the International Standard CISPR 16-2-3:2010 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

- | | |
|------------------------|--|
| [1] CISPR 11:2009 | NOTE Harmonized as EN 55011:2009 (modified). |
| [3] CISPR 22:2008 | NOTE Harmonized as EN 55022:200X ¹⁾ (modified). |
| [4] IEC 61140:2001 | NOTE Harmonized as EN 61140:2002 (not modified). |
| [6] ISO/IEC 17000:2004 | NOTE Harmonized as EN ISO/IEC 17000:2004 (not modified). |
| [7] IEC 61000-4-21 | NOTE Harmonized as EN 61000-4-21. |

Foreword to amendment A1

The text of document CISPR/A/878/CDV, future amendment 1 to CISPR 16-2-3:2010, prepared by CISPR SC A, Radio-interference measurements and statistical methods, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as amendment A1 to EN 55016-2-3:2010 on 2010-10-01.

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

The following dates were fixed:

- latest date by which the amendment has to be
implemented at national level by publication of
an identical national standard or by endorsement (dop) 2011-07-01
- latest date by which the national standards conflicting
with the amendment have to be withdrawn (dow) 2013-10-01

Endorsement notice

The text of amendment 1:2010 to the International Standard IEC 55016-2-3:2010 was approved by CENELEC as an amendment to the European Standard without any modification.

¹⁾ At draft stage.

Foreword to amendment A2

The text of document CISPR/A/1054/FDIS, future amendment 2 to edition 3 of CISPR 16-2-3, prepared by SC A "Radio-interference measurements and statistical methods" of IEC/TC CISPR "International special committee on radio interference" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 55016-2-3:2010/A2:2014.

The following dates are fixed:

- latest date by which the document has (dop) 2015-01-18
to be implemented at national level by
publication of an identical national
standard or by endorsement
- latest date by which the national (dow) 2017-04-18
standards conflicting with the
document have to be withdrawn

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

Endorsement notice

The text of the International Standard CISPR 16-2-3:2010/A2:2014 was approved by CENELEC as a European Standard without any modification.

This page deliberately set blank

Annex ZA (normative)

Normative references to international publications with their corresponding European publications

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

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

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
CISPR 14-1	2005	Electromagnetic compatibility - Requirements for household appliances, electric tools and similar apparatus - Part 1: Emission	EN 55014-1	2006
CISPR 16-1-1	-	Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-1: Radio disturbance and immunity measuring apparatus - Measuring apparatus	EN 55016-1-1	-
CISPR 16-1-2	2003	Specification for radio disturbance and immunity measuring apparatus and methods - Part 1-2: Radio disturbance and immunity measuring apparatus - Ancillary equipment - Conducted disturbances	EN 55016-1-2	2004
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	EN 55016-1-4	2010
CISPR 16-2-1	2008	Specification for radio disturbance and immunity measuring apparatus and methods - Part 2-1: Methods of measurement of disturbances and immunity - Conducted disturbance measurements	EN 55016-2-1	2009
CISPR 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 - Uncertainty in EMC measurements	EN 55016-4-2	-
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	-	-

<u>Publication</u>	<u>Year</u>	<u>Title</u>	<u>EN/HD</u>	<u>Year</u>
IEC 60050-161	1990	International Electrotechnical Vocabulary (IEV) - 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	EN 61000-4-3	2006
IEC 61000-4-20	-	Electromagnetic compatibility (EMC) - Part 4-20: Testing and measurement techniques - Emission and immunity testing in transverse electromagnetic (TEM) waveguides	EN 61000-4-20	-

