BS EN 55016-2-1:2014

BSI Standards Publication

Specification for radio disturbance and immunity measuring apparatus and methods

Part 2-1: Methods of measurement of disturbances and immunity — Conducted disturbance measurements

bsi.

...making excellence a habit.™

National foreword

This British Standard is the UK implementation of EN 55016-2-1:2014. It is identical to CISPR 16-2-1:2014. It supersedes BS EN 55016-2-1:2009+A2:2013, which will be withdrawn on 2 April 2017.

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 75423 4
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 July 2014.

Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 55016-2-1

July 2014

ICS 33.100.10; 33.100.20

Supersedes EN 55016-2-1:2009

English Version

Specification for radio disturbance and immunity measuring apparatus and methods - Part 2-1: Methods of measurement of disturbances and immunity - Conducted disturbance measurements (CISPR 16-2-1:2014)

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 16-2-1:2014)

Anforderungen an Geräte und Einrichtungen sowie Festlegung der Verfahren zur Messung der hochfrequenten Störaussendung (Funkstörungen) und Störfestigkeit - Teil 2-1: Verfahren zur Messung der hochfrequenten Störaussendung (Funkstörungen) und Störfestigkeit - Messung der leitungsgeführten Störaussendung
(CISPR 16-2-1:2014)

This European Standard was approved by CENELEC on 2014-04-02. 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 CEN-CENELEC Management Centre 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 CEN-CENELEC Management Centre 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, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

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

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

© 2014 CENELEC All rights of exploitation in any form and by any means reserved worldwide for CENELEC Members.

Ref. No. EN 55016-2-1:2014 E

Foreword

The text of document CISPR/A/1053/FDIS, future edition 3 of CISPR 16-2-1, 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 55016-2-1:2014.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2015-01-11
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2017-04-02

This document supersedes EN 55016-2-1:2009.

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 16-2-1:2014 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:

CISPR 11:2003 + A1:2004	NOTE	Harmonized as EN 55011:2007 [1] (modified).
CISPR 16-1-4:2010	NOTE	Harmonized as EN 55016-1-4:2010 (not modified).
CISPR 16-2-3:2010	NOTE	Harmonized as EN 55016-2-3:2010 (not modified).
IEC 60364-4 Series	NOTE	Harmonized as HD 60364-4 Series (modified).
IEC 61000-4-6:2008	NOTE	Harmonized as EN 61000-4-6:2009 (modified).
IEC 61010-1:2001	NOTE	Harmonized as EN 61010-1:2001 (modified).

---

[1] Superseded by EN 55011:2009 (CISPR 11:2009, mod.)

Annex ZA
(normative)

Normative references to international publications with their corresponding European publications

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

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

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

Publication	Year	Title	EN/HD	Year
CISPR 14-1	-	Electromagnetic compatibility - Requirements for household appliances, electric tools and similar apparatus - Part 1: Emission	EN 55014-1	-
CISPR 16-1-1	2010	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	2010
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	EN 55016-1-2	2014
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	EN 55016-4-2	-
IEC 60050	Series	International Electrotechnical Vocabulary	-	-

CONTENTS

1 Scope 10
2 Normative references 10
3 Terms, definitions and abbreviations 11
  3.1 Terms and definitions 11
  3.2 Abbreviations 16
4 Types of disturbance to be measured 17
  4.1 General 17
  4.2 Types of disturbance 17
  4.3 Detector functions 17
5 Connection of measuring equipment 18
  5.1 General 18
  5.2 Connection of ancillary equipment 18
  5.3 Connections to RF reference ground 18
  5.4 Connection between the EUT and the artificial mains network 19
6 General measurement requirements and conditions 20
  6.1 General 20
  6.2 Disturbance not produced by the equipment under test 20
    6.2.1 General 20
    6.2.2 Compliance testing 20
  6.3 Measurement of continuous disturbance 20
    6.3.1 Narrowband continuous disturbance 20
    6.3.2 Broadband continuous disturbance 20
    6.3.3 Use of spectrum analyzers and scanning receivers 21
  6.4 EUT arrangement and measurement conditions 21
    6.4.1 EUT arrangement 21
    6.4.2 Normal load conditions 23
    6.4.3 Duration of operation 23
    6.4.4 Running-in/warm-up time 23
    6.4.5 Supply 24
    6.4.6 Mode of operation 24
    6.4.7 Operation of multifunction equipment 24
    6.4.8 Determination of EUT arrangement(s) that maximize(s) emissions 24
    6.4.9 Recording of measurement results 24
  6.5 Interpretation of measuring results 24
    6.5.1 Continuous disturbance 24
    6.5.2 Discontinuous disturbance 25
    6.5.3 Measurement of the duration of disturbances 25
  6.6 Measurement times and scan rates for continuous disturbance 25
    6.6.1 General 25
    6.6.2 Minimum measurement times 25
    6.6.3 Scan rates for scanning receivers and spectrum analyzers 26
    6.6.4 Scan times for stepping receivers 27
    6.6.5 Strategies for obtaining a spectrum overview using the peak detector 28

