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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

TR CISPR 18-2:2010(E)

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FOREWORD

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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 second edition cancels and replaces the first edition published in 1986. It is a technical revision.

This edition includes the following significant technical changes with respect to the previous edition: while the first edition of CISPR 18-2 only considered the direct distance D_0 for the establishment of standard profiles for the lateral radio noise field emanating from HV overhead power lines, this second edition now also allows for use of the lateral distance y_0 for these purposes. This way it allows for conduction of on-site measurements and simplified recording and use of measurement data obtained at lateral distances *y* slant to the pathway of modern HV and UHV overhead power line constructions with tall suspension towers.

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

DTR	Report on voting
CISPR/B/494/DTR	CISPR/B/502/RVC

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 technical report 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.

INTRODUCTION

This technical report forms the second of a three-part publication dealing with radio noise generated by electrical power transmission and distribution facilities (overhead lines and substations). It contains recommendations for conduction 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 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 second edition of CISPR/TR 18-2 was adapted to the modern structure and content of technical reports issued by IEC. The first edition of CISPR 18-2 underwent thorough edition and adaptation to modern terminology. Furthermore its content was adjusted such as to allow for use of the lateral distance *y* for the conduction of measurements in the field.

The CISPR 18 series does not deal with biological effects on living matter or any issues related to exposure in 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 fields on site near to an overhead line 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 as the procedures applicable to VHF frequency-modulation 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 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 is 0,15 MHz to 300 MHz.

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 300 MHz 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 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. 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]*.

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.

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

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

* 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*

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*

CISPR/TR 18-1:2010, *Radio interference characteristics of overhead power lines and high-voltage equipment – Part 1: Description of phenomena*

CISPR/TR 18-3:2010, *Radio interference characteristics of overhead power lines and high-voltage equipment – Part 3: Code of practice for minimizing the generation of radio noise*

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

NOTE Informative references are listed in the Bibliography.

3 Terms and definitions

For the purposes of this document, the terms and definitions given in the IEC 60050-161 and the ISO/IEC Guide 99 apply.

4 Measurements

4.1 Measuring instruments

4.1.1 Response of a standard quasi-peak CISPR measuring receiver to a.c. generated corona noise

CISPR 16-1-1 specifies the response characteristic of a measuring receiver to periodically repeated pulses, according to their repetition frequency, for a number of different frequency ranges and bandwidths including the range 0,15 MHz to 30 MHz and a resolution bandwidth of 9 kHz.

Figure 1 indicates the form these pulses take as they progress through the various stages of the measuring receiver. However, in the special case of corona pulses generated by high-voltage a.c. power systems, the individual pulses are not equally spaced throughout a cycle but occur in closely packed groups or bursts around the peak of the voltage waveform. A burst has a duration not exceeding 2 ms to 3 ms and this is followed by a quiescent no-corona period.

Owing to its inherent time constants, a standard quasi-peak CISPR measuring receiver is unable to respond to individual pulses within a burst, which is seen as a single pulse whose amplitude is discussed below.

Hence, the pulse repetition frequency, in the meaning of the CISPR definition is constant at $2f$ (where f is the power system frequency) for single phase and $6f$ for three-phase single or multi-circuit systems, provided that the individual circuits are part of the same system.

Figure 2 indicates the usual case where individual corona pulses generated around the positive peaks of the voltage waveform are much greater in amplitude than those generated around the negative peaks. Hence in a three-phase power line there are three bursts of higher amplitude and three burst of lower amplitude noise during each period of $1/f$.

Also, in the measurement of the radio noise field strength in close vicinity of an operational line, the antenna of the measuring receiver is not located at the same distance from all the phase conductors. Then because a quasi-peak detector responds only to the higher amplitude bursts and disregards the lower ones, rules of summation of the radio noise generated by the individual phases of a line can be formulated which are specific to the CISPR characteristics and are given in Clause 4 of CISPR/TR 18-3. It should be noted that the loudspeaker of a radio receiver, and consequently the listener, perceives the overall generated noise.

To examine the response of the CISPR measuring receiver to a given burst of pulses, it should be borne in mind that each individual pulse becomes, at the output of the amplifier of figure 1 of pass-band Δf, a damped oscillation whose duration can be taken as approximately 2/RBW (i.e. 0,5 times its IF amplifier resolution bandwidth), or 0,22 ms for 9 kHz. When there are a large number of pulses distributed at random within a burst, the resulting oscillations will overlap randomly and the overall quasi-peak signal will be approximately equal to the quadratic sum of the individual quasi-peak values. This statement, which is difficult to prove mathematically, has been well proven by experience and justifies the use, in quasi-peak detection, of the quadratic summation law which would moreover be rigorous if the noise levels were expressed in r.m.s. values.

