

INTERNATIONAL STANDARD



INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

BASIC EMC PUBLICATION

**Specification for radio disturbance and immunity measuring apparatus and methods –
Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus**



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**Specification for radio disturbance and immunity measuring apparatus and methods –
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INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.100.10

ISBN 978-2-8322-2928-6

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

CISPR 16-1-1
Edition 4.0 2015-09

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

**Part 1-1: Radio disturbance and immunity measuring apparatus –
Measuring apparatus**

INTERPRETATION SHEET 1

This interpretation sheet has been prepared by subcommittee CISPR A: Radio-interference measurements and statistical methods, of IEC technical committee CISPR: International special committee on radio interference.

The text of this interpretation sheet is based on the following documents:

FDIS	Report on voting
CIS/A/1244/FDIS	CIS/A/1255/RVD

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

INTRODUCTION:

CISPR/A/1118/FDIS was approved (see CISPR/A/1135/RVD) and consequently the corresponding international standard, CISPR 16-1-1:2015 (Edition 4.0) was published on 22 September 2015.

However, seven National Committees had submitted a negative vote. Most concerns were related to the measuring receiver specifics covered in K.4. That clause states:

“This standard specifies measuring receiver requirements using a “black box” approach. This means that the instrument shall show a specific response when a defined signal is applied to its input. Therefore, the demonstration of compliance of measuring receivers with specifications defined in this standard can be provided through the manufacturer’s calibration process or the procedures and measuring equipment defined in this standard.

In case compliance of a measuring receiver is determined with the specifications in this standard, the following minimum set of parameters shown in Table K.1 shall be included in the verification process.”

It was argued that the wording in these two cited paragraphs might be misinterpreted in such a way that the specifications in CISPR 16-1-1 are not met when using the manufacturer's calibration process. Furthermore, concerns were raised that the wording may have the effect that only manufacturers' calibration procedures can be used to show compliance with the specifications in CISPR 16-1-1.

Because of these concerns, K.4 could benefit from further clarification. An interpretation sheet would be helpful to users of the standard, with the intent that this clarification would be published in a future amendment to the standard.

This information does not change the standard; it serves only to clarify the points noted.

INTERPRETATION:

Demonstration of compliance with CISPR 16-1-1

For demonstrating compliance with CISPR 16-1-1 using the manufacturer's calibration process, the specifications in CISPR 16-1-1 shall be met, including verification of the minimum set of parameters listed in Table K.1.

It is permissible to use either the manufacturer's calibration process or a calibration laboratory's own process that is applying the procedures and measuring equipment defined in this standard. The user of CISPR 16-1-1 is responsible for deciding which of these two approaches to use, both which are considered equivalent.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION
INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

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

**Part 1-1: Radio disturbance and immunity measuring apparatus –
Measuring apparatus**

FOREWORD

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International Standard CISPR 16-1-1 has been prepared by CISPR subcommittee A: Radio-interference measurements and statistical methods.

This fourth edition cancels and replaces the third edition published in 2010, Amendment 1:2010 and Amendment 2:2014. This edition constitutes a technical revision.

The main technical change with respect to the previous edition consists of the addition of a new normative annex on calibration requirements for measuring receivers.

It has the status of a basic EMC publication in accordance with IEC Guide 107, *Electromagnetic compatibility – Guide to the drafting of electromagnetic compatibility publications*.

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

FDIS	Report on voting
CISPR/A/1118/FDIS	CISPR/A/1135/RVD

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.

A list of all parts of the CISPR 16 series can be found, under the general title *Specification for radio disturbance and immunity measuring apparatus and methods*, 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 website 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.

The contents of the Interpretation sheet of April 2018 have been included in this copy.

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

The CISPR 16 series, published under the general title *Specification for radio disturbance and immunity measuring apparatus and methods*, is comprised of the following sets of standards and reports:

- CISPR 16-1 – ~~five~~ **six** parts covering measurement instrumentation specifications;
- CISPR 16-2 – five parts covering methods of measurement;
- CISPR 16-3 – a single publication containing various technical reports (TRs) with further information and background on CISPR and radio disturbances in general;
- CISPR 16-4 – five parts covering uncertainties, statistics and limit modelling.

CISPR 16-1 consists of the following parts, under the general title *Specification for radio disturbance and immunity measuring apparatus and methods – Radio disturbance and immunity measuring apparatus*:

- Part 1-1: Measuring apparatus
- Part 1-2: Ancillary equipment – Conducted disturbances
- Part 1-3: Ancillary equipment – Disturbance power
- Part 1-4: Ancillary equipment – Radiated disturbances
- Part 1-5: Antenna calibration **sites and reference test sites for 5 MHz to 18 GHz**
- **Part 1-6: EMC-antenna calibration**

The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent concerning the measuring receiver with rms-average detector (patent no DE 10126830) given in Clause 7.

IEC takes no position concerning the evidence, validity and scope of this patent right.

The holder of this patent right has assured the IEC that he/she is willing to negotiate licences either free of charge or under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holder of this patent right is registered with IEC. Information may be obtained from:

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ISO (www.iso.org/patents) and IEC (<http://patents.iec.ch>) maintain on-line data bases of patents relevant to their standards. Users are encouraged to consult the data bases for the most up to date information concerning patents.

SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY MEASURING APPARATUS AND METHODS –

Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus

1 Scope

This part of CISPR 16 specifies the characteristics and performance of equipment for the measurement of radio disturbance in the frequency range 9 kHz to 18 GHz. In addition, requirements are provided for specialized equipment for discontinuous disturbance measurements.

NOTE In accordance with IEC Guide 107, CISPR 16-1-1 is a basic EMC standard for use by product committees of the IEC. As stated in Guide 107, product committees are responsible for determining the applicability of the EMC standard. CISPR and its sub-committees are prepared to co-operate with product committees in the evaluation of the value of particular EMC tests for specific products.

The specifications in this standard apply to EMI receivers and spectrum analyzers. The term “measuring receiver” used in this standard refers to both EMI receivers and spectrum analyzers. The calibration requirements for measuring receivers are detailed in Annex J.