6.6.6 Timing considerations using FFT-based instruments 31
7 Measurement of disturbances conducted along leads, 9 kHz to 30 MHz 33
7.1 General 33
7.2 Measuring equipment (receivers, etc.) 33
7.2.1 General 33
7.2.2 Use of detectors for conducted disturbance measurements 33
7.3 Ancillary measuring equipment 34
7.3.1 General 34
7.3.2 Artificial networks (ANs) 34
7.3.3 Voltage probes 34
7.3.4 Current probes 35
7.4 Equipment under test configuration 35
7.4.1 Arrangement of the EUT and its connection to the AN 35
7.4.2 Procedure for the measurement of unsymmetric disturbance voltages with V-networks (AMNs) 40
7.4.3 Measurement of common mode voltages at differential mode signal terminals 47
7.4.4 Measurements using voltage probes 48
7.4.5 Measurement using a capacitive voltage probe (CVP) 51
7.4.6 Measurements using current probes 51
7.5 System test configuration for conducted emissions measurements 51
7.5.1 General approach to system measurements 51
7.5.2 System configuration 52
7.5.3 Measurements of interconnecting lines 54
7.5.4 Decoupling of system components 55
7.6 In situ measurements 55
7.6.1 General 55
7.6.2 Reference ground 55
7.6.3 Measurement with voltage probes 56
7.6.4 Selection of measuring points 56
8 Automated measurement of disturbances 56
8.1 Precautions for automating measurements 56
8.2 Generic measurement procedure 57
8.3 Prescan measurements 57
8.4 Data reduction 58
8.5 Disturbance maximization and final measurement 58
8.6 Post processing and reporting 59
8.7 Disturbance measurement strategies with FFT-based measuring instruments 59
9 Test set-up and measurement procedure using the CDNE in the frequency range 30 MHz to 300 MHz 59
9.1 General 59
9.2 Test set-up 60
9.3 Measurement procedure 62
Annex A (informative) Guidelines for connection of electrical equipment to the artificial mains network 63
A.1 General 63
A.2 Classification of the possible cases 63
A.2.1 Well-shielded but poorly filtered EUT (Figures A.1 and A.2) 63

A.2.2 Well-filtered but incompletely shielded EUT (Figures A.3 and A.4) 64
A.2.3 Practical general case 64
A.3 Method of grounding 66
A.4 Conditions of grounding 66
A.4.1 General 66
A.4.2 Classification of typical testing conditions 67
A.5 Connection of the AMN as a voltage probe 68
Annex B (informative) Use of spectrum analyzers and scanning receivers 70
B.1 General 70
B.2 Overload 70
B.3 Linearity test 70
B.4 Selectivity 70
B.5 Normal response to pulses 70
B.6 Peak detection 70
B.7 Frequency scan rate 71
B.8 Signal interception 71
B.9 Average detection 71
B.10 Sensitivity 71
B.11 Amplitude accuracy 72
Annex C (informative) Decision tree for use of detectors for conducted disturbance measurements 73
Annex D (informative) Scan rates and measurement times for use with the average detector 75
D.1 General 75
D.2 Suppression of impulsive disturbance 75
D.2.1 General 75
D.2.2 Suppression of impulsive disturbance by digital averaging 76
D.3 Suppression of amplitude modulation 76
D.4 Measurement of slowly intermittent, unsteady or drifting narrowband disturbances 76
D.5 Recommended procedure for automated or semi-automated measurements 78
Annex E (informative) Guidelines for the improvement of the test set-up with ANs 79
E.1 In situ verification of the AN impedance and voltage division factor 79
E.2 PE chokes and sheath current absorbers for the suppression of ground loops 82
Annex F (normative) Determination of suitability of spectrum analyzers for compliance tests 84
Annex G (informative) Basic guidance for measurements on telecommunications ports 85
G.1 Limits 85
G.2 Combination of current probe and capacitive voltage probe (CVP) 86
G.3 Basic ideas of the capacitive voltage probe 86
G.4 Combination of current limit and voltage limit 87
G.5 Adjusting the TCM impedance with ferrites 89
G.6 Ferrite specifications for use with methods of Annex H 89
Annex H (normative) Specific guidance for conducted disturbance measurements on telecommunication ports 92
H.1 General 92

