



TECHNICAL REPORT



INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

**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**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.100.10; 33.100.20

ISBN 978-2-8322-1770-2

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

REDLINE VERSION



INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

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



CONTENTS

FOREWORD.....	4
1 Scope	6
2 Normative references	6
3 Terms and definitions	6
4 Symbols and abbreviated terms	8
5 Introduction	8
6 Procedure to derive limits for an alternative test method	9
6.1 Overview	9
6.2 Select the reference quantity X	12
6.3 Describe the test methods and measurands	13
6.4 Determine the deviations of the measured quantities from the reference quantity	13
6.5 Determine the average values of the deviations.....	13
6.6 Estimate the standard uncertainties of the test methods	14
6.7 Estimate the expanded uncertainties of the test methods.....	15
6.8 Calculate the average conversion factor.....	16
6.9 Verify the calculated values	17
6.10 Apply the conversion	17
7 Measurement-based procedure to derive limits for an alternative test method based on measurement results	17
7.1 General.....	17
7.2 Application of practical measurement results to determine the conversion factors.....	17
Annex A (informative) Remarks on EUT modelling	21
Annex B (informative) Examples of application of the test method comparison procedure	22
Annex C (informative) Example of the application of the test method comparison procedure based on measurement results	52
Bibliography	58
Figure 1 – Overview of quantities to estimate for use in conversion procedure.	10
Figure 2 – Overview of limit conversion procedure using estimated quantities.	11
Figure B.1 – Example reference quantity	22
Figure B.2 – EUT and antenna set-up for fully anechoic room emission measurement.....	23
Figure B.3 – EUT and antenna set-up for open-area test site measurement	23
Figure B.4 – Radiation characteristics of elementary radiator (left), and scheme of EUT-model (right)	24
Figure B.5 – Maximum average deviations for 3 m FAR (top) and 10 m OATS (bottom)	27
Figure B.6 – Sample cumulative distribution function	29
Figure B.7 – Uncertainties due to the unknown EUT characteristic for 3 m FAR (top) and 10 m OATS (bottom)	31
Figure B.8 – Expanded uncertainties ($k = 2$) of alternative (3 m FAR, top) and established (10 m OATS, bottom) test methods	35
Figure B.9 – Maximum average conversion factors for different volumes	36
Figure B.10 – Photo (left) and cut-view of simulation model (right) of the specimen EUT	38

Figure B.11 – Deviations of the specimen EUT: 3 m fully anechoic room (top) and 10 m open area test site (bottom)	39
Figure B.12 – Sample FAR measurement	40
Figure B.13 – OATS 10 m limit line converted to FAR 3 m conditions	40
Figure B.14 – Expanded uncertainties	40
Figure B.15 – Comparison of the measured values with the corrected converted limit.....	41
Figure B.16 – EUT and antenna set-up of 3 m open area test site measurement	42
Figure B.17 – Maximum average deviations for 3 m OATS.....	43
Figure B.18 – Uncertainties due to the unknown EUT characteristic for 3 m OATS	44
Figure B.19 – Expanded uncertainties ($k = 2$) of alternative test method [OATS (3 m)].....	46
Figure B.20 – Maximum average conversion factors	47
Figure B.21 – Deviations of the specimen EUT: Open area test site (3 m).....	49
Figure B.22 – Sample OATS (3 m) measurement.....	50
Figure B.23 – OATS (10 m) limit line converted to OATS (3 m) conditions.....	50
Figure B.24 – Expanded uncertainties	51
Figure B.25 – Comparison of the corrected values with the converted limit.....	51
Figure C.1 – EUTs used during RRT	52
Figure C.2 – Measurement results of the asymmetrical voltage using both CDNEs	53
Figure C.3 – Measured disturbance field strength	54
Figure C.4 – Conversion factors of all measurements	55
Figure C.5 – Mean conversion factors for each EUT	55
Figure C.6 – Measured polarization.....	55
Figure C.7 – Comparison with CISPR 15:2013.....	55
Figure C.8 – Deviation of the conversion factors from the average conversion factor of each EUT	56
Figure C.9 – Deviation of the conversion factors from the trend line [poly (mean value $K(f)$)]	56
Table 1 – Summary of steps in conversion procedure	9
Table 2 – Overview of quantities and defining equations for conversion process	12
Table B.1 – Instrumentation uncertainty of the 3 m fully anechoic chamber test method	28
Table B.2 – Uncertainties in dB due to the unknown EUT characteristic for 3 m FAR.....	33
Table B.3 – Uncertainties in dB due to the unknown EUT characteristic for 10 m OATS.....	34
Table B.4 – Maximum average conversion factors in dB between 10 m OATS and 3 m FAR.....	37
Table B.5 – Uncertainties in dB due to the unknown EUT characteristic for 3 m OATS.....	45
Table B.6 – Maximum average conversion factors in dB between 10 m and 3 m OATS.....	48