Further guidance on the use of use of spectrum analyzers and scanning receivers can be found in Annex B of any one of the following standards: CISPR 16-2-1:2014, CISPR 16-2-2:2010 or CISPR 16-2-3:2010.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

CISPR 11:2009 2015, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*

CISPR 14-1:2005, *Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 1: Emission*

CISPR 14-1:2005/AMD1:2008

CISPR 14-1:2005/AMD2:2011

CISPR 16-2-1:2008 2014, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-1: Methods of measurement of disturbances and immunity – Conducted disturbance measurements*

CISPR 16-2-2:2003 2010, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-2: Methods of measurement of disturbances and immunity – Measurement of disturbance power*

Amendment 1 (2004)

Amendment 2 (2005)

CISPR 16-2-3:2006 2010, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-3: Methods of measurement of disturbances and immunity – Radiated disturbance measurements*

CISPR 16-2-3:2010/AMD1:2010

CISPR 16-2-3:2010/AMD2:2014

CISPR TR 16-3:2003 2010, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 3: CISPR technical reports*

Amendment 1 (2005)

Amendment 2 (2006)

CISPR TR 16-3:2010/AMD1:2012

CISPR TR 16-3:2010/AMD2:2015

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

Amendment 1 (1997)

Amendment 2 (1998)

IEC 60050-161:1990/AMD1:1997

IEC 60050-161:1990/AMD2:1998

IEC 60050-161:1990/AMD3:2014

IEC 60050-161:1990/AMD4:2014

IEC 60050-161:1990/AMD5:2015

3 Terms and definitions

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

Note 1 to entry: n is the stated attenuation in dB.

3.2 CISPR indication range

range specified by the manufacturer which gives the maximum and the minimum meter indications within which the measuring receiver meets the requirements of this part of CISPR 16

3.3 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 1 to entry: 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 IF amplifier is applied to the input of the stage immediately preceding the detector. The indication, D , of an instrument having no inertia (e.g. an 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 0,63 D . The duration of this signal is equal to the charge time of the detector.

3.4 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 1 to entry: 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 0,37 D is the discharge time constant of the detector.

3.5 impulse area

A_{imp}

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

$$A_{\text{imp}} = \int_{-\infty}^{+\infty} V(t) dt \quad (1)$$

Note 1 to entry: Impulse area, sometimes referred to as impulse strength, is typically expressed in μVs or $\text{dB}(\mu\text{Vs})$.

Note 2 to entry: Spectral density (D) is related to impulse area and expressed in $\mu\text{V}/\text{MHz}$ or $\text{dB}(\mu\text{V}/\text{MHz})$. For rectangular impulses of pulse duration T at frequencies $f \ll 1/T$, the relationship $D (\mu\text{V}/\text{MHz}) = \sqrt{2} \times 10^6 A_{\text{imp}} (\mu\text{Vs})$ applies.

3.6 impulse bandwidth

B_{imp}

$$B_{\text{imp}} = \frac{A(t)_{\text{max}}}{2G_0 \times A_{\text{imp}}} \quad (2)$$

where

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

G_0 is the gain of the circuit at the centre frequency.

Specifically for two critically-coupled tuned transformers,

$$B_{\text{imp}} = 1,05 \times B_6 = 1,31 \times B_3 \quad (3)$$

where B_6 and B_3 are respectively the bandwidths at the –6 dB and –3 dB points

Note 1 to entry: See A.2 for further information.

3.7 measuring receiver

instrument such as a tunable voltmeter, an EMI receiver, a spectrum analyzer or a FFT-based measuring instrument, with or without preselection, that meets ~~the requirements of~~ the relevant parts of this standard

~~NOTE 1 The term “measuring receiver” used in this standard refers to both EMI receivers and spectrum analyzers.~~

Note 1 to entry: See Annex I for further information.

3.8

mechanical time constant of a critically damped indicating instrument

T_M

$$T_M = \frac{T_L}{2\pi} \quad (4)$$

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

Note 1 to entry: For a critically damped instrument, the equation of motion of the system may be written as:

$$T_M^2 \left(\frac{d^2\alpha}{dt^2} \right) + 2T_M \frac{d\alpha}{dt} + \alpha = ki \quad (5)$$

where

α is the deflection;

i is the current through the instrument; and

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 to entry: The methods of measurement and adjustment are deduced from one of the following:

- the period of free oscillation having been adjusted to $2\pi T_M$, damping is added so that $\alpha T = 0,35\alpha_{\max}$.
- when the period of oscillation cannot be measured, the damping is adjusted to be just below critical such that the overshoot is not greater than 5 % and the moment of inertia of the movement is such that $\alpha T = 0,35\alpha_{\max}$.

3.9

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

Note 1 to entry: 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).

3.10

symmetric voltage

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

3.11

weighting (of e.g. impulsive disturbance)

pulse-repetition-frequency (PRF) dependent conversion (mostly reduction) of a peak-detected impulse voltage level to an indication that corresponds to the interference effect on radio reception

Note 1 to entry: For the analogue receiver, the psychophysical annoyance of the interference is a subjective quantity (audible or visual, usually not a certain number of misunderstandings of a spoken text).

Note 2 to entry: For the digital receiver, the interference effect is an objective quantity that may be defined by the critical bit error ratio (BER) or bit error probability (BEP) for which perfect error correction can still occur or by another, objective and reproducible parameter.

3.11.1

weighted disturbance measurement

measurement of disturbance using a weighting detector

3.11.2

weighting characteristic

peak voltage level as a function of PRF for a constant effect on a specific radiocommunication system, i.e. the disturbance is weighted by the radiocommunication system itself

3.11.3

weighting detector

detector which provides an agreed weighting function

3.11.4

weighting factor

value of the weighting function relative to a reference PRF or relative to the peak value

Note 1 to entry: Weighting factor is expressed in dB.

3.11.5

weighting function

weighting curve

relationship between input peak voltage level and PRF for constant level indication of a measuring receiver with a weighting detector, i.e. the curve of response of a measuring receiver to repeated pulses

3.12

measurement time

T_m

effective, coherent time for a measurement result at a single frequency (in some areas also called dwell time)

- for the peak detector, the effective time to detect the maximum of the signal envelope
- for the quasi-peak detector, the effective time to measure the maximum of the weighted envelope
- for the average detector, the effective time to average the signal envelope
- for the rms detector, the effective time to determine the rms of the signal envelope

3.13

calibration

operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication

Note 1 to entry: A calibration may be expressed by a statement, calibration function, calibration diagram, calibration curve, or calibration table. In some cases, it may consist of an additive or multiplicative correction of the indication with associated measurement uncertainty.

Note 2 to entry: Calibration should not be confused with adjustment of a measuring system, often mistakenly called "self-calibration", nor with verification of calibration.

Note 3 to entry: Often, the first step alone in the above definition is perceived as being calibration.

[SOURCE: ISO/IEC Guide 99:2007, 2.39] [17]¹

¹ Figures in brackets refer to Bibliography.

3.14

verification

provision of objective evidence that a given item fulfils specified requirements

EXAMPLE Checking whether the functions of a measuring instrument or auxiliary equipment, such as a common mode absorption device (CMAD), meets stated specifications, such as those given in a data sheet.

