



BSI Standards Publication

## Specification for radio disturbance and immunity measuring apparatus and methods

---

Part 4-4: Uncertainties, statistics and limit modelling – Statistics of complaints and a model for the calculation of limits for the protection of radio services

## National foreword

This Published Document is the UK implementation of CISPR TR 16-4-4:2007+A2:2020. It supersedes PD CISPR/TR 16-4-4:2007+A1:2017, which is withdrawn.

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 to Technical Committee GEL/210/11, EMC - Standards Committee.

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 2020  
Published by BSI Standards Limited 2020

ISBN 978 0 580 99656 6

ICS 33.100.20; 33.100.10

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

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 August 2007.

### Amendments/corrigenda issued since publication

Date	Text affected
31 March 2018	Implementation of CISPR amendment A1:2017
31 May 2020	Implementation of CISPR amendment A2:2020



# CISPR TR 16-4-4

Edition 2.0 2020-04

## TECHNICAL REPORT



INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

---

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

**Part 4-4: Uncertainties, statistics and limit modelling – Statistics of complaints and a model for the calculation of limits for the protection of radio services**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

ICS 33.100.10; 33.100.20

ISBN 978-2-8322-8224-3

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

## CONTENTS

FOREWORD.....	7
1 Scope.....	9
2 Normative references .....	9
3 Terms, definitions, symbols and abbreviated terms.....	9
3.1 Terms and definitions .....	9
3.2 Symbols and abbreviated terms.....	10
4 Statistics of complaints and sources of interference .....	11
4.1 Introduction and history .....	11
4.2 Relationship between radio frequency interference and complaints .....	11
4.2.1 Radio frequency interference to a fixed radio receiver .....	11
4.2.2 Radio frequency interference to a mobile radio receiver .....	11
4.2.3 Consequences of the move from analogue to digital radio systems.....	11
4.3 Towards the loss of a precious indicator: interference complaints.....	12
4.4 CISPR recommendations for collation of statistical data on interference complaints and classification of interference sources .....	12
4.5 Forms for statistics of interference complaints.....	13
5 A model for the calculation of limits .....	18
5.1 Introduction .....	18
5.1.1 Generation of EM disturbances.....	18
5.1.2 Immunity from EM disturbances.....	18
5.1.3 Planning a radio service .....	18
5.2 Probability of interference.....	19
5.2.1 Derivation of probability of interference .....	19
5.3 Circumstances of interferences .....	20
5.3.1 Close coupling and remote coupling .....	21
5.3.2 Measuring methods .....	22
5.3.3 Disturbance signal waveforms and associated spectra .....	24
5.3.4 Characteristics of interfered radio services .....	25
5.3.5 Operational aspects.....	26
5.3.6 Criteria for the determination of limits .....	27
5.4 A mathematical basis for the calculation of CISPR limits .....	31
5.4.1 Generation of EM disturbances (source of disturbance).....	31
5.4.2 Immunity from EM disturbances (victim receiver).....	32
5.5 Application of the mathematical basis.....	32
5.5.1 Radiation coupling.....	32
5.5.2 Wire-line coupling.....	34
5.6 Another suitable method for equipment in the frequency range 150 kHz to 1 GHz.....	42
5.6.1 Introduction .....	42
5.6.2 Derivation of limits.....	42
5.6.3 Application of limits .....	47
5.6.4 Overview of proposals for determination of disturbance limits for a given type of equipment.....	47
5.6.5 Rationale for determination of CISPR limits in the frequency range below 30 MHz.....	48