CONTENTS

1	Scope	10
2	Normative references	10
3	A2 Terms, definitions and abbreviations A2	11
4	Types of disturbance to be measured	16
4.1	General	16
4.2	Types of disturbance	16
4.3	Detector functions	17
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	A2 EUT arrangement and measurement conditions A2	18
6.4.1	A2 General arrangement of the EUT A2	18
6.4.2	A2 Operation of the EUT A2	21
6.4.3	A2 EUT time of operation A2	21
6.4.4	A2 EUT running-in time A2	21
6.4.5	A2 EUT supply A2	21
6.4.6	A2 EUT mode of operation A2	21
A2 6.4.7	Operation of multifunction equipment	21
6.4.8	Determination of arrangement(s) causing maximum emissions	22
6.4.9	Recording of measurements	22 A2
6.5	Interpretation of measuring results	22
6.5.1	Continuous disturbance	22
6.5.2	Discontinuous disturbance	23
A2 6.5.3	Measurement of the duration of disturbance	23 A2
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	26
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
7.2.3	Test environment	34
7.2.4	Configuration of the equipment under test	34
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	36
7.3.3	General measurement method	36
7.3.4	Measurement distance	37
7.3.5	Antenna height variation	37
7.3.6	Product specification details	37
7.3.7	Measurement instrumentation	39
7.3.8	Field-strength measurements on other outdoor sites	39
7.3.9	Measurement uncertainty for OATS and SAC	39
7.4	Fully-anechoic room measurements (30 MHz to 1 GHz)	40
7.4.1	Test set-up and site geometry	40
7.4.2	EUT position	42
7.4.3	Cable layout and termination	43
7.4.4	Measurement uncertainty for FAR	44
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	44
7.5.1	Applicability	44
7.5.2	EUT perimeter definition and antenna-to-EUT separation distance	45
7.5.3	Uniform test volume	45
7.5.4	Specifications for EUT set-up in common emissions/immunity test setup	46
7.5.5	Measurement uncertainty for common emission/immunity set-up and method	51
7.6	Fully-anechoic room and absorber-lined OATS/SAC measurements (1 GHz to 18 GHz)	51
7.6.1	Quantity to measure	51
7.6.2	Measurement distance	51
7.6.3	Set-up and operating conditions of the equipment under test (EUT)	51
7.6.4	Measurement site	52
7.6.5	Measurement instrumentation	52
7.6.6	Measurement procedure	52
7.6.7	Measurement uncertainty for FAR	60
7.7	<i>In situ</i> measurements (9 kHz to 18 GHz)	60
7.7.1	Applicability of and preparation for <i>in situ</i> measurements	60
7.7.2	Field-strength measurements <i>in situ</i> in the frequency range 9 kHz to 30 MHz	61
7.7.3	Field-strength measurements <i>in situ</i> in the frequency range above 30 MHz	62
7.7.4	<i>In situ</i> measurement of the disturbance effective radiated power using the substitution method	63
7.7.5	Documentation of the measurement results	67
7.7.6	Measurement uncertainty for <i>in situ</i> method	67
7.8	Substitution measurements (30 MHz to 18 GHz)	67
7.8.1	General	67
7.8.2	Test site	67
7.8.3	Test antennas	68
7.8.4	EUT configuration	68
7.8.5	Test procedure	68
7.8.6	Measurement uncertainty for substitution method	69
7.9	Reverberation chamber measurements (80 MHz to 18 GHz)	69
7.10	TEM waveguide measurements (30 MHz to 18 GHz)	69
8	Automated measurement of emissions	69