[SOURCE: ISO/IEC Guide 99:2007, 2.44, modified – addition of an example] [17]

3.15

adjustment (of a measuring system)

set of operations carried out on a measuring system so that it provides prescribed indications corresponding to given values of a quantity to be measured

Note 1 to entry: Types of adjustment of a measuring system include zero adjustment of a measuring system, offset adjustment, and span adjustment (sometimes called gain adjustment).

Note 2 to entry: Adjustment of a measuring system should not be confused with calibration, which is a prerequisite for adjustment.

Note 3 to entry: After an adjustment of a measuring system, the measuring system shall usually be recalibrated.

[SOURCE: ISO/IEC Guide 99:2007, 3.11] [17]

3.16

correction

compensation for an estimated systematic effect

Note 1 to entry: See Guide ISO/CEI 98-3:2008, 3.2.3 [16] for an explanation of 'systematic effect'.

Note 2 to entry: The compensation can take different forms, such as an addend or a factor, or can be deduced from a table.

[SOURCE: ISO/IEC Guide 99:2007, 2.53] [17]

3.17

(metrological) traceability

property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty

[SOURCE: ISO/IEC Guide 99:2007, 2.41] [17]

4 Quasi-peak measuring receivers for the frequency range 9 kHz to 1 000 MHz

4.1 General

The receiver specification depends on the frequency of operation. There is one receiver specification covering the frequency range 9 kHz to 150 kHz (Band A), one covering 150 kHz to 30 MHz (Band B), one covering 30 MHz to 300 MHz (Band C), and one covering 300 MHz to 1 000 MHz (Band D). Fundamental characteristics of a quasi-peak measuring instrument are provided in Annex H.

Spectrum analyzers and FFT-based measuring instruments that meet the requirements of this clause can be used for compliance measurements. For emission measurements, FFT-based measuring instruments shall sample and evaluate the signal continuously during the measurement time.

4.2 Input impedance

The input circuit of measuring receivers shall be unbalanced. For receiver control settings within the CISPR indication range, the input impedance shall be nominally 50 Ω with a voltage

standing wave ratio (VSWR) not to exceed 2,0:1 when the radio frequency (RF) attenuation is 0 dB and 1,2:1 when the RF attenuation is 10 dB or greater.

Symmetric input impedance in the frequency range 9 kHz to 30 MHz: to permit symmetrical measurements a balanced input transformer is used. The preferred input impedance for the frequency range 9 kHz to 150 kHz is 600 Ω . This symmetric input impedance may be incorporated either in the relevant symmetrical artificial network necessary to couple to the receiver or optionally in the measuring receiver.

4.3 Sine-wave voltage accuracy

The accuracy of measurement of sine-wave voltages shall be better than ± 2 dB when the instrument measures a sine-wave signal with 50 Ω resistive source impedance.

4.4 Response to pulses

4.4.1 Amplitude relationship (absolute calibration)

Referring to Table 1, the response of the measuring receiver to pulses of impulse area of a) μ Vs (microvolt second) e.m.f. at 50 Ω source impedance, having a uniform spectrum up to at least b) MHz, repeated at a frequency of c) Hz shall, for all frequencies of tuning, be equal to the response to an unmodulated sine-wave signal at the tuned frequency having an e.m.f. of rms value 2 mV [66 dB(μ V)].

When external preamplifiers are used, refer to Annex J for applicable requirements.

The source impedances of the pulse generator and the signal generator shall both be the same. A tolerance of $\pm 1,5$ dB shall be permitted on the sine-wave voltage level.

Table 1 – Test pulse characteristics for quasi-peak measuring receivers (see 4.4.1)

Frequency range	a) μ Vs	b) MHz	c) Hz
9 kHz to 150 kHz	13,5	0,15	25
0,15 MHz to 30 MHz	0,316	30	100
30 MHz to 300 MHz	0,044	300	100
300 MHz to 1 000 MHz	0,044	1 000	100

NOTE Annexes B and C describe methods for determining the output characteristics of a pulse generator for use in testing the requirements of this subclause.

4.4.2 Variation with repetition frequency (relative calibration)

The response of the measuring receiver to repeated pulses shall be such that for a constant indication on the measuring receiver of e.g. 20 dB(μ V), the relationship between pulse amplitude and repetition frequency is in accordance with Figures 1, 2, 3 and 4. ~~The response of a spectrum analyzer without preselection to repeated pulses shall be identical to Figure 1 for pulse repetition frequencies equal to or greater than 20 Hz.~~

As an alternative the response of the measuring receiver to repeated pulses shall be such that for a constant voltage setting of the pulse generator of e.g. 50 dB(μ V) at repetition frequencies of 25 Hz (Band A) and 100 Hz (Bands B, C and D), the relationship between receiver indication and repetition frequency is in accordance with Figures 1, 2, 3 and 4 under opposite sign conditions.

For all measurements, a sufficient signal-to-noise ratio is required. The use of a 10 dB attenuator at the output of the pulse generator is recommended.