5.6.6	Model for limits for the magnetic component of the disturbance field strength for the protection of radio reception in the range below 30 MHz.....	54
5.7	Rational for determination of CISPR limits in the frequency range above 1 GHz.....	57
5.7.1	Introduction .....	57
5.7.2	Consideration and estimated values of $\mu P_1$ to $\mu P_7$ .....	59
5.7.3	Equivalent EMC environment below and above 1 GHz.....	64
5.7.4	Overview on parameters of radio communication services operating in the frequency range above 1 GHz and up to 16 GHz with effect to electromagnetic compatibility.....	65
Annex A	Excerpt from CISPR Report No. 31 Values of mains decoupling factor in the range 0,1 MHz to 200 MHz .....	69
Annex B (informative)	Conversion of H-field limits below 30 MHz for measurement distances .....	74
Annex C (informative)	Model for estimation of radiation from photovoltaic (PV) power generating systems.....	86
Annex D (informative)	Model for the estimation of radiation from in-house extra low voltage (ELV) lighting installations .....	119
Bibliography	.....	133
Figure 1a	– Standard form for statistics on interference complaints recommended for radio services with analogue modulation and fixed or stationary radio reception .....	13
Figure 1b	– Standard form for statistics on interference complaints recommended for radio services with analogue modulation and mobile or portable radio reception .....	14
Figure 1c	– Standard form for statistics on interference complaints recommended for radio services with digital modulation and fixed or stationary radio reception .....	15
Figure 1d	– Standard form for statistics on interference complaints recommended for radio services with digital modulation and mobile or portable radio reception .....	16
Figure 1	– Standard forms for statistics on interference complaints.....	16
Figure 2	– Model for remote coupling situation derived disturbance field strength $e_{fr}$ at receiving distance $r$ .....	28
Figure 3	– Model for close coupling situations.....	30
Figure 4	– Example of conversion factors – field strength / common-mode voltage (in dB) – at feed point, found in practice .....	39
Figure 5	– Example of conversion factors – field strength generated by differential-mode voltage – at feed point, found in practice .....	40
Figure 6	– Example of conversion factors – field strength generated by differential-mode voltage – outside buildings and electrical substations, found in practice .....	41
Figure 7	– Example of conversion factors – field strength generated by differential-mode voltage – inside buildings, found in practice .....	42
Figure 8	– horizontal plane radiation pattern on a small purely magnetic antenna .....	50
Figure 9	– typical source of magnetic field disturbance .....	52
Figure 10	– Model for magnetic field limit at measuring equipment .....	55
Figure A.1	– Mains decoupling coefficient as measured by various authors .....	71
Figure A.2	– Median and minimum values of mains decoupling factor for the range 0,1 MHz to 200 MHz .....	72

Figure A.3 – Typical distributions of deviations from median value of decoupling factor as indicated in Figure A.2 ..... 72

Figure A.4 – Measurement of the mains decoupling factor ..... 73

Figure B.1 – Commercial tool model for H-field conversion ..... 74

Figure B.2 – Commercial tool model for the application of image theory..... 75

Figure B.3 – Photos of OATS measurement setup ..... 76

Figure B.4 – Comparative simulation result with ground plane and with image theory ..... 76

Figure B.5 – Comparison between the simulated conversion factors and the measurement results ..... 77

Figure B.6 – Conversion factor  $C_{3\_min}$ ..... 78

Figure B.7 – Conversion factor  $C_{10\_min}$ ..... 79

Figure B.8 – Conversion factor  $C_{10-3\_min}$ ..... 81

Figure B.9 – Recommended conversion factor  $CF_{30m\ to\ 3m}$  ..... 83

Figure B.10 – Recommended conversion factor  $CF_{30m\ to\ 10m}$  ..... 84

Figure B.11 – Recommended conversion factor  $CF_{10m\ to\ 3m}$  ..... 85

Figure C.1 – Schematic overview of the considered model influence factors ..... 87

Figure C.2 – Schematic representation of probability of existence of PV generator groups in the field ..... 90

Figure C.3 – Schematic representation of mean value  $\bar{C}_{PV}$  and variance  $\sigma_{CPV}$  ..... 90

Figure C.4 – General model for coupling of CM disturbances of a GCPC to an attached photovoltaic power generating system (PV generator) ..... 91

Figure C.5 – Geometric representation of a PV generator with 18 modules ..... 93

Figure C.6 – Field strength determination by maximization (height scan) along a red line ..... 94