8.1	Introduction – precautions for automated measurements	69
8.2	Generic measurement procedure.....	70
8.3	Pre-scan measurements.....	70
8.3.1	General	70
8.3.2	Determination of the required measurement time.....	70
8.3.3	Pre-scan requirements for different types of measurements	71
8.4	Data reduction.....	72
8.5	Emission maximization and final measurement.....	73
8.6	Post-processing and reporting.....	74
	Annex A (informative) Measurement of disturbances in the presence of ambient emissions	75
	Annex B (informative) Use of spectrum analyzers and scanning receivers	89
	Annex C (informative) Scan rates and measurement times for use with the average detector	92
	Annex D (informative) Explanation of APD measurement method applying to the compliance test.....	96
	Annex E (normative) Determination of suitability of spectrum analyzers for compliance tests	98
	Bibliography.....	99
	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 – Concept of magnetic field induced current measurements made with the loop antenna system.....	34
	Figure 6 – 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	36
	Figure 7 – Typical FAR site geometry, where a , b , c , e depend upon the room performance	40
	Figure 8 – Typical test set-up for table-top equipment within the test volume of a FAR	41
	Figure 9 – Typical test set-up for floor-standing equipment within the test volume of a FAR	42
	Figure 10 – Positions of reference planes for uniform field calibration (top-view)	45
	Figure 11 – Test set-up for table-top equipment.....	49
	Figure 12 – Test set-up for table-top equipment – Top view.....	49
	Figure 13 – Test set-up for floor-standing equipment	50
	Figure 14 – Test set-up for floor-standing equipment – Top view	50
	Figure 15 – Measurement method above 1 GHz, receive antenna in vertical polarization.....	53
	Figure 16 – Illustration of height scan requirements for two different categories of EUTs	55
	Figure 17 – Determination of the transition distance	66
	Figure 18 – Substitution method set-up geometries for: a) measurement, b) calibration	68
	Figure 19 – Process to give reduction of measurement time	70
	Figure 20 – FFT scan in segments.....	31
	Figure 21 – Frequency resolution enhanced by FFT-based measuring instrument.....	32
■ A2	Figure 22 – Position of CMAD for table-top equipment on OATS or in SAC.....	39

Figure A.1 – Flow diagram for the selection of bandwidths and detectors and the estimated measurement errors due to that selection	77
Figure A.2 – Relative difference in adjacent emission amplitudes during preliminary testing	79
Figure A.3 – Disturbance by an unmodulated signal (dotted line)	80
Figure A.4 – Disturbance by an amplitude-modulated signal (dotted line)	80
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	81
Figure A.6 – Indication of a pulse-modulated signal (pulse width 50 μ s) as a function of pulse repetition frequency with peak, QP and average detectors	82
Figure A.7 – Disturbance by a broadband signal (dotted line)	82
Figure A.8 – Unmodulated EUT disturbance (dotted line)	83
Figure A.9 – Amplitude-modulated EUT disturbance (dotted line)	84
Figure A.10 – Increase of peak value with superposition of two unmodulated signals	85
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)]	86
Figure A.12 – Increase of average indication measured with a real receiver and calculated from Equation (A.8)	87
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	94
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	94
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	95
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	95
Figure D.1 – Example of APD measurement Method 1 for fluctuating disturbances	96
Figure D.2 – Example of APD measurement Method 2 for fluctuating disturbances	97
Table 1 – Minimum scan times for the three CISPR bands with peak and quasi-peak detectors	24
Table 2 – Applicable frequency ranges and document references for CISPR radiated emission test sites and test methods	33
Table 3 – Minimum dimension of w ($w_{\min}$)	54
Table 4 – Example values of w for three antenna types	55
Table 5 – Horizontal polarization correction factors as a function of frequency	65
Table 6 – Recommended antenna heights to guarantee signal interception (for pre-scan) in the frequency range 30 MHz to 1 000 MHz	72
Table 7 – Minimum measurement times for the four CISPR bands	24
Table A.1 – Combinations of EUT disturbance and ambient emissions	76
Table A.2 – Measurement error depending on the detector type and on the combination of ambient and disturbing signal spectra	88
Table C.1 – Pulse suppression factors and scan rates for a 100 Hz video bandwidth	93
Table C.2 – Meter time constants and the corresponding video bandwidths and maximum scan rates	93
Table E.1 – Maximum amplitude difference between peak and quasi-peak detected signals	98

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

CISPR 14-1:2005, *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, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-2: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Conducted disturbances*
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 – Radiated disturbances*

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

CISPR 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 – Uncertainty in EMC measurements*

CISPR 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 (IEV) – 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*

Amendment 1 (2007)

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

3 Terms, definitions and abbreviations

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

3.1

absorber-lined OATS/SAC

OATS or SAC with ground plane partially covered by RF-energy absorbing material

3.2

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

3.3

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

3.4

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. It may be expressed for the *H* plane or for the *E* plane of the antenna

NOTE Antenna beamwidth is expressed in degrees.