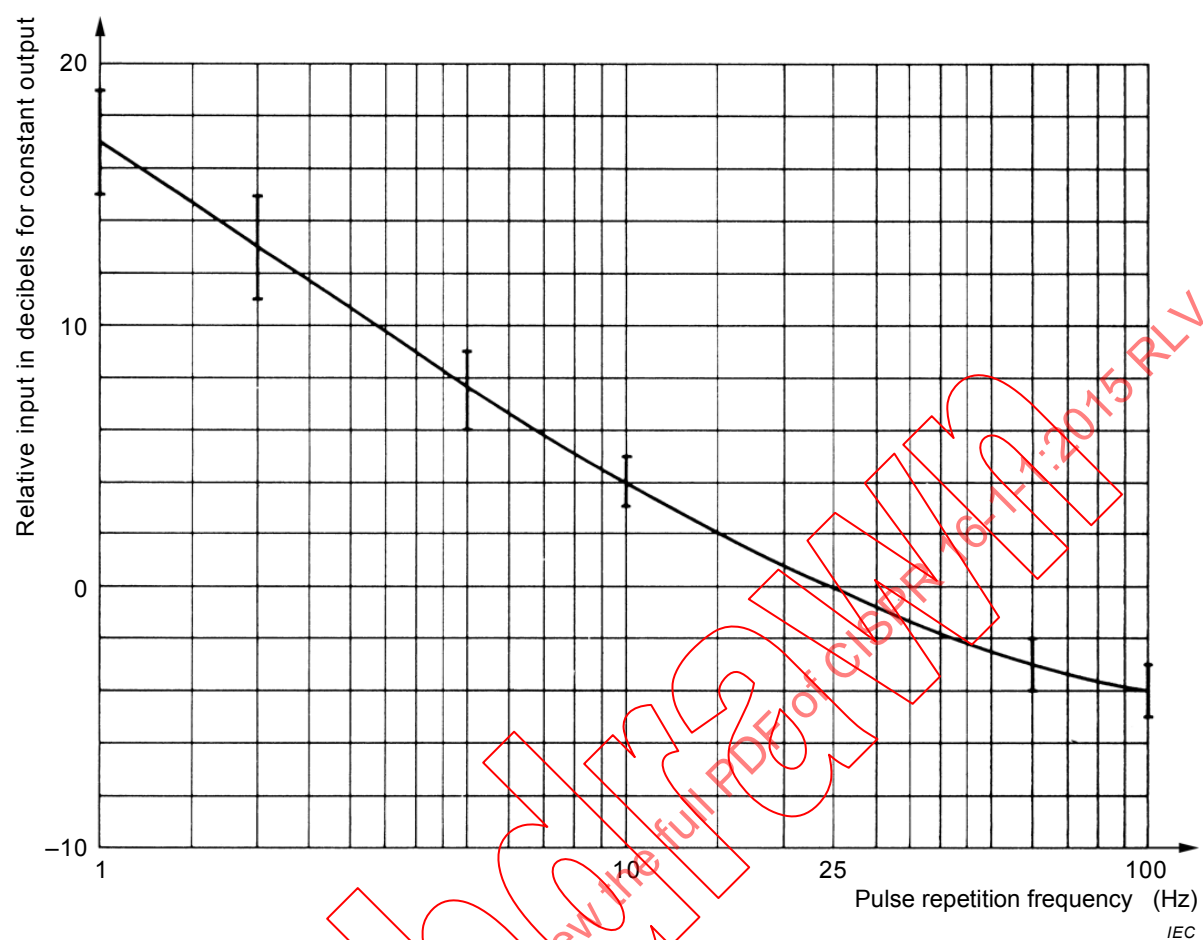


Figure 1a) 1 - Pulse response curve (Band A)

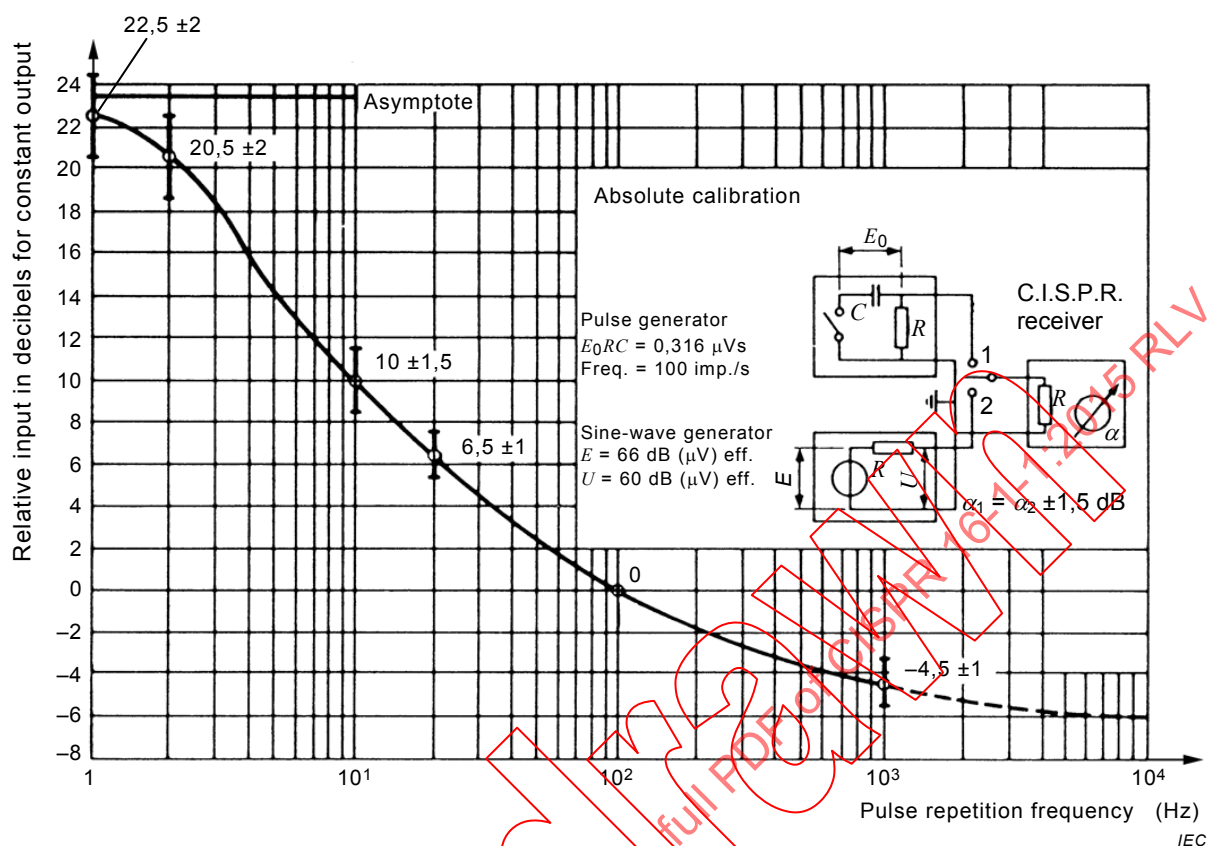


Figure 1b) 2 – Pulse response curve (Band B)