Figure C.7 – Geometrical representation of Group A PV generators..... 101

Figure C.8 – Combined coupling factor  $C_{PV\ Group\ A\ sim}$  for Group A PV generators ( $r = 10m$ )..... 101

Figure C.9 – Geometrical representation of Group B PV generators..... 102

Figure C.10 – Combined coupling factor  $C_{PV\ Group\ B\ sim}$  for Group B PV generators ( $r = 10\ m$ ) ..... 102

Figure C.11 – Geometrical representation of Group C PV generators..... 103

Figure C.12 – Combined coupling factor  $C_{PV\ Group\ C\ sim}$  for Group C PV generators ( $r = 10\ m$ )..... 103

Figure C.13 – Geometrical representation of Group D PV generators..... 104

Figure C.14 – Combined coupling factor  $C_{PV\ Group\ D\ sim}$  for Group D PV generators ( $r = 10\ m$ )..... 104

Figure C.15 – Measurement setup ..... 106

Figure C.16 – Antenna orientations ..... 106

Figure C.17 – Coupling factor  $C_{PV\ Group\ A\ meas}$  for Group A PV generators..... 107

Figure C.18 – Coupling factor  $C_{PV\ Group\ C\ meas}$  for Group C PV generators ..... 108

Figure C.19 – Coupling factor  $C_{PV\ Group\ D\ meas}$  for Group D PV generators ..... 108

Figure C.20 – Ratio of registered PV power generating systems in Germany .....	110
Figure C.21 – Ratio of registered PV power generating systems in Sweden .....	111
Figure C.22 – Simulation results $m_{TC}$ (test case) .....	113
Figure C.23 – Simulation results $m_L$ (use case) .....	114
Figure C.24 – Overview of the calculated $U_{TC}$ Limit values for radio services between 150 kHz and 30 MHz at a distance of $d = 10$ m .....	118
Figure D.1 – Application of ELV lamps .....	120
Figure D.2 – Typical components and wiring for an ELV lamp connected to a power source and the associated lumped-circuit model of the ELV part .....	121
Figure D.3 – Coupling scenarios .....	123
Figure D.4 – Two wire scenario .....	123
Figure D.5 – Field strength derived by Biot-Savart-law applied to a differential mode current in comparison with the values in CISPR 15:2018, Table 9 (3 m) converted to 10 m .....	125
Figure D.6 – Principal model used for the simulations .....	126
Figure D.7 – Electric field distribution (at 10 MHz) on a vertical plane at a distance of 10 m from the vertical two wire system .....	127
Figure D.8 – Coupling factor result for 3 different scenarios .....	128
Figure D.9 – Overview of the calculated $U_{Limit}$ values for radio services between 150 kHz and 30 MHz .....	132
Table 1 – Classification of sources of radio frequency interference and other causes of complaint .....	17
Table 2 – Guidance survey of RFI measuring methods .....	24
Table 3 – Tabulation of the method of determining limits for equipment in the frequency range 0,150 MHz to 960 MHz .....	44
Table 4 – Calculation of permissible limit for disturbances at about 1 800 MHz from existing CISPR limits in the frequency range of 900 MHz .....	65
Table 5 – List of radio services, technical parameters, and influence factors .....	67
Table B.1 – Conversion factor $C_{3\_min}$ .....	78
Table B.2 – Conversion factor $C_{10\_min}$ .....	80
Table B.3 – Conversion factor $C_{10-3\_min}$ .....	82
Table B.4 – Recommended conversion factor $CF_{30m\ to\ 3m}$ .....	83
Table B.5 – Recommended conversion factor $CF_{30m\ to\ 10m}$ .....	84
Table B.6 – Recommended conversion factor $CF_{10m\ to\ 3m}$ .....	85
Table C.1 – Coupling factors $C_{PV_{sim}}$ .....	105
Table C.2 – Coupling factors $C_{PV_{meas}}$ and calibration factors .....	109
Table C.3 – Overview coupling factors $C_{PV_i}$ .....	109
Table C.4 – Estimation of $\rho_i$ .....	111
Table C.5 – Mismatch loss values $m_L$ and $m_{TC}$ determined by measurement and simulation .....	114

