

TECHNICAL REPORT



INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

**Radio interference characteristics of overhead power lines and high-voltage equipment –
Part 2: Methods of measurement and procedure for determining limits**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.100.01

ISBN 978-2-8322-4894-2

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

CONTENTS

FOREWORD.....	6
INTRODUCTION.....	8
1 Scope.....	10
2 Normative references	10
3 Terms and definitions	11
4 Measurements.....	11
4.1 Measuring instruments.....	11
4.1.1 Response of a standard quasi-peak CISPR measuring receiver to AC generated corona noise	11
4.1.2 Other measuring instruments.....	12
4.2 On-site measurements on HV overhead power lines	12
4.2.1 General	12
4.2.2 Measurements in the frequency range 0,15 MHz to 30 MHz.....	12
4.2.3 Measurements in the frequency range from 30 MHz to 300 MHz.....	14
4.2.4 Measurements in the frequency range from 300 MHz to 3 GHz.....	15
4.3 Statistical evaluation of the radio noise level of a line	15
4.4 Additional information to be given in the report	17
4.5 Measurements on HV equipment in the laboratory	17
4.5.1 Overview	17
4.5.2 State of the test object.....	17
4.5.3 Test area	18
4.5.4 Atmospheric conditions.....	18
4.5.5 Test circuit – Basic diagram.....	18
4.5.6 Practical arrangement of the test circuit.....	19
4.5.7 Test circuit components.....	19
4.5.8 Measuring receiver connections.....	20
4.5.9 Mounting and arrangement of test object.....	21
4.5.10 Measurement frequency	21
4.5.11 Checking of the test circuit	21
4.5.12 Calibration of the test circuit.....	22
4.5.13 Test procedure	23
4.5.14 Related observations during the test.....	24
4.5.15 Data to be given in test report.....	24
5 Methods for derivation of limits for HV power systems	24
5.1 Overview.....	24
5.2 Significance of CISPR limits for power lines.....	25
5.3 Technical considerations for derivation of limits for lines.....	26
5.3.1 Basic approach.....	26
5.3.2 General	26
5.3.3 Minimum broadcast signal levels to be protected	27
5.3.4 Required signal-to-noise ratio.....	28
5.3.5 Use of data on radio noise compiled during measurements in the field	29
5.3.6 Use of data obtained by prediction of the radio noise from high-voltage overhead power lines.....	30
5.4 Methods of determining compliance of measured data with limits.....	31
5.4.1 Long-term recording	31

5.4.2	Sampling method.....	31
5.4.3	Survey methods.....	32
5.4.4	Alternative criteria for an acceptable noise level	32
5.5	Examples for derivation of limits in the frequency range below 30 MHz.....	33
5.5.1	Radio reception	33
5.5.2	Television reception, 47 MHz to 230 MHz	35
5.5.3	Digital terrestrial television reception, 470 MHz to 950 MHz.....	35
5.6	Additional remarks	35
5.7	Technical considerations for derivation of limits for line equipment and HVAC substations.....	35
5.7.1	General	35
5.7.2	Current injected by line components and hardware.....	36
5.7.3	Current injected by substation equipment	36
5.7.4	Practical derivation of limits in the l.f. and m.f. band	37
6	Methods for derivation of limits for the radio noise produced by insulator sets	38
6.1	General considerations	38
6.2	Insulator types	39
6.3	Influence of insulator surface conditions	39
6.3.1	General	39
6.3.2	Clean insulators.....	40
6.3.3	Slightly polluted insulators	40
6.3.4	Polluted insulators	40
6.4	Criteria for setting up radio noise limits for insulators	41
6.4.1	General	41
6.4.2	Criterion for insulators to be installed in type A areas	41
6.4.3	Criterion for insulators to be installed in type B areas	41
6.4.4	Criterion for insulators to be installed in type C areas	42
6.5	Recommendations	42
7	Methods for derivation of limits for the radio noise due to HVDC converter stations and similar installations	44
7.1	General considerations	44
7.2	Sources of interference.....	44
7.2.1	Mechanism of radio noise generation.....	44
7.2.2	Influence of station design on radio interference.....	46
7.3	Radiated fields from valve halls	46
7.3.1	Frequency spectra	46
7.3.2	Lateral attenuation.....	46
7.3.3	Reduction of the radio interference due to direct radiation from the valve hall	46
7.4	Conducted interference along the transmission lines.....	47
7.4.1	Description of the mechanism and typical longitudinal profiles	47
7.4.2	Reduction of the interference conducted along the transmission lines.....	48
7.5	General criteria for stating limits	48
7.5.1	Overview	48
7.5.2	Direct radiation	48
7.5.3	Propagation along the lines	48
8	Figures.....	50
	Annex A (informative) Radio interference measuring apparatus differing from the CISPR basic standard instruments.....	64

