TECHNICAL REPORT

CISPR 16-3

Second edition
2003-11

INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

Specification for radio disturbance and immunity measuring apparatus and methods –

Part 3: CISPR technical reports

Reference number
CISPR 16-3/TR:2003(E)

Publication numbering

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Commission Electrotechnique Internationale
International Electrotechnical Commission
Международная Электротехническая Комиссия

PRICE CODE XH

For price, see current catalogue

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY MEASURING APPARATUS AND METHODS –

Part 3: CISPR technical reports

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.
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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 16-3, which is a technical report, has been prepared by CISPR subcommittee A: Radio interference measurements and statistical methods.

This second edition of CISPR 16-3, together with CISPR 16-4-1, CISPR 16-4-3 and CISPR 16-4-4 cancels and replaces the first edition of CISPR 16-3, published in 2000, and its amendment 1 (2002). It contains the relevant clauses of CISPR 16-3 without technical changes.

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

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

The committee has decided that the contents of this publication will remain unchanged until 2006. At this date, the publication will be

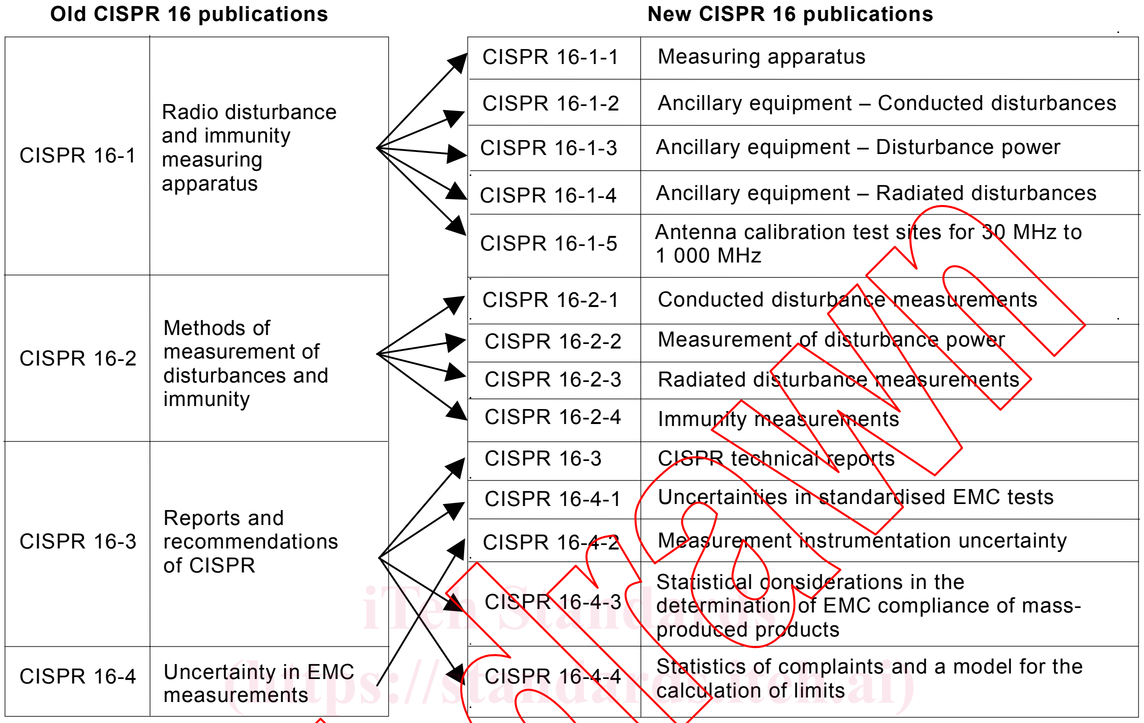
- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

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

Report 33 – p/o CISPR 8, 1969; Report 38 – p/o CISPR 8, 1969; Report 49 – p/o CISPR 8C, 1980; Report: CIS/A(Sec)67 + CIS/A(Sweden)29; RM 2828/CISPR/A, 1985; CIS/A(CO)32, 1985; CIS/A(Sec)58, 1983; CIS/A(Sec)58A, 1983; CIS/A(Sec)67, 1985; CIS/A(CO)77A, 1993; CIS/A(CO)81, 1987; CIS/A(CO)82, 1994; CIS/A(CO)84, 1994; CIS/A(Sec)84, 1987; CIS/A(Sec)88, 1988; CIS/A(Sec)88A, 1988; CIS/A(Sec)94, 1989; CIS/A(Sec)115, 1991; CIS/A(Sec)115A, 1991; CIS/A(Sec)116, 1991; CIS/A(Sec)124, 1991; CIS/A(Sec)128, 1992; CIS/A(Sec)132, 1993; CIS/A/166/CD, 1995.