H.2 Characteristics of AANs ... 93
H.3 Characteristics of current probe ... 94
H.4 Characteristics of capacitive voltage probe ... 94
H.5 Procedures for common mode measurements ... 94
H.5.1 General ... 94
H.5.2 Measurement procedure using AANs ... 94
H.5.3 Measurement procedure using a 150 Ω load connected to the outside surface of the cable screen ... 95
H.5.4 Measurement procedure using a combination of current probe and capacitive voltage probe ... 96
H.5.5 Measurement of cable, ferrite and AE common mode impedance ... 97
Annex I (informative) Examples of AANs and ANs for screened cables ... 99
Bibliography ... 108

Figure 1 – Example of a recommended test set-up with PE chokes with three AMNs and a sheath current absorber on the RF cable ... 19
Figure 2 – Measurement of a combination of a CW signal (“NB”) and an impulsive signal (“BB”) using multiple sweeps with maximum hold ... 28
Figure 3 – Example of a timing analysis ... 29
Figure 4 – A broadband spectrum measured with a stepped receiver ... 30
Figure 5 – Intermittent narrowband disturbances measured using fast short repetitive sweeps with maximum hold function to obtain an overview of the disturbance spectrum ... 30
Figure 6 – FFT scan in segments ... 32
Figure 7 – Frequency resolution enhanced by FFT-based measuring instrument ... 32
Figure 8 – Illustration of current I_{CCM} ... 35
Figure 9 – Test configuration: table-top equipment for conducted disturbance measurements on power mains ... 37
Figure 10 – Arrangement of EUT and AMN at 40 cm distance, with a) vertical RGP and b) horizontal RGP ... 38
Figure 11 – Optional example test configuration for an EUT with only a power cord attached ... 38
Figure 12 – Test configuration: floor-standing equipment (see 7.4.1 and 7.5.2.3) ... 39
Figure 13 – Example test configuration: floor-standing and table-top equipment (see 7.4.1 and 7.5.2.3) ... 40
Figure 14 – Schematic of disturbance voltage measurement configuration (see also 7.5.2.3) ... 42
Figure 15 – Equivalent circuit for measurement of unsymmetric disturbance voltage for safety-class I (grounded) EUT ... 43
Figure 16 – Equivalent circuit for measurement of unsymmetric disturbance voltage for safety-class II (ungrounded) EUT ... 44
Figure 17 – RC element for artificial hand ... 46
Figure 18 – Portable electric drill with artificial hand ... 46
Figure 19 – Portable electric saw with artificial hand ... 46
Figure 20 – Measuring example for voltage probes ... 49
Figure 21 – Measurement arrangement for two-terminal regulating controls ... 50
Figure 22 – Generic process to help reduce measurement time ... 57
Figure 23 – Test set-up for measurement of an EUT with one cable ... 61

Figure 24 – Test set-up for measurement of an EUT with two cables connected adjacent surfaces of the EUT ... 61
Figure 25 – Test set-up for measurement of an EUT with two cables connected on the same surface of the EUT ... 62
Figure A.1 – Basic schematic of well-shielded but poorly filtered EUT ... 63
Figure A.2 – Detail of well-shielded but poorly filtered EUT ... 64
Figure A.3 – Well-filtered but incompletely shielded EUT ... 64
Figure A.4 – Well-filtered but incompletely shielded EUT, with U_2 reduced to zero ... 64
Figure A.5 – Disturbance supply through shielded conductors ... 65
Figure A.6 – Disturbance supply through unshielded but filtered conductors ... 65
Figure A.7 – Disturbance supply through ordinary conductors ... 66
Figure A.8 – AMN configurations ... 68
Figure C.1 – Decision tree for optimizing speed of conducted disturbance measurements with peak, quasi-peak and average detectors ... 73
Figure D.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 ... 77
Figure D.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 ... 77
Figure D.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 ... 78
Figure D.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 ... 78
Figure E.1 – Parallel resonance of enclosure capacitance and ground strap inductance ... 79
Figure E.2 – Connection of an AMN to RGP using a wide grounding sheet for low inductance grounding ... 80
Figure E.3 – Impedance measured with the arrangement of Figure E.2 both with reference to the front panel ground and to the grounding sheet ... 80
Figure E.4 – VDF in the configuration of Figure E.2 measured with reference to the front panel ground and to the grounding sheet ... 80
Figure E.5 – Arrangement showing the measurement grounding sheet (shown with dotted lines) when measuring the impedance with reference to RGP ... 81
Figure E.6 – Impedance measured with the arrangement of Figure E.5 with reference to the RGP ... 81
Figure E.7 – VDF measured with parallel resonances in the AMN grounding ... 81
Figure E.8 – Attenuation of a sheath current absorber measured in a 150 Ω test arrangement ... 82
Figure E.9 – Arrangement for the measurement of attenuation due to PE chokes and sheath current absorbers ... 83
Figure G.1 – Basic circuit for considering the limits with a defined TCM impedance of 150 Ω ... 88
Figure G.2 – Basic circuit for the measurement with unknown TCM impedance ... 88
Figure G.3 – Impedance layout of the components used in Figure H.2 ... 90
Figure G.4 – Basic test set-up to measure combined impedance of the 150 Ω and ferrites ... 91
Figure H.1 – Measurement set-up using an AAN ... 95