Annex B (normative) List of additional information to be included in the report on the results of measurements on operational lines	65
Annex C (informative) Minimum radio signal levels to be protected – ITU recommendations	66
C.1 Broadcast radio (low frequency (l.f.) and medium frequency (m.f.) bands).....	66
C.2 Broadcast radio (high frequency (h.f.) bands).....	67
C.3 Amateur radio	67
Annex D (informative) Minimum broadcast signals to be protected – North American standards.....	69
Annex E (informative) Required signal-to-noise ratios for satisfactory reception.....	70
Annex F (informative) Derivation of the equation for the protected distance	73
Bibliography.....	74
Figure 1 – Transformation of pulses through a CISPR measuring receiver	50
Figure 2 – Bursts of corona pulses generated by alternating voltage.....	51
Figure 3 – Example of extrapolation to determine the radio noise field strength reference level of a power line, here at the direct reference distance of 20 m	51
Figure 4 – Basic test circuit.....	52
Figure 5 – Standard test circuit	52
Figure 6 – Connection to the measuring receiver by a coaxial cable	53
Figure 7 – Connection to the measuring receiver by a balanced cable	53
Figure 8 – Special test circuit.....	53
Figure 9 – Arrangement for calibration of the standard test circuit.....	54
Figure 10 – Map showing boundaries of zones A, B, and C in regions 1 and 3	55
Figure 11 – Illustration of the four basic parameters for a power transmission line	56
Figure 12 – Example of typical statistical yearly "all-weather" distributions of the radio-noise levels of a bipolar direct current line (—) and for an alternating current line in a moderate climate (- - -)	57
Figure 13 – Example of radio noise voltage level V , as a function of the relative air humidity R.H., in clean conditions and slightly polluted conditions, of a standard insulator (—) and a particular type of "low noise" insulator (- - -).....	57
Figure 14 – Example of frequency spectra of pulses with different rise times, simulating commutation phenomena in mercury valves and in thyristor valves	58
Figure 15 – Example of frequency spectra of the radio interference recorded outside the hall of a mercury arc valve converter station with and without toroidal filters	59
Figure 16 – Example of frequency spectra of the radio interference recorded outside the hall of a thyristor valve converter station for different operating conditions	59
Figure 17 – Attenuation of the field strength as a function of the distance on a horizontal plane, for different frequencies	60
Figure 18 – Example of frequency spectrum of the radio interference in the vicinity of a DC line (30 m) at a short distance from the converter station	61
Figure 19 – Example of frequency spectra of the radio interference in the vicinity of an AC line (20 m) at a short distance from the converter station	62
Figure 20 – Frequency spectra of radio interference at 20 m from the electrode line at 1,5 km from the Gotland HVDC link in Sweden with mercury arc groups or thyristor groups in operation	62
Figure 21 – Frequency spectra of radio interference at 20 m from the electrode line at 1,5 km and 4,5 km from the Gotland HVDC link in Sweden with mercury arc groups in operation	63

Figure 22 – Frequency spectra of the radio interference recorded along a 200 kV DC line, at 20 m from the conductor, at different distances from the converter station..... 63

Table 1 – Number of n sets of the radio noise level measurements and corresponding values for factor k 16

Table 2 – Minimum usable broadcast signal field strengths in the v.h.f bands according to CCIR..... 27

Table 3 – Recommendations for the radio noise voltage limits and for the test methods for insulator sets installed in different areas 43

Table C.1 – Minimum field strength (l.f. and m.f. radio) 66

Table C.2 – Nominal usable field strength 66

Table C.3 – Minimum field strength (h.f. radio)..... 67

Table C.4 – Field strength limit (amateur radio) 68

Table D.1 – Signal levels at the edge of the service area in North America 69

Table E.1 – Summary of signal-to-noise ratios for corona from AC lines (Signal measured with average detector, noise measured with quasi-peak detector)..... 70

Table E.2 – Quality of radio reception or degree of annoyance due to RFI 71

INTERNATIONAL ELECTROTECHNICAL COMMISSION
INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

**RADIO INTERFERENCE CHARACTERISTICS
OF OVERHEAD POWER LINES
AND HIGH-VOLTAGE EQUIPMENT –**

**Part 2: Methods of measurement
and procedure for determining limits**

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.

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 18-2, which is a technical report, has been prepared by CISPR subcommittee B: Interference relating to industrial, scientific and medical radio-frequency apparatus, to other (heavy) industrial equipment, to overhead power lines, to high voltage equipment and to electric traction.

This third edition cancels and replaces the second edition published in 2010. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition:

- a) updated description of the RF characteristics of spark discharges;
- b) measurement method for radiated disturbances in the frequency range from 300 MHz to 3 GHz.

The text of this technical report is based on the following documents:

DTR	Report on voting
CIS/B/654/DTR	CIS/B/675/RVDTR

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

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

A list of all parts of the CISPR 18 series can be found, under the general title *Radio interference characteristics of overhead power lines and high-voltage equipment*, on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC 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 document using a colour printer.

INTRODUCTION

This Technical Report is the second of a three-part series dealing with radio noise generated by electrical power transmission and distribution facilities (overhead lines and substations). It contains recommendations for performance of on-site measurements of electromagnetic noise fields in the vicinity of high-voltage (HV) overhead power lines and substations and for determination of limits for protection of radio reception.