INTRODUCTION

CISPR 16-1, CISPR 16-2, CISPR 16-3 and CISPR 16-4 have been reorganised into 14 parts, to accommodate growth and easier maintenance. The new parts have also been renumbered. See the list given below.



Old CISPR 16 publications

CISPR 16-1	Radio disturbance and immunity measuring apparatus
CISPR 16-2	Methods of measurement of disturbances and immunity
CISPR 16-3	Reports and recommendations of CISPR
CISPR 16-4	Uncertainty in EMC measurements

New CISPR 16 publications

CISPR 16-1-1	Measuring apparatus
CISPR 16-1-2	Ancillary equipment – Conducted disturbances
CISPR 16-1-3	Ancillary equipment – Disturbance power
CISPR 16-1-4	Ancillary equipment – Radiated disturbances
CISPR 16-1-5	Antenna calibration test sites for 30 MHz to 1 000 MHz
CISPR 16-2-1	Conducted disturbance measurements
CISPR 16-2-2	Measurement of disturbance power
CISPR 16-2-3	Radiated disturbance measurements
CISPR 16-2-4	Immunity measurements
CISPR 16-3	CISPR technical reports
CISPR 16-4-1	Uncertainties in standardised EMC tests
CISPR 16-4-2	Measurement instrumentation uncertainty
CISPR 16-4-3	Statistical considerations in the determination of EMC compliance of mass-produced products
CISPR 16-4-4	Statistics of complaints and a model for the calculation of limits

More specific information on the relation between the ‘old’ CISPR 16-3 and the present ‘new’ CISPR 16-3 is given in the table after this introduction (TABLE RECAPITULATING CROSS REFERENCES).

Measurement instrumentation specifications are given in five new parts of CISPR 16-1, while the methods of measurement are covered now in four new parts of CISPR 16-2. Various reports with further information and background on CISPR and radio disturbances in general are given in CISPR 16-3. CISPR 16-4 contains information related to uncertainties, statistics and limit modelling.

TABLE RECAPITULATING CROSS-REFERENCES

First edition of CISPR 16-3 Clauses, subclauses	Second edition of CISPR 16-3 Clauses, subclauses
1.1	1
1.2	2
1.3	3
4	4
4.1	4.1
4.2	4.2
4.3	4.3
4.4	4.4
4.5	4.5
4.6	4.6
5	5
5.1	5.1
5.2	5.2

SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY MEASURING APPARATUS AND METHODS –

Part 3: CISPR technical reports

1 Scope

This part of CISPR 16 contains specific technical reports and information on the history of CISPR.

Over the years, the CISPR prepared a number of recommendations and reports that have significant technical merit but were not generally available. Reports and recommendations were for some time published in CISPR 7 and 8.

At its meeting in Campinas, Brazil, in 1988, subcommittee A agreed on the table of contents of part 3 and to publish the reports for posterity by giving the reports a permanent place in part 3.

With the reorganization of CISPR 16 in 2003, the significance of CISPR limits has been moved to CISPR 16-4-3, whereas recommendations on statistics of disturbance complaints and on the report on the determination of limits has been moved to CISPR 16-4-4. The contents of Amendment 1 (2002) has been moved to CISPR 16-4-1.

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.

CISPR 11, *Industrial, scientific and medical (ISM) radio-frequency equipment – Electromagnetic disturbance characteristics – Limits and methods of measurement*

CISPR 16-1 (all parts), *Specification for radio disturbance and immunity measuring apparatus and methods – Radio disturbance and immunity measuring apparatus*

CISPR 16-2 (all parts), *Specification for radio disturbance and immunity measuring apparatus and methods – Methods of measurement of disturbances and immunity*

CISPR 16-4 (all parts), *Specification for radio disturbance and immunity measuring apparatus and methods – Uncertainties, statistics and limit modelling*

ITU-R Recommendation BS. 468-4, *Measurement of audio-frequency noise voltage level in sound broadcasting*

3 Definitions

For the purpose of this part of CISPR 16, the definitions of CISPR 16-1 and IEV 60050(161) as well as the following definitions apply.