3.5

associated equipment

AE

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

3.6

auxiliary equipment

AuxEq

peripheral equipment that is part of the system under test

3.7

basic standard

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

NOTE A basic standard may function as a standard for direct application or as a basis for other standards.
[ISO/IEC Guide 2, definition 5.1]

3.8

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

3.9

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

[CISPR 16-1-4, 3.1.4]

3.10

conformity assessment

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

NOTE The subject field of conformity assessment includes activities defined elsewhere in ISO/IEC 17000:2004, such as testing, inspection and certification, as well as the accreditation of conformity assessment bodies.

[ISO/IEC 17000:2004, 2.1, modified]

3.11

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

[IEC 60050-161:1990, 161-02-11, modified]

3.12

(electromagnetic) emission

phenomenon by that electromagnetic energy emanates from a source

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

3.13

emission limit (from a disturbing source)

specified maximum emission level of a source of electromagnetic disturbance

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

3.14

equipment-under-test

EUT

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

3.15

fully-anechoic room

FAR

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

3.16

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

3.17

measurement, scan and sweep times

3.17.1

measurement time

T_m
effective, coherent time for a measurement result at a single frequency (in some areas also called dwell time)

- 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

3.17.2

scan

continuous or stepped frequency variation over a given frequency span

3.17.3

span

Δf

difference between stop and start frequencies of a sweep or scan

3.17.4

sweep

continuous frequency variation over a given frequency span

3.17.5

sweep or scan rate

frequency span divided by the sweep or scan time

3.17.6

sweep or scan time

T_s

time between start and stop frequencies of a sweep or scan

3.17.7

observation time

T_o

sum of measurement times T_m on a certain frequency in case of multiple sweeps; if n is the number of sweeps or scans, then $T_o = n \times T_m$

3.17.8

total observation time

T_{tot}

effective time for an overview of the spectrum (either single or multiple sweeps); if c is the number of channels within a scan or sweep, then $T_{tot} = c \times n \times T_m$

3.18

measuring receiver

A1 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 **A1**

3.19

number of sweeps per time unit (e.g. per second)

n_s

reciprocal of the sum of sweep time and retrace time, i.e. $1 / (\text{sweep time} + \text{retrace time})$

3.20

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.

3.21

product standard

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

NOTE 1 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 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.

[ISO/IEC Guide 2, definition 5.4]

3.22

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 electromagnetic energy in the frequency range of interest, and the bottom horizontal surface is a conducting ground plane for use with OATS test set

3.23

test configuration

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

3.24

weighting (of e.g. impulsive disturbance)

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 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 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

3.24.1

weighted disturbance measurement

measurement of disturbance using a weighting detector

3.24.2

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

3.24.3

weighting detector

detector that provides an agreed weighting function

3.24.4

weighting factor

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

NOTE Weighting factor is expressed in dB.

3.24.5

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



3.25

measurement

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

[2.1 of ISO/IEC Guide 99:2007][8]¹

3.26

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 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.

[IEC 60050-151:2001, 151-16-13][9]



3.27

highest internal frequency

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

3.28

module

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

3.29 Abbreviations²

The following abbreviations, not already provided in 3.1 through 3.28, 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



¹ Figures in square brackets refer to the Bibliography.



² At the next maintenance, when a new edition is published, terms and definitions will be placed in a new subclause 3.1 and renumbered, and abbreviations will be re-located to a new subclause 3.2.

 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 

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 psychophysical¹ 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.

¹ Psychophysical means psychological relationship between physical stimuli and sensory response.

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 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;

A1 Text deleted **A1**

6.2 Disturbance not produced by the equipment under test

6.2.1 General

A1 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. **A1**

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 required ambient level may be determined by measuring the ambient noise level with the test unit in place but not operating.

A2 When evaluating compliance with a limit, **A2** 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. **A2** Further guidance on measurement of disturbances in the presence of ambient emissions is provided in Annex A. **A2**

A2 Text deleted **A2**

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 the level of which 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 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 **A2** EUT arrangement and measurement conditions **A2**

The EUT shall be operated under the following conditions:

A2 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. **A2**

A2 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.