The recommendations given in this Part 2 of the CISPR 18 series are intended to be a useful aid to engineers involved in maintenance of overhead power lines and substations and also to anyone concerned with checking the radio noise performance of a line to ensure satisfactory protection of radio reception. Information on the physical phenomena involved in the generation of electromagnetic noise fields is found in CISPR TR 18-1. It also includes the main properties of such fields and their numerical values. CISPR TR 18-3 eventually contains a Code of Practice for minimizing the generation of radio noise.

This third edition of CISPR TR 18-2 is adapted to the modern structure and content of technical reports issued by IEC. The second edition of CISPR TR 18-2 underwent thorough edition and adaptation to modern terminology. This third edition now also covers an adequate method of measurement for radiated disturbances from HV overhead power lines and substations in the range 300 MHz to 3 GHz, since gap-type discharges can be a potential noise source disturbing modern digital radio communication. However, because

- 1) there is not sufficient experience and information regarding gap-type noise and thus further investigations regarding noise characteristics and how gap noise disturbs digital radio communication are necessary,
- 2) gap noise is not persistent in normal operation of the electric power facility and tends to emerge from defective components,

there is no discussion in this edition regarding technical considerations for derivation of limits in the frequency range 300 MHz to 3 GHz.

The CISPR 18 series does not deal with biological effects on living matter or any issues related to exposure to electromagnetic fields.

The main content of this technical report is based on historical CISPR Rec. No. 56 given below:

RECOMMENDATION No. 56

METHODS OF MEASUREMENT OF RADIO INTERFERENCE CAUSED BY OVERHEAD POWER LINES AND HIGH-VOLTAGE EQUIPMENT AND THE PROCEDURE FOR DETERMINING LIMITS

The CISPR

CONSIDERING

- a) that a general description of the radio interference characteristics of overhead power lines and high-voltage equipment has been published in CISPR 18-1,
- b) that the methods of measurement of these characteristics need to be established,
- c) that national authorities require guidance on the procedure for determining limits of such radio interference.

RECOMMENDS

That the latest edition of CISPR TR 18-2, including amendments, be used for methods of measurement of radio interference characteristics of overhead power lines and high-voltage equipment and for procedures for determining limits.

CISPR TR 18-1 describes the main properties of the physical phenomena involved in the production of disturbing electromagnetic fields by overhead lines and provides numerical values of such fields.

In CISPR TR 18-2, methods of measurement and procedures for determining limits of such radio interference are recommended.

The methods of measurement in CISPR TR 18-2 detail the techniques and procedures for use when measuring electromagnetic fields arising from radio interference at sites close to overhead lines and also the techniques and procedures for making laboratory measurements of interference voltages and currents generated by line equipment and accessories.

The procedures for determining limits define the expected values of radio noise field and the width of the "disturbed" corridor following the route of the line.

This corridor takes into account the effective field strength of the wanted signal, the signal-to-noise ratio selected and the expected strength of the noise field for a given line.

The procedures are only valid for long and medium waves because procedures applicable to VHF analogue television broadcasting and digital terrestrial television broadcasting have not yet been decided, due to insufficient knowledge.

It is emphasized that this part of CISPR 18 does not specify a single set of limits to be applied internationally. Rather it details the procedures to enable national authorities to specify limits where it is decided that there is a need for regulations.

RADIO INTERFERENCE CHARACTERISTICS OF OVERHEAD POWER LINES AND HIGH-VOLTAGE EQUIPMENT –

Part 2: Methods of measurement and procedure for determining limits

1 Scope

This part of CISPR 18, which is a Technical Report, applies to radio noise from overhead power lines and high-voltage equipment which may cause interference to radio reception.

The frequency range covered by this publication is 0,15 MHz to 3 GHz.

A general procedure for establishing the limits of the radio noise field from the power lines and equipment is recommended, together with typical values as examples, and methods of measurement.

The clause on limits concentrates on the low frequency and medium frequency bands and it is only in these bands where ample evidence, based on established practice, is available. No examples of limits to protect radio reception in the frequency band 30 MHz to 3 GHz have been given, as measuring methods and certain other aspects of the problems in this band have not yet been fully resolved. Site measurements and service experience have shown that levels of noise from power lines at frequencies higher than 300 MHz in normal operation are so low that interference is unlikely to be caused to television reception.

The values of limits given as examples are calculated to provide a reasonable degree of protection to the reception of broadcasting at the boundary of the recognized service areas of the appropriate transmitters in the radio frequency bands used for a.m. radio broadcasting, in the least favourable conditions likely to be generally encountered. These limits are intended to provide guidance at the planning stage of the line and national standards or other specifications against which the performance of the line may be checked after construction and during its useful life.

The measuring apparatus and methods used for checking compliance with limits should comply with the respective CISPR specifications, as e.g. the basic standards series CISPR 16, see [1]¹.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

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

IEC 60060-2, *High-voltage test techniques – Part 2: Measuring systems*

¹ The figures in square brackets refer to the Bibliography.

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*

ISO IEC Guide 99, *International vocabulary of metrology – Basic and general concepts and associated terms (VIM)*

NOTE Informative references are listed in the Bibliography.