4.1.2 Other measuring instruments

Measuring instruments differing from standard CISPR instruments are referred to in Annex A although measuring instruments having detectors other than quasi-peak are also referred to in CISPR 16-1-1.

4.2 On-site measurements on HV overhead power lines

4.2.1 General

On-site measurements in the vicinity of HV overhead power lines should be carried out in accordance with the instructions given in this clause. Further information about a possible assessment and documentation of measured data is found in 5.3.5 and 5.4.

4.2.2 Measurements in the frequency range from 0,15 MHz to 30 MHz

4.2.2.1 Reference frequency

The reference measurement frequency is 0,5 MHz. It is recommended that measurements are made at a frequency of 0,5 MHz ± 10 % but other frequencies, for example 1 MHz, may also be used. The frequency of 0,5 MHz (or 1 MHz) is preferred because, usually, the level of radio noise at this part of the spectrum is representative of the higher levels and also because 0,5 MHz lies between the low and medium frequency broadcast bands.

Because of the possibility of error due to the presence of standing waves, it is inadvisable to rely on the measured value of the radio noise field strength at a single frequency but to draw a mean curve through the results of a number of readings throughout the noise spectrum. Measurements should be made at, or near, the following frequencies: 0,15 MHz, 0,25 MHz, 0,5 MHz, 1,0 MHz, 1,5 MHz, 3,0 MHz, 6,0 MHz, 10,15 MHz and 30 MHz although, clearly, frequencies at which interference to the wanted noise is received, should be avoided.

4.2.2.2 Measurement antenna

The antenna used for the measurements shall be an electrically-screened vertical loop, whose dimensions are such that the antenna will be completely enclosed by a square having a side of 600 mm in length. The balance shall be such that in a uniform field the ratio between the maximum and minimum indications on the measuring receiver when the antenna is rotated shall not be less than 20 dB. The base of the loop should be about 2 m above ground. The antenna shall be rotated around a vertical axis and the maximum indication noted. If the plane of the loop is not effectively parallel to the direction of the power line, the orientation should be stated.

NOTE According to the ANSI/IEEE Standard 430 (1986) [4], the antenna height using measurement vehicle is recommended as below:

If a vehicle-mounted antenna is used, the antenna should be at least 2 m above the roof of the vehicle. The effects of vehicles on vehicle-mounted antennas have been found to be negligible if this minimum height of 2 m is maintained; however, the vehicle and antenna combination should be calibrated to confirm the antenna factors and to check for existence of azimuthal asymmetries in the antenna pattern, as described in Section 5 of IEEE Standard 473 (1985) [5].

A check shall be made to ensure that the supply mains, if used, or other conductors connected to the measuring apparatus do not affect the measurements.

4.2.2.3 Selection of measurement points along the pathway of the overhead HV power transmission line

To determine the radio noise performance of a line certain positions of measurement should be avoided; but these restrictions would not apply when an investigation into a case of interference is being carried out.

Measurements should be made at mid-span between the towers and preferably at several such positions. Measurements should not be made near points where lines change direction or intersect.

Sites at an abnormal height of span should be avoided. The measuring site should be flat, free from trees and bushes and remote from large metal structures and other overhead power and telephone lines.

Ideally the measuring site should be at a distance greater than 10 km from a line termination, in order to avoid reflection effects and consequently inaccurate results, but lower voltage distribution lines are sometimes too short to enable this condition to be met. However, the results of measurement (see reference [6]) indicate that the level of the radio noise field strength in the absence of reflections corresponds to the geometric mean of the maximum and minimum values, in microvolt per metre (µV/m), of the frequency spectrum from a line subjected to reflections.

If the line is transposed, the measuring site should be located as far as possible from the transposition towers.

The atmospheric conditions should be approximately uniform along the line. Measurements under rain conditions will be valid only if the rain extends over at least 10 km of the line on either side of the measuring site.

Annex B gives a list of such information.

4.2.2.4 Selection of measurement points lateral to the pathway of the overhead HV power transmission line

Measurements are performed e.g. for determination of the lateral field strength profile of the radio noise field generated by overhead HV power transmission lines. In these conditions a number of measurement points at mid-span in between two towers should be chosen along a straight line departing perpendicular from the pathway of the overhead HV power transmission line under test. The distances of measurement shall be taken laterally from the vertical projection to ground of the outmost sub-conductor of the transmission line (reference point (x,y,z), i.e. x = place along the line at mid-span where the measurements are made, y = 0 m and z = 0 m corresponding to the vertical projection to ground of the outmost sub-conductor) to the centre of the antenna used for the measurements. For determination of the overall typical lateral field strength profile of the radio noise field of a given overhead HV power transmission line it may be sufficient to consider lateral distances y in the range from 0 m to 200 m.