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). **A2**

A2 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. ^{A2}

A2 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.

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. **A2**

A2 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. **A2**

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 4.2 of CISPR 14-1).
- 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.

A1 6.5.3 Measurement of the duration of disturbance

The duration of a disturbance must 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. A1

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

A2 The minimum measurement (dwell) times are given in Table 7. From Table 7, the minimum scan times for measurements over a complete CISPR band have been derived in Table 1. These minimum measurement (dwell) times for scanning receivers and FFT-based measuring instruments in Table 7 and the scan times for spectrum analyzers in Table 1 apply to CW signals.

In addition, the test report shall include the value of the measurement instrumentation uncertainty corresponding to the used test setup, calculated as per the requirements of CISPR 16-4-2. A2

Table 7 – 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

A1

Table 1 – 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

A2 *Text deleted* **A2** 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 must 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:

$$T_{s \min} = k \times \frac{\Delta f}{B_{\text{res}}^2} \quad (1)$$

where

- $T_{s \min}$ 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:

$$T_{s \min} = k \times \frac{\Delta f}{B_{\text{res}} B_{\text{video}}} \quad (2)$$

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

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

where $T_{m \min}$ 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.

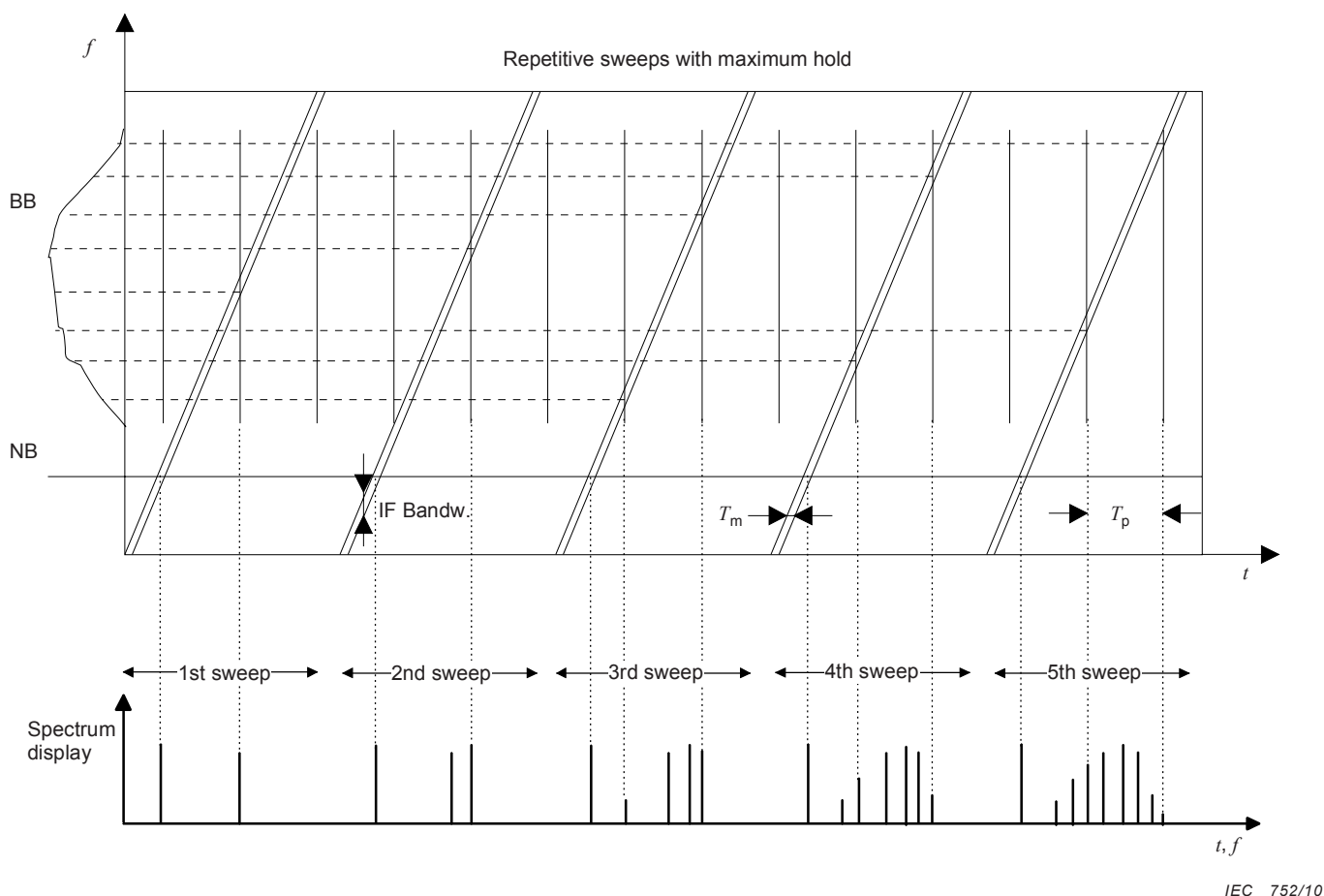
For purely broadband emissions, the frequency step size may be increased. In this case, the objective is to find the maxima of the emission spectrum only.