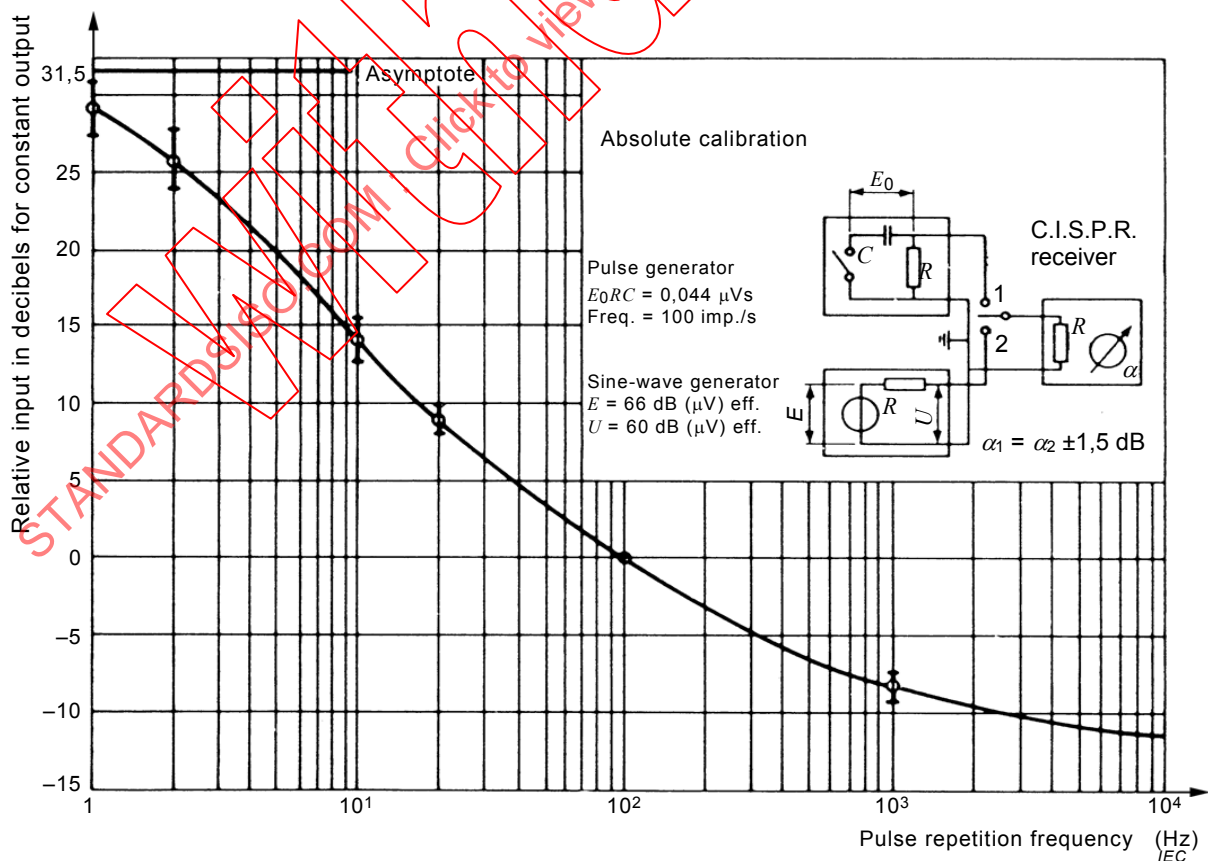
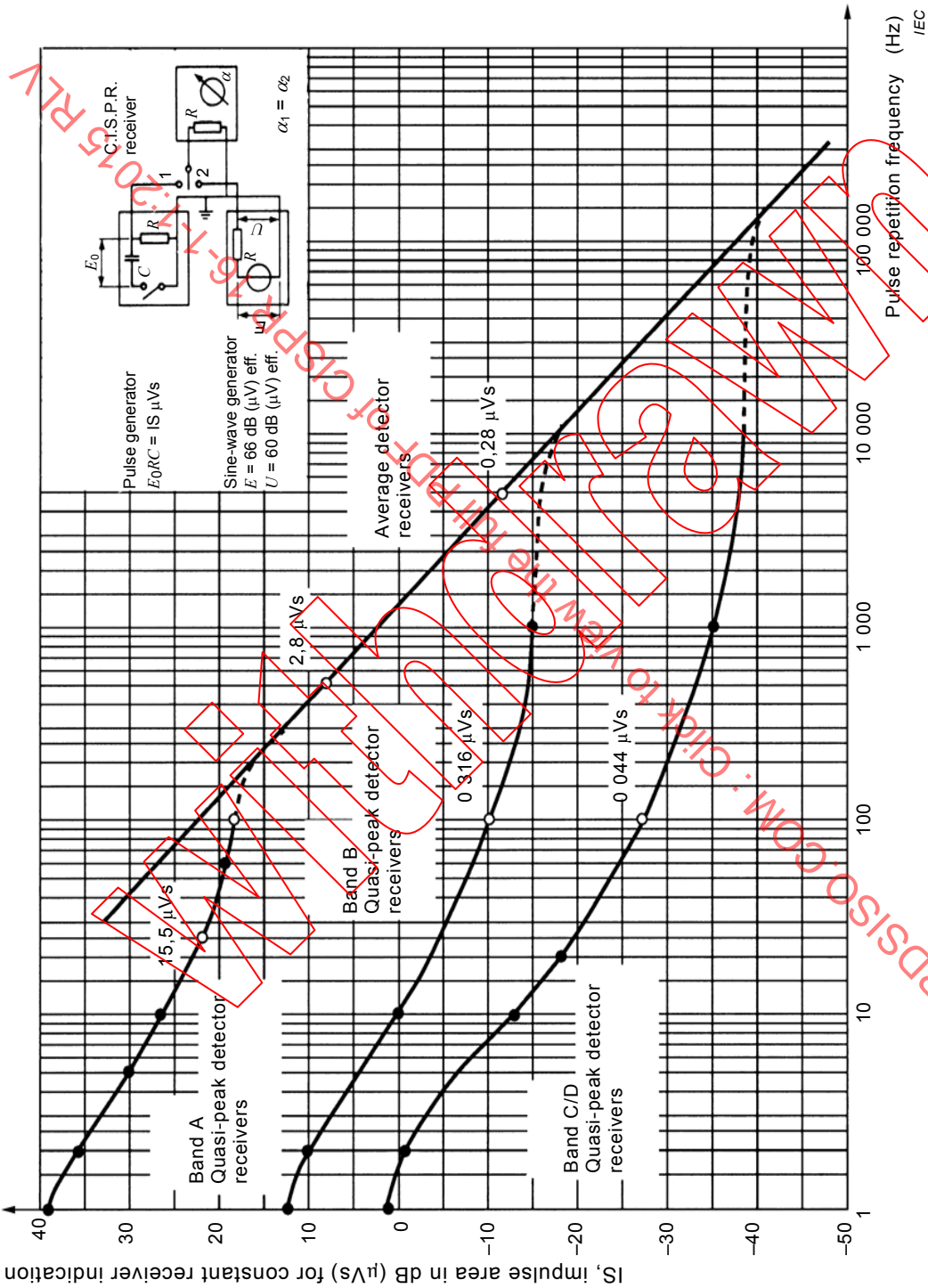


Figure 1c) 3 – Pulse response curve (Bands C and D)



The response curve for a particular measuring receiver shall lie between the limits defined in the appropriate figure and quantified in Table 2. For spectrum analyzers without preselection, the requirements in Table 2 for pulse repetition frequencies less than 20 Hz are not applicable. The use of such instruments for compliance testing is conditional. If such spectrum analyzers are used for measurements, the user shall verify and document that the equipment under test does not emit broadband signals of pulse repetition frequencies of 20 Hz or lower. A determination of the suitability of a spectrum analyzer for testing shall be made by performing the procedure documented in Annex B of CISPR 16-2-1:2014, Annex B of CISPR 16-2-2:2010, or Annex B of CISPR 16-2-3:2010.

The pulse response is restricted due to overload at the input to the receiver at frequencies above 300 MHz. The values marked with an asterisk (*) in Table 2 are optional and are not essential.