3.1

bandwidth (B_n)

width of the overall selectivity curve of the receiver between two points at a stated attenuation, below the midband response. The bandwidth is represented by the symbol B_n, where n is the stated attenuation in decibels

3.2
impulse bandwidth (B_{imp})

$$B_{imp} = A(t)_{max} / (2G_o \times IS)$$

where

$A(t)_{max}$ is the peak of the envelope at the IF output of the receiver with an impulse area IS applied at the receiver input;

G_o is the gain of the circuit at the centre frequency.

Specifically, for two critically coupled tuned transformers,

$$B_{imp} = 1{,}05 \times B_6 = 1{,}31 \times B_3$$

where B_6 and B_3 are respectively the bandwidths at the –6 dB and –3 dB points (see CISPR 16-1-1 for further information)

3.3
impulse area (sometimes called impulse strength) (IS)

the voltage-time area of a pulse defined by the integral:

$$IS = \int_{-\infty}^{+\infty} V(t)\mathrm{d}t \text{ (expressed in } \mu\text{Vs or dB}(\mu\text{Vs}))$$

NOTE Spectral density (D) is related to impulse area and expressed in µV/MHz or dB(µV)/MHz. For rectangular impulses of pulse duration T at frequencies $f << 1/T$, the relationship D (µV/MHz) = $2 \times 10^6/IS$ (µVs) applies since D is calibrated in r.m.s. values of a corresponding sine wave.

3.4
electrical charge time constant (T_C)

time needed after the instantaneous application of a constant sine-wave voltage to the stage immediately preceding the input of the detector for the output voltage of the detector to reach 63 % of its final value

NOTE This time constant is determined as follows. A sine-wave signal of constant amplitude and having a frequency equal to the mid-band frequency of the i.f. amplifier is applied to the input of the stage immediately preceding the detector. The indication, D, of an instrument having no inertia (for example, a cathode-ray oscilloscope) connected to a terminal in the d.c. amplifier circuit so as not to affect the behaviour of the detector, is noted. The level of the signal is chosen such that the response of the stages concerned remains within the linear operating range. A sine-wave signal of this level, applied for a limited time only and having a wave train of rectangular envelope is gated such that the deflection registered is 0,63D. The duration of this signal is equal to the charge time of the detector.

3.5
electrical discharge time constant (T_D)

time needed after the instantaneous removal of a constant sine-wave voltage applied to the stage immediately preceding the input of the detector for the output of the detector to fall to 37 % of its initial value

NOTE The method of measurement is analogous to that for the charge time constant, but instead of a signal being applied for a limited time, the signal is interrupted for a definite time. The time taken for the deflection to fall to 0,37D is the discharge time constant of the detector.

3.6
mechanical time constant (T_M) of a critically damped indicating instrument

$$T_M = T_L / 2\pi$$

where T_L is the period of free oscillation of the instrument with all damping removed.

NOTE 1 For a critically damped instrument, the equation of motion of the system may be written as

$$T_{\mathrm{M}}^{2}(\mathrm{d}^{2}\alpha / \mathrm{d}t^{2}) + 2T_{\mathrm{M}}(\mathrm{d}\alpha / \mathrm{d}t) + \alpha = \mathrm{k}i$$

where

α is the deflection;

i is the current through the instrument;

k is a constant.

It can be deduced from this relation that this time constant is also equal to the duration of a rectangular pulse (of constant amplitude) that produces a deflection equal to 35 % of the steady deflection produced by a continuous current having the same amplitude as that of the rectangular pulse.

NOTE 2 The methods of measurement and adjustment are deduced from one of the following:

a) The period of free oscillation having been adjusted to $2\pi T_{\mathrm{M}}$, damping is added so that α_{TM} = 0,35 α_{max}.

b) When the period of oscillation cannot be measured, the damping is adjusted to be just below critical such that the overswing is not greater than 5 % and the moment of inertia of the movement is such that α_{TM} = 0,35 α_{max}.

3.7
overload factor

ratio of the level that corresponds to the range of practical linear function of a circuit (or a group of circuits) to the level that corresponds to full-scale deflection of the indicating instrument.

The maximum level at which the steady-state response of a circuit (or group of circuits) does not depart by more than 1 dB from ideal linearity defines the range of practical linear function of the circuit (or group of circuits)

3.8
symmetric voltage

in a two-wire circuit, such as a single-phase mains supply, the symmetric voltage is the radio-frequency disturbance voltage appearing between the two wires. This is sometimes called the differential mode voltage. If *Va* is the vector voltage between one of the mains terminals and earth and *Vb* is the vector voltage between the other mains terminal and earth, the symmetric voltage is the vector difference (*Va* – *Vb*)

3.9
asymmetric voltage

radio-frequency disturbance voltage appearing between the electrical mid-point of the mains terminals and earth. It is sometimes called the common-mode voltage and is half the vector sum of *Va* and *Vb*, i.e. (*Va* + *Vb*)/2.