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 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.

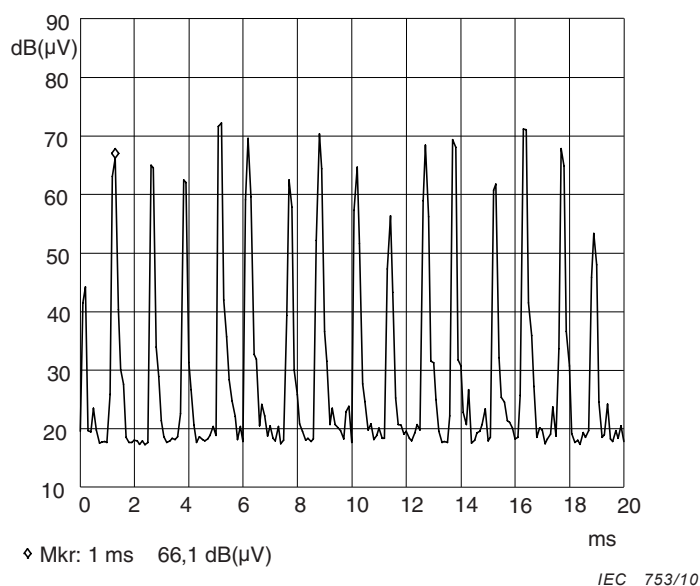


T_0 is the pulse-repetition interval of the impulsive signal. A pulse occurs at each vertical line of the spectrum-vs.-time display (upper part of the figure).

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.