Table 2 – Pulse response of quasi-peak measuring receivers

Repetition frequency Hz	Relative equivalent level in dB of pulse for stated band			
	Band A 9 kHz to 150 kHz	Band B 0,15 MHz to 30 MHz	Band C 30 MHz to 300 MHz	Band D 300 MHz to 1 000 MHz
1 000	Note 4	$-4,5 \pm 1,0$	$-8,0 \pm 1,0$	$-8,0 \pm 1,0$
100	$-4,0 \pm 1,0$	0 (ref.)	0 (ref.)	0 (ref.)
60	$-3,0 \pm 1,0$	–	–	–
25	0 (ref.)	–	–	–
20	–	$+6,5 \pm 1,0$	$+9,0 \pm 1,0$	$+9,0 \pm 1,0$
10	$+4,0 \pm 1,0$	$+10,0 \pm 1,5$	$+14,0 \pm 1,5$	$+14,0 \pm 1,5$
5	$+7,5 \pm 1,5$	–	–	–
2	$+13,0 \pm 2,0$	$+20,5 \pm 2,0$	$+26,0 \pm 2,0$	$+26,0 \pm 2,0^*$
1	$+17,0 \pm 2,0$	$+22,5 \pm 2,0$	$+28,5 \pm 2,0$	$+28,5 \pm 2,0^*$
Isolated pulse	$+19,0 \pm 2,0$	$+23,5 \pm 2,0$	$+31,5 \pm 2,0$	$+31,5 \pm 2,0^*$

* These values are optional and not essential.

NOTE 1 The influence of the receiver characteristics upon its pulse response is considered in Annex D.

NOTE 2 The relationships between the pulse responses of a quasi-peak receiver and receivers with other detector types are given in 5.5, 6.5 and 7.5.

NOTE 3 The theoretical pulse response curves of quasi-peak and average detector receivers combined on an absolute scale are shown in Figure 4. The ordinate of Figure 4 shows the open-circuit impulse areas in dB(μVs) corresponding to the open-circuit sine-wave voltage of 66 dB(μV) rms. The indication on a measuring receiver with an input matched to the calibrating generators will then be 60 dB(μV). Where the measuring bandwidth is less than the pulse repetition frequency, the curves of Figure 4 are valid when the receiver is tuned to a discrete line of the spectrum.

NOTE 4 It is not possible to specify a response above 100 Hz in the frequency range 9 kHz to 150 kHz because of the overlapping of pulses in the IF amplifier.

NOTE 5 Annex A deals with the determination of the curve of response to repeated pulses.

4.5 Selectivity

4.5.1 Overall selectivity (passband)

The curve representing the overall selectivity of the measuring receiver shall lie within the limits shown in Figure 5, 6 or 7.

Selectivity shall be described by the variation with frequency of the amplitude of the input sine-wave voltage that produces a constant indication on the measuring receiver.

NOTE For the measurement of equipment that requires higher selectivity at the transition between 130 kHz and 150 kHz (e.g. mains signalling equipment as defined in EN 50065-1), a high-pass filter ~~may~~ can be added in front of the measuring receiver to achieve the combined selectivity of CISPR measuring receiver and high-pass filter as shown in Table 3.

Table 3 – Combined selectivity of CISPR measuring receiver and high-pass filter

Frequency kHz	Relative attenuation dB
150	≤ 1
146	≤ 6
145	≥ 6
140	≥ 34
130	≥ 81

NOTE 2 The measuring receiver in conjunction with the high-pass filter should meet the requirements of this standard.

4.5.2 Intermediate frequency rejection ratio

The ratio of the input sine-wave voltage at the intermediate frequency to that at the tuned frequency that produces the same indication of the measuring receiver shall be not less than 40 dB. Where more than one intermediate frequency is used, this requirement shall be met at each intermediate frequency.

4.5.3 Image frequency rejection ratio

The ratio of the input sine-wave voltage at the image frequency to that at the tuned frequency that produces the same indication on the measuring receiver shall be not less than 40 dB. Where more than one intermediate frequency is used, this requirement shall be met at the image frequencies corresponding to each intermediate frequency.

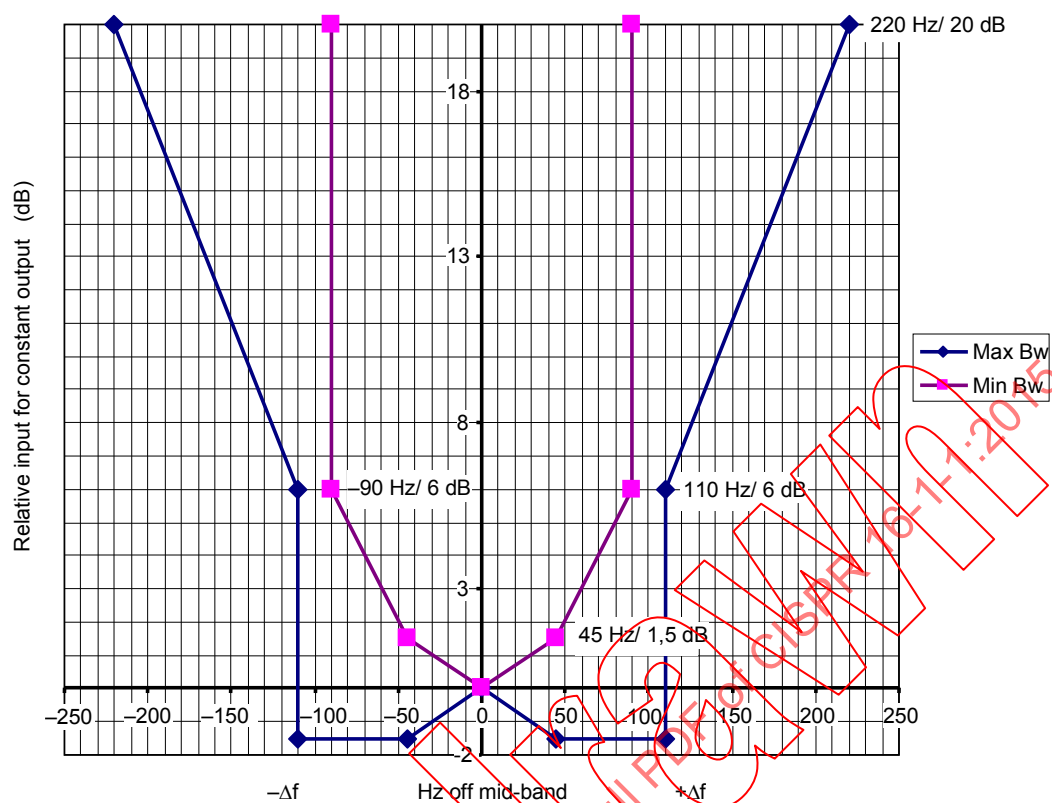


Figure 5 – Limits of overall selectivity – Pass band
(see 4.5.1, 5.6, 6.6, 7.6) (Band A)