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**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**

FOREWORD

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

This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

CISPR TR 16-4-5 edition 1.1 contains the first edition (2006-10) [documents CISPR/A/665/DTR and CISPR/A/685/RVC] and its amendment 1 (2014-07) [documents CISPR/A/1050/DTR and CISPR/A/1069/RVC].

In this Redline version, a vertical line in the margin shows where the technical content is modified by amendment 1. Additions are in green text, deletions are in strikethrough red text. A separate Final version with all changes accepted is available in this publication.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

CISPR 16-4-5, which is a technical report, has been prepared by CISPR subcommittee A: Radio-interference measurements and statistical methods.

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

A list of all parts of the CISPR 16-4 series, published under the general title *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4: Uncertainties, statistics and limit modelling*, can be found on the IEC website.

The committee has decided that the contents of the base publication and its amendment will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

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

A bilingual version of this publication may be issued at a later date.

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

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

1 Scope

This part of CISPR 16-4 specifies a method to enable product committees to develop limits for alternative test methods, using conversions from established limits. This method is generally applicable for all kinds of disturbance measurements, but focuses on radiated disturbance measurements (i.e. field strength), for which several alternative methods are presently specified. These limits development methods are intended for use by product committees and other groups responsible for defining emissions limits in situations where it is decided to use alternative test methods and the associated limits in product standards.

2 Normative references

IEC 60050-161:1990, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

CISPR 16-4-1:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-1: Uncertainties, statistics and limit modelling – Uncertainty in standardized EMC tests*

CISPR 16-4-2:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-2: Uncertainties, statistics and limit modelling – Uncertainty in EMC measurements*

FINAL VERSION



INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

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



CONTENTS

FOREWORD.....	4
1 Scope	6
2 Normative references	6
3 Terms and definitions	6
4 Symbols and abbreviated terms	8
5 Introduction	8
6 Procedure to derive limits for an alternative test method	9
6.1 Overview	9
6.2 Select the reference quantity X	12
6.3 Describe the test methods and measurands	13
6.4 Determine the deviations of the measured quantities from the reference quantity	13
6.5 Determine the average values of the deviations.....	13
6.6 Estimate the standard uncertainties of the test methods	14
6.7 Estimate the expanded uncertainties of the test methods.....	15
6.8 Calculate the average conversion factor.....	16
6.9 Verify the calculated values	17
6.10 Apply the conversion	17
7 Measurement-based procedure to derive limits for an alternative test method based on measurement results	17
7.1 General.....	17
7.2 Application of practical measurement results to determine the conversion factors.....	18
Annex A (informative) Remarks on EUT modelling	21
Annex B (informative) Examples of application of the test method comparison procedure	22
Annex C (informative) Example of the application of the test method comparison procedure based on measurement results	52
Bibliography	58
Figure 1 – Overview of quantities to estimate for use in conversion procedure.	10
Figure 2 – Overview of limit conversion procedure using estimated quantities.	11
Figure B.1 – Example reference quantity	22
Figure B.2 – EUT and antenna set-up for fully anechoic room emission measurement.....	23
Figure B.3 – EUT and antenna set-up for open-area test site measurement	23
Figure B.4 – Radiation characteristics of elementary radiator (left), and scheme of EUT-model (right)	24
Figure B.5 – Maximum average deviations for 3 m FAR (top) and 10 m OATS (bottom)	27
Figure B.6 – Sample cumulative distribution function	29
Figure B.7 – Uncertainties due to the unknown EUT characteristic for 3 m FAR (top) and 10 m OATS (bottom)	31
Figure B.8 – Expanded uncertainties ($k = 2$) of alternative (3 m FAR, top) and established (10 m OATS, bottom) test methods	35
Figure B.9 – Maximum average conversion factors for different volumes	36
Figure B.10 – Photo (left) and cut-view of simulation model (right) of the specimen EUT	38