3.10
unsymmetric voltage

amplitude of the vector voltage, *Va* or *Vb* defined in 3.8 and 3.9. This is the voltage measured by the use of an artificial mains V-network

3.11
CISPR indicating range

range specified by the manufacturer which gives the maximum and the minimum meter indications within which the receiver meets the requirements of CISPR 16-1-1.

4 Technical reports

4.1 Correlation between measurements made with apparatus having characteristics differing from the CISPR characteristics and measurements made with CISPR apparatus

4.1.1 Introduction

CISPR standards for instrumentation and methods of measurement have been established to provide a common basis for controlling radio interference from electrical and electronic equipment in international trade.

The basis for establishing limits is that of providing a reasonably good correlation between measured values of the interference and the degradation it produces in a given communications system. The acceptable value of signal-to-noise ratio in any given communication system is a function of its parameters including bandwidth, type of modulation and other design factors. As a consequence, various types of measurements are used in the laboratory in research and development work in order to carry out the required investigations.

The purpose of this subsection is to analyse the dependence of the measured values on the parameters of the measuring equipment and on the waveform of the measured interference.

4.1.2 Critical interference measuring instrument parameters

The most critical factors in determining the response of an instrument for measuring interference are the following: the bandwidth, the detector, and the type of interference being measured. Considered to be of secondary importance, but, nevertheless, quite significant in correlating instruments under particular circumstances, are: overload factor, AGC design (if used), image and other spurious responses, and meter time constant and damping.

For purposes of discussion, reference is made to three fundamental types of radio noise: impulse, random and sine wave. The dependence of the response to each of these on the bandwidth and the type of detector is given in table 4.1-1. In this table, δ is the magnitude of the impulse strength, Δf_{imp} is the impulse bandwidth, Δf_{rn} is the random noise bandwidth, $P(\alpha)$ is the pulse response for the quasi-peak detector, f_{PR} is the pulse repetition frequency, and E' is the spectral amplitude of the random noise. The relative responses of various detectors to impulse interference for one instrument are shown in figure 4.1-1.

Table 4.1-1 shows that the dependence of the noise meter response on bandwidth is different for all three types of interference. If the waveform being measured can be defined as being any of the three types listed in table 4.1-1, and if a standard source provides that type of waveform, then by using the substitution method, a satisfactory calibration can be obtained for any instrument with adequate overload factor independent of its bandwidth. Thus, with a purely random interference or a purely impulsive interference of known repetition rate, calibration can be made using a corresponding source, or a correlation factor calculated on the basis of known circuit parameters.

If a particular interference waveform is of a type intermediate between these three types, then the correction or correlation factors will also be intermediate. In any given case, it will be necessary to classify the noise waveform in such a manner that a significant correlation factor can be established. Hence, in order to develop this subject to any significant extent, it will be necessary to examine typical interference sources and to determine the extent to which they are of impulsive, random, or sine-wave type.

If an interference measuring set with several types of detectors is available, for example, peak, quasi-peak and average, the type of interference can be assessed by measuring the ratios of the readings obtained with these detectors. These ratios will, of course, depend upon the bandwidth and other characteristics of the instrument being used for the measurement.

4.1.3 Impulse interference – Correlation factors

The quasi-peak detector response of any interference measuring set to regularly repeated impulses of uniform amplitude can be determined by the use of the "pulse response curve" which is shown in figure 4.1-2. This figure shows the response of the detector in percentage of peak response for any given bandwidth and value of charge resistance and discharge resistance. Applying this curve, it should be noted that the peak itself is dependent upon the bandwidth, so that as the bandwidth increases, peak value increases, but the percentage of peak, which is read by the detector, decreases; over a narrow range of bandwidth, these effects tend to counteract each other. The bandwidth used in this curve is the 6 dB bandwidth, which, for the passband characteristics typical of most interference measuring equipment, is about 5 % less than the so-called impulse bandwidth. A theoretical comparison of instruments having various bandwidths and detector parameters with the CISPR instrument is shown in figure 4.1-3.