Figure H.2 – Measurement set-up using a 150 Ω load to the outside surface of the shield 96

Figure H.3 – Measurement set-up using current and capacitive voltage probes 97

Figure H.4 – Characterization set-up 98

Figure I.1 – Example AAN for use with unscreened single balanced pairs 99

Figure I.2 – Example AAN with high LCL for use with either one or two unscreened balanced pairs 100

Figure I.3 – Example AAN with high LCL for use with one, two, three, or four unscreened balanced pairs 101

Figure I.4 – Example AAN, including a 50 Ω source matching network at the voltage measuring port, for use with two unscreened balanced pairs 102

Figure I.5 – Example AAN for use with two unscreened balanced pairs 103

Figure I.6 – Example AAN, including a 50 Ω source matching network at the voltage measuring port, for use with four unscreened balanced pairs 104

Figure I.7 – Example AAN for use with four unscreened balanced pairs 105

Figure I.8 – Example AN for use with coaxial cables, employing an internal common mode choke created by bifilar winding an insulated centre-conductor wire and an insulated screen-conductor wire on a common magnetic core (for example, a ferrite toroid) 106

Figure I.9 – Example AN for use with coaxial cables, employing an internal common mode choke created by miniature coaxial cable (miniature semi-rigid solid copper screen or miniature double-braided screen coaxial cable) wound on ferrite toroids 106

Figure I.10 – Example AN for use with multi-conductor screened cables, employing an internal common mode choke created by bifilar winding multiple insulated signal wires and an insulated screen-conductor wire on a common magnetic core (for example, a ferrite toroid) 107

Figure I.11 – Example AN for use with multi-conductor screened cables, employing an internal common mode choke created by winding a multi-conductor screened cable on ferrite toroids 107

Table 1 – Minimum scan times for the three CISPR bands with peak and quasi-peak detectors 26

Table 2 – Minimum measurement times for the four CISPR bands 26

Table A.2 – Testing conditions for types of EUTs – Screened cable 69

Table B.1 – Sweep time/frequency or fastest scan rate 71

Table D.1 – Pulse suppression factors and scan rates for a 100 Hz video bandwidth 76

Table D.2 – Meter time constants and the corresponding video bandwidths and maximum scan rates 77

Table F.1 – Maximum amplitude difference between peak and quasi-peak detected signals 84

Table G.1 – Summary of advantages and disadvantages of the methods described in the specific subclauses of Annex H 86

Table H.1 – Telecommunication port disturbance measurement procedure selection 92

Table H.2 – a_{LCL} values 93

SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY MEASURING APPARATUS AND METHODS –

Part 2-1: Methods of measurement of disturbances and immunity – Conducted disturbance measurements

1 Scope

This part of CISPR 16 is designated a basic standard, which specifies the methods of measurement of disturbance phenomena in general in the frequency range 9 kHz to 18 GHz and especially of conducted disturbance phenomena in the frequency range 9 kHz to 30 MHz. With a CDNE, the frequency range is 9 kHz to 300 Hz.

NOTE In accordance with IEC Guide 107, CISPR 16 is a basic EMC standard 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 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, *Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 1: Emission*

CISPR 16-1-1:2010, *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 16-4-2, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-2: Uncertainties, statistics and limit modelling – Uncertainty in EMC measurements*

IEC 60050 (all parts), *International Electrotechnical Vocabulary* (available at <http://www.electropedia.org>)