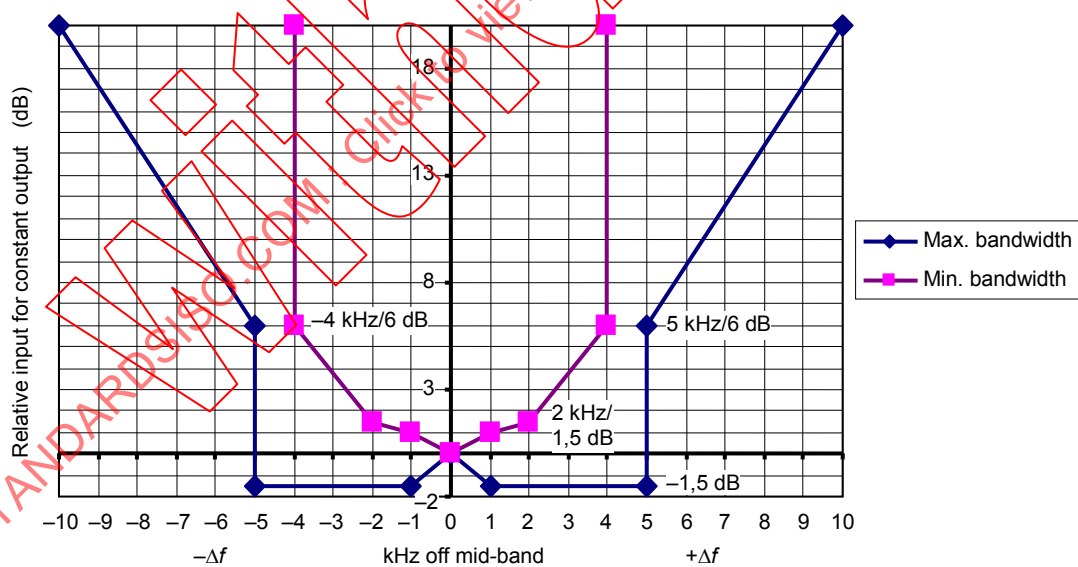


Figure 6 – Limits of overall selectivity –
Pass band (see 4.5.1, 5.6, 6.6, 7.6) (Band B)

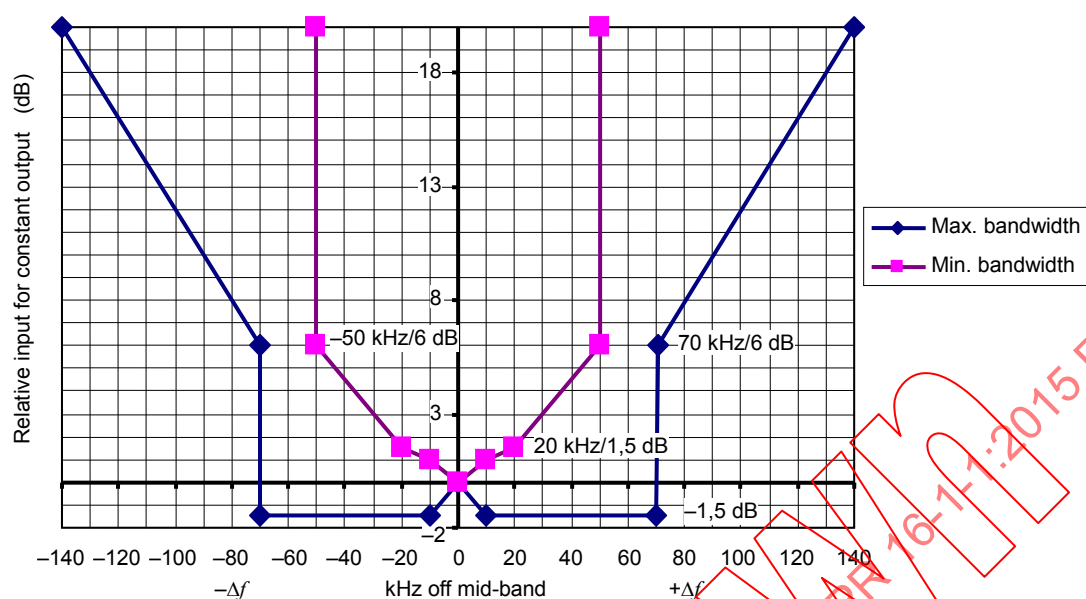


**Figure 7 – Limits of overall selectivity –
Pass band (see 4.5.1, 5.6, 6.6, 7.6) Bands (C and D)**

4.5.4 Other spurious responses

The ratio of the input sine-wave voltage at frequencies other than those specified in 4.5.2 and 4.5.3 to that at the tuned frequency that produces the same indication on the measuring receiver shall be not less than 40 dB. Examples of the frequencies from which such spurious responses may occur are as follows:

$$\left(\frac{1}{m}\right)(nf_L \pm f_i) \text{ and } \left(\frac{1}{k}\right)(f_0) \quad (6)$$

where

m, n, k are integers;

f_L is the local oscillator frequency;

f_i is the intermediate frequency;

f_0 is the tuned frequency.

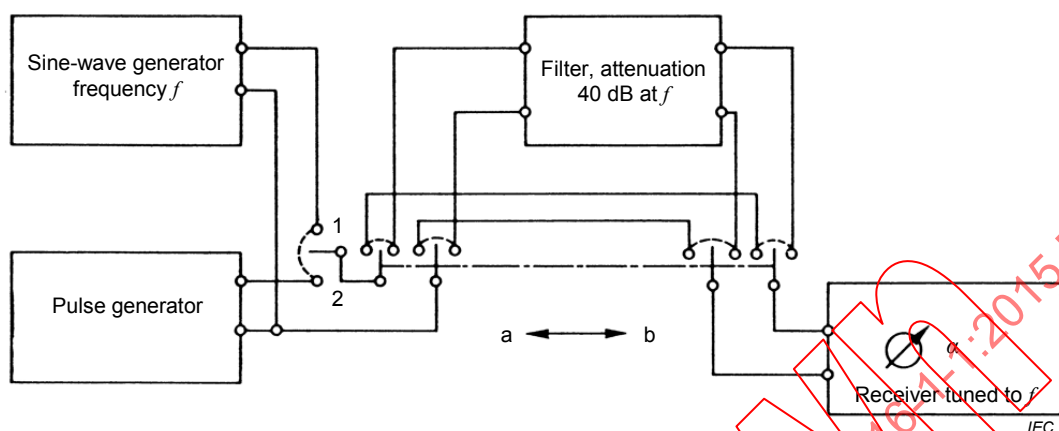
NOTE Where more than one intermediate frequency is used, the frequencies f_L and f_i may refer to each of the local oscillator and intermediate frequencies used. In addition, spurious responses may occur when no input signal is applied to the measuring receiver; for example, when harmonics of the local oscillators differ in frequency by one of the intermediate frequencies. The requirements of this subclause therefore cannot apply in these latter cases. The effect of these spurious responses is dealt with in 4.7. Examples of sources of spurious signals include local oscillators (or their harmonics), internal clocks, computer boards, and their mixing products with the input signal into the receiver.