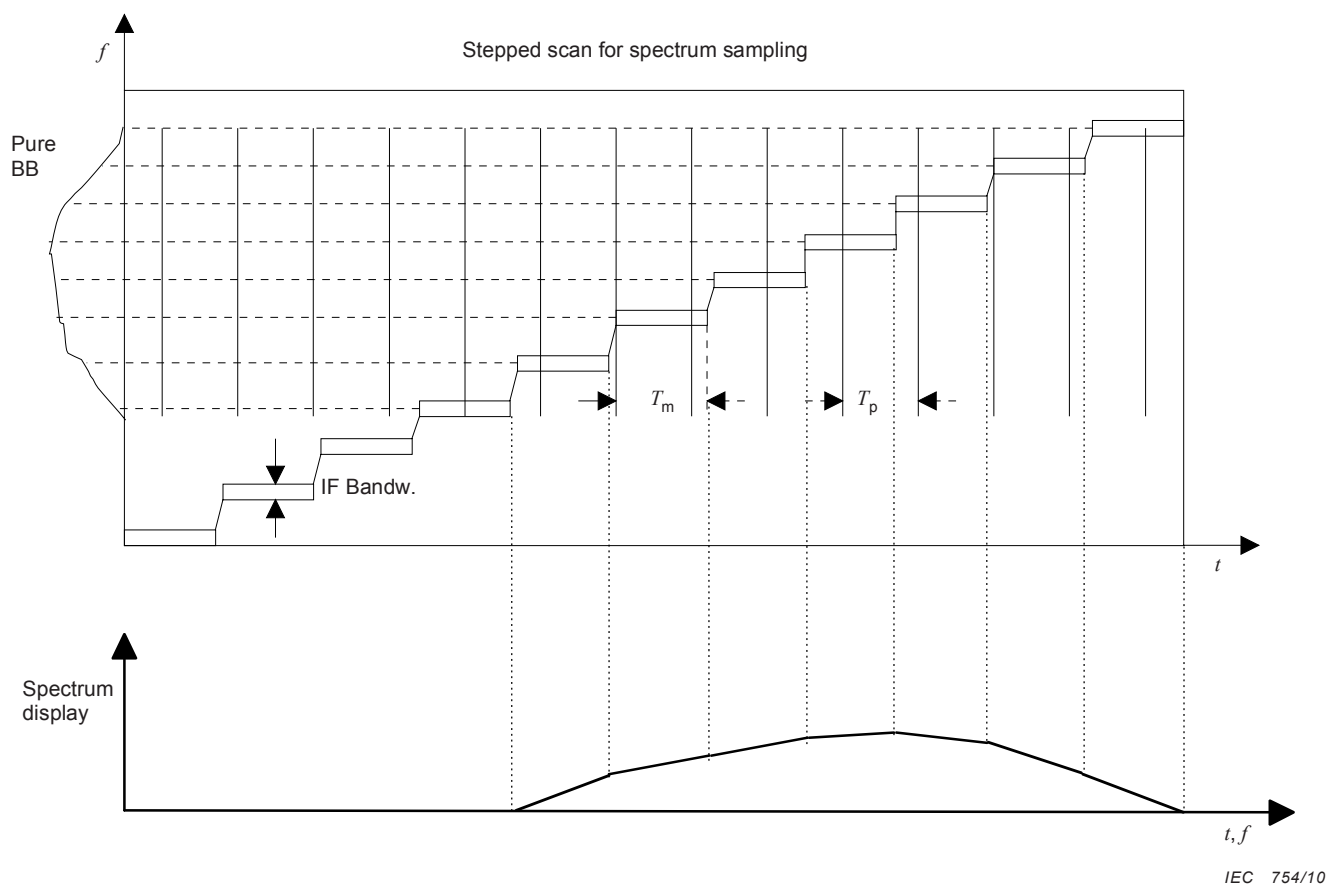


NOTE Disturbance from a d.c. collector motor; due to the number of collector segments, the pulse repetition frequency is high (approximately 800 Hz) and the pulse amplitude varies considerably. Therefore for this example, the recommended measurement (dwell) time with the peak detector is > 10 ms.