Table C.6 – Calculation of  $U_{TC}$  Limit for radio services between 150 kHz and 30 MHz  
at a distance of  $d = 10$  m ..... 116

Table D.1 – Calculation of  $U_{Limit}$  for radio services between 150 kHz and 30 MHz..... 131

Currently in preview, click buy full version

INTERNATIONAL ELECTROTECHNICAL COMMISSION  
INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE**SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY  
MEASURING APPARATUS AND METHODS –****Part 4-4: Uncertainties, statistics and limit modelling –  
Statistics of complaints and a model for the calculation of limits  
for the protection of radio services**

## 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 expressed, as far 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 provides no marking procedure to indicate its approval and cannot be rendered responsible for any equipment declared to be in conformity with an IEC Publication.
- 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.

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".

This second edition of CISPR 16-4-4, which is a technical report, has been prepared by CISPR subcommittee H: Limits for the protection of radio services.

This second edition of CISPR 16-4-4 contains two thoroughly updated Clauses 4 and 5, compared with its first edition. It also contains, in its new Annex A, values of the classical CISPR mains decoupling factor which were determined by measurements in real LV AC mains grids in the 1960s. It is deemed that these mains decoupling factors are still valid and representative also for modern and well maintained LV AC mains grids around the world.

The information in Clause 4 – Statistics of complaints and sources of interference – was accomplished by the history and evolution of the CISPR statistics on complaints about radio frequency interference (RFI) and by background information on evolution in radio-based communication technologies. Furthermore, the forms for collation of actual RFI cases were detailed and structured in a way allowing for more qualified assessment and evaluation of compiled annual data in regard to the interference situation, as e.g. fixed or mobile radio reception, or analogue or digital modulation of the interfered with radio service or application concerned.

The information in Clause 5 – A model for the calculation of limits – was accomplished in several ways. The model itself was accomplished in respect of the remote coupling situation as well as the close coupling one. Further supplements of this model were incorporated regarding certain aspects of the coupling path via induction and wave propagation (radiation) of classical telecommunication networks. Furthermore, the calculation model on statistical and probability underwent revision and was brought in line with a more modern mathematical approach. Eventually the present model was extended for a possible determination of CISPR limits in the frequency range above 1 GHz.

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

Enquiry draft	Report on voting
CISPR/H/147/DTR	CISPR/H/153/RVC

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

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

The committee has decided that the contents of this publication will remain unchanged until the maintenance result 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.

## SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY MEASURING APPARATUS AND METHODS –

### Part 4-4: Uncertainties, statistics and limit modelling – Statistics of complaints and a model for the calculation of limits for the protection of radio services

## 1 Scope

This part of CISPR 16 contains a recommendation on how to deal with statistics of radio interference complaints. Furthermore it describes the calculation of limits for disturbance field strength and voltage for the measurement on a test site based on models for the distribution of disturbances by radiated and conducted coupling, respectively.

## 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.

- A2 IEC 60050-161, *International Electrotechnical Vocabulary (IEV) – Part 161: Electromagnetic compatibility* (available at <http://www.electropedia.org>) A2
  - A2 CISPR 11, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement* A2
- CISPR 16-4-3, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-3: Uncertainties, statistics and limit modelling – Statistical considerations in the determination of EMC compliance of mass-produced products*
- A2 CISPR 15:2018, *Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment* A2

## A2 3 Terms, definitions, symbols and abbreviated terms

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- IEC Electropedia: available at <http://www.electropedia.org/>
- ISO Online browsing platform: available at <http://www.iso.org/obp>

### 3.1 Terms and definitions

#### 3.1.1 complaint

request for assistance made to the RFI investigation service by the user of a radio receiving equipment who complains that reception is degraded by radio frequency interference (RFI)