The response of the average detector to impulsive noise is an interesting case. The reading of an average detector for impulsive noise is independent of the bandwidth of the pre-detector stages. It is, of course, directly proportional to the repetition rate. In most cases, the reading obtained with an average detector for impulsive noise is so low as to be of no practical value unless the noise meter bandwidth is exceedingly narrow, such as of the order of a few hundred hertz. For a repetition rate of 100 Hz and a bandwidth of the order of 10 kHz, the average value would be approximately 1 % of the peak value. Such a value is too low to measure with any degree of precision. Furthermore, for many communication systems, the annoyance effect may be well above the reading obtained with the average meter. This, of course, is one of the justifications for the use of the quasi-peak instrument.

4.1.4 Random noise

The response of a noise meter to random noise is proportional to the square root of the bandwidth. This result is independent of the type of detector used. The ratio of the random noise bandwidth to the 3 dB bandwidth is a function of the type of filter circuit. On the other hand, it has been shown that for many circuits typical of those used in interference measuring equipment, a ratio of effective random noise bandwidth to the 3 dB bandwidth of about 1,04 is a reasonable figure.

4.1.5 The r.m.s. detector

One of the advantages of the r.m.s. detector in correlation work is that for broadband noise the output obtained from it will be proportional to the square root of the bandwidth, i.e. the noise power is directly proportional to the bandwidth. This feature makes the r.m.s. detector particularly desirable and is one of the main reasons for adopting the r.m.s. detector to measure atmospheric noise. Another advantage is that the r.m.s. detector makes a correct addition of the noise power produced by different sources, for example, impulsive noise and random noise, thus for instance allowing a high degree of background noise.

The r.m.s. values of noise often give a good assessment of the subjective effect of interference to a.m. sound and television reception. However, the very wide dynamic range needed when using very wide-band instruments for measuring impulsive noise, limits the use of r.m.s. detectors to narrow-band instruments.

4.1.6 Discussion

The preceding paragraphs have indicated the theoretical basis for comparing measurements obtained with different instruments. As mentioned previously, the possibility of establishing significant correlation factors depends upon the extent to which noise can be classified and identified so that the proper correlation factors may be used. In many frequency ranges, impulsive interference appears to be the most serious; however, for power lines where corona interference is the primary concern, random interference would be expected to be more characteristic. Additional quantitative data are needed on typical interference characteristics. Another important parameter is the overload factor.

4.1.7 Application to typical noise sources

Commutator motors

The noise generated by commutator motors is usually a combination of impulse and random noise. The random noise originates in the varying brush contact resistance, while the impulse noise is generated from the switching action at the commutator bars. For optimum adjustment of commutation the impulse noise can be minimized. However, where variable loading is possible, measurements have confirmed that for the peak and quasi-peak detectors, the dominant noise is of impulse type and the random component may be neglected. While the repetition rate may be of the order of 4 kHz, the effective rate is lower because the amplitude of the impulses is usually modulated at twice the line frequency. Hence, experimental results have shown that quasi-peak readings are consistent with bandwidth variations if the repetition rate of the impulse is assumed to be twice the line frequency.

Peak measurements show fluctuating levels on such noise because of the irregular nature of the commutator switching action.

The quasi-peak to average ratio is lower than would be obtained for pure impulse noise for two reasons.

1) The modulation of the commutator switching transients by line frequency produces many pulses below the measured quasi-peak level. These pulses do not contribute to the quasi-peak value but do contribute to the average.
2) The relatively low level, but continuous, random noise can likewise contribute substantially only to the average value. Experimental values of quasi-peak to average ratio ranged from 13 dB to 23 dB with the highest ratios for the widest bandwidths (120 kHz).

Impulsive sources

Tests on an ignition model, commutator motor appliances, and appliances using vibrating regulators showed reasonable agreement on instruments with the same nominal bandwidth, but with time constant ratios of the order of 3 to 1 on restricted portions of the output indicator scale. Deviations at higher scale values are without explanation. Relatively poor correlation was obtained on sources producing very low repetition rate pulses.

Ignition interference

CISPR Recommendation 35 recognizes that correlation between quasi-peak and peak detectors can be established as a practical matter. The conversion factor of 20 dB is explained partly on the basis of theory for uniform repeated impulses, and partly on the basis of the actual irregularity of the amplitude and wave shape of such impulses.

Noise from high-voltage lines

Comparative tests were made with an instrument meeting CISPR specification and one meeting those of the U.S.A. Standards Institute. The latter read 0 dB to 1 dB higher in one test and 1 dB to 3 dB higher in another (see IEEE Special Publication 31C44).