Figure 2 – Example of a timing analysis

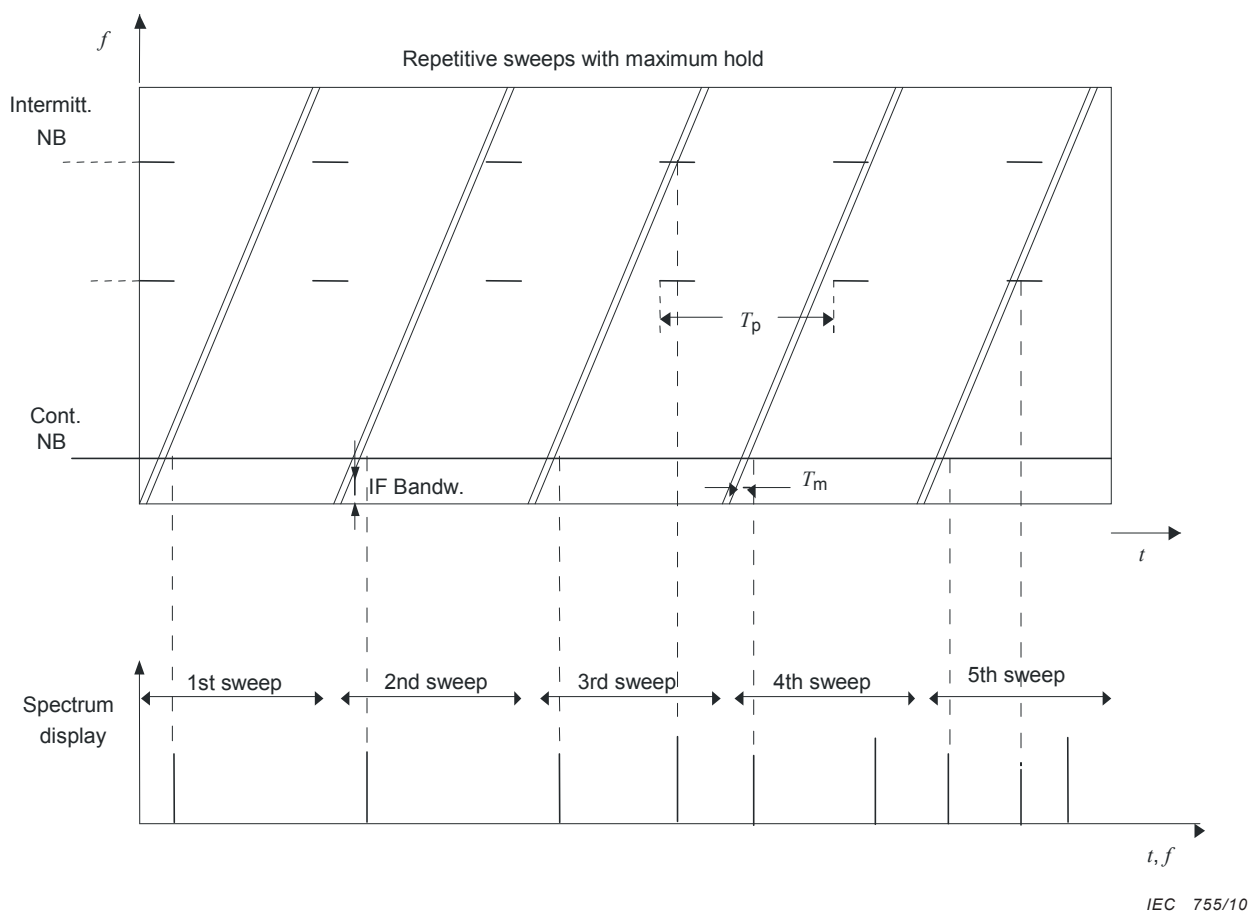
From such a timing analysis, pulse durations and pulse repetition frequencies can be determined and scan rates or dwell times selected, and according to the following:

- 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.



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



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 20 for three segments. The total scan time for the frequency range of interest T_{scan} is calculated as:

$$T_{\text{scan}} = T_m N_{\text{seg}} \quad (18)$$

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 $f_{\text{step FFT}}$ 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, $f_{\text{step final}}$.

A1 Hence the first calculation over the given frequency range considers the following frequencies:

$$\begin{aligned} &f_{\min}, \\ &f_{\min} + f_{\text{step FFT}}, \\ &f_{\min} + 2f_{\text{step FFT}}, \\ &f_{\min} + 3f_{\text{step FFT}} \dots \end{aligned}$$

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

$$\begin{aligned} &f_{\min} + f_{\text{step final}}, \\ &f_{\min} + f_{\text{step final}} + f_{\text{step FFT}}, \\ &f_{\min} + f_{\text{step final}} + 2f_{\text{step FFT}}, \\ &f_{\min} + f_{\text{step final}} + 3f_{\text{step FFT}} \dots \end{aligned}$$

This procedure, applied for a step ratio of 3, is displayed on Figure 21.

The scan time T_{scan} is calculated as:

$$T_{\text{scan}} = T_m \frac{f_{\text{step FFT}}}{f_{\text{step final}}} \quad (19)$$

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:

$$T_{\text{scan}} = T_m N_{\text{seg}} \frac{f_{\text{step FFT}}}{f_{\text{step final}}} \quad (20)$$

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

A2 NOTE 2 Additional background information on the definition of the FFT-based receiver can be found in CISPR 16-3 [2]. **A2**