Figure B.11 – Deviations of the specimen EUT: 3 m fully anechoic room (top) and 10 m open area test site (bottom)	39
Figure B.12 – Sample FAR measurement	40
Figure B.13 – OATS 10 m limit line converted to FAR 3 m conditions	40
Figure B.14 – Expanded uncertainties	40
Figure B.15 – Comparison of the measured values with the corrected converted limit.....	41
Figure B.16 – EUT and antenna set-up of 3 m open area test site measurement	42
Figure B.17 – Maximum average deviations for 3 m OATS.....	43
Figure B.18 – Uncertainties due to the unknown EUT characteristic for 3 m OATS	44
Figure B.19 – Expanded uncertainties ($k = 2$) of alternative test method [OATS (3 m)].....	46
Figure B.20 – Maximum average conversion factors	47
Figure B.21 – Deviations of the specimen EUT: Open area test site (3 m).....	49
Figure B.22 – Sample OATS (3 m) measurement.....	50
Figure B.23 – OATS (10 m) limit line converted to OATS (3 m) conditions	50
Figure B.24 – Expanded uncertainties	51
Figure B.25 – Comparison of the corrected values with the converted limit.....	51
Figure C.1 – EUTs used during RRT	52
Figure C.2 – Measurement results of the asymmetrical voltage using both CDNEs	53
Figure C.3 – Measured disturbance field strength	54
Figure C.4 – Conversion factors of all measurements	55
Figure C.5 – Mean conversion factors for each EUT	55
Figure C.6 – Measured polarization.....	55
Figure C.7 – Comparison with CISPR 15:2013.....	55
Figure C.8 – Deviation of the conversion factors from the average conversion factor of each EUT	56
Figure C.9 – Deviation of the conversion factors from the trend line [poly (mean value $K(f)$)]	56
Table 1 – Summary of steps in conversion procedure	9
Table 2 – Overview of quantities and defining equations for conversion process	12
Table B.1 – Instrumentation uncertainty of the 3 m fully anechoic chamber test method	28
Table B.2 – Uncertainties in dB due to the unknown EUT characteristic for 3 m FAR.....	33
Table B.3 – Uncertainties in dB due to the unknown EUT characteristic for 10 m OATS.....	34
Table B.4 – Maximum average conversion factors in dB between 10 m OATS and 3 m FAR.....	37
Table B.5 – Uncertainties in dB due to the unknown EUT characteristic for 3 m OATS.....	45
Table B.6 – Maximum average conversion factors in dB between 10 m and 3 m OATS.....	48

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**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**

FOREWORD

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

This consolidated version of the official IEC Standard and its amendment has been prepared for user convenience.

CISPR TR 16-4-5 edition 1.1 contains the first edition (2006-10) [documents CISPR/A/665/DTR and CISPR/A/685/RVC] and its amendment 1 (2014-07) [documents CISPR/A/1050/DTR and CISPR/A/1069/RVC].

This Final version does not show where the technical content is modified by amendment 1. A separate Redline version with all changes highlighted is available in this publication.

The main task of IEC technical committees is to prepare International Standards. However, a technical committee may propose the publication of a technical report when it has collected data of a different kind from that which is normally published as an International Standard, for example "state of the art".

CISPR 16-4-5, which is a technical report, has been prepared by CISPR subcommittee A: Radio-interference measurements and statistical methods.

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

A list of all parts of the CISPR 16-4 series, published under the general title *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4: Uncertainties, statistics and limit modelling*, can be found on the IEC website.

The committee has decided that the contents of the base publication and its amendment will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

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

A bilingual version of this publication may be issued at a later date.

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

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

1 Scope

This part of CISPR 16-4 specifies a method to enable product committees to develop limits for alternative test methods, using conversions from established limits. This method is generally applicable for all kinds of disturbance measurements, but focuses on radiated disturbance measurements (i.e. field strength), for which several alternative methods are presently specified. These limits development methods are intended for use by product committees and other groups responsible for defining emissions limits in situations where it is decided to use alternative test methods and the associated limits in product standards.

2 Normative references

IEC 60050-161:1990, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*

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

CISPR 16-4-2:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-2: Uncertainties, statistics and limit modelling – Uncertainty in EMC measurements*