4.6 Limitation of intermodulation effects

The influence of intermodulation effects on the response of the measuring receiver shall be minimized. The following method shall be applied to determine the suitability of a measuring instrument.

Arrange the apparatus as shown in Figure 8. The pulse generator has a spectrum substantially uniform up to frequency 3) but at least 10 dB down at frequency 4) of the

frequencies given in Table 4. The band-stop filter has an attenuation at the test frequency of at least 40 dB. Its bandwidth, B_6 , relative to the maximum attenuation of the filter shall lie between the frequencies 1) and 2) given in Table 4.



NOTE Following the discussion in 4.6, the measuring receiver responses are:

$$\begin{aligned}\alpha_{1a} &= \alpha_{2a} \\ \alpha_{1b} &= \alpha_{1a} - 40 \text{ dB} \\ \alpha_{2b} &= \alpha_{2a} - 36 \text{ dB}\end{aligned}$$

Figure 8 – Arrangement for testing intermodulation effects

Table 4 – Bandwidth characteristics for intermodulation test of quasi-peak measuring receivers (see 4.6)

Frequency range	1) kHz	2) kHz	3) MHz	4) MHz
9 kHz to 150 kHz (Band A)	0,4	4	0,15	0,3
0,15 MHz to 30 MHz (Band B)	20	200	30	60
30 MHz to 300 MHz (Band C)	500	2 000	300	600
300 MHz to 1 000 MHz (Band D)	500	6 000	1 000	2 000

Connect the sine-wave generator output direct to the measuring receiver input and adjust for a convenient reading. Substitute the pulse generator for the sine-wave generator and adjust for the same reading. The pulse repetition frequency shall be 100 Hz for Band A and 1 000 Hz for the other bands.

With the pulse generator connected as described above, switching the filter into circuit shall introduce attenuation of not less than 36 dB for measuring receivers, and of not less than 20 dB for spectrum analyzers without preselection.

4.7 Limitation of receiver noise and internally generated spurious signals

4.7.1 Random noise

Background noise shall not introduce an error in excess of 1 dB.

NOTE The point where the background noise causes an error of 1 dB can be found by applying a signal, S , such that the meter indication is much larger (e.g. 40 dB) than the noise level N . By reducing the signal level S , the meter indication will reach a point, S_1 , where $(S_1 + N)$ deviates by 1 dB from the linear characteristic.

4.7.2 Continuous wave

~~Where more than one intermediate frequency is used,~~ The existence of spurious responses as described in the note to 4.5.4 shall not introduce a measurement error in excess of 1 dB for any signal input to the measuring receiver. ~~For a measuring receiver incorporating attenuation in the IF amplifier,~~ This requirement shall be regarded as satisfied if the receiver complies with 4.7.1 when tested as described in 4.7.1 ~~except that the attenuation in the intermediate stages shall be introduced after the last mixer stage.~~

4.8 Screening effectiveness

4.8.1 General

Screening effectiveness is a measure of the ability of the measuring receiver to operate in an electromagnetic field without degradation. The requirement applies to receivers operating within the "CISPR indication range" specified by the manufacturer as defined in 3.2.

The screening of the receiver shall be such that when it is immersed in an ambient electromagnetic field of 3 V/m (unmodulated) at any frequency in the range 9 kHz to 1 000 MHz, an error of not greater than 1 dB is produced at the maximum and minimum of the CISPR indication range as specified by the manufacturer of the receiver. In cases where a measuring receiver is not immune to the requirement of 3 V/m, the field strength and frequency at which the error exceeds 1 dB shall be stated by the manufacturer. The test shall be performed as described below.

The receiver is placed inside a screened enclosure. An input signal is applied to the receiver via a 2 m long well-screened cable (e.g. semi-rigid), through a feedthrough in the enclosure wall, to a signal generator placed outside the enclosure. The level of the input signal shall be at the maximum and the minimum of the CISPR indication range as specified by the manufacturer of the receiver. All other coaxial terminals of the receiver shall be terminated in their characteristic impedance.

Only essential leads (e.g. mains and input cables) for the normal use of the measuring receiver in its minimum configuration (excluding options such as headphones) shall be connected during the test. The leads shall have the lengths and be arranged as in typical use.

The strength of the ambient field in the vicinity of the measuring receiver shall be measured by a field strength monitor.

The receiver meter indication in the presence of the ambient electromagnetic field shall differ by not more than 1 dB from the meter indication when the field is absent.

4.8.2 Limitation of radio-frequency emissions from the measuring receiver

4.8.2.1 Conducted emissions

The radio disturbance voltage at any connecting pin of external lines (not only the mains terminals) shall not exceed the limits for class B equipment given in CISPR 11. The measurement of the radio disturbance voltage is however not required on the inner conductors of screened connections to screened equipment. The local oscillator injection power at the measuring receiver input terminated with its characteristic impedance shall not exceed 34 dB(pW) which is equivalent to 51 dB(μV) across 50 Ω.

4.8.2.2 Radiated emissions

The radio disturbance field strength emitted by the measuring receiver shall not exceed the limits for class B equipment given in CISPR 11, for the frequency range of 9 kHz to 1 000 MHz. The limits shall also apply for frequency bands (ISM frequencies) listed in Table 1 of the same publication. In the frequency range of 1 GHz to 18 GHz, a limit of 45 dB(pW) shall apply, based on an ERP measurement.

Before performing radiated and conducted emission measurements, it is essential that the noise contributions of the test equipment do not affect the measured results (e.g. computer control).

4.9 Facilities for connection to a discontinuous disturbance analyzer

For all bands, the disturbance measuring receiver shall have ~~both~~ an intermediate-frequency output ~~and an output from the quasi-peak detector~~ if the instrument is to be used for the measurement of discontinuous disturbance. The loading of this output shall have no influence on the indication of the ~~instrument~~ measurement result.

5 Measuring receivers with peak detector for the frequency range 9 kHz to 18 GHz

5.1 General

This clause specifies requirements for measuring receivers employing a peak detector when used for the measurement of impulsive or pulse-modulated disturbance.

Spectrum analyzers and FFT-based measuring instruments that meet the requirements of this clause can be used for compliance measurements. For emission measurements, FFT-based measuring instruments shall sample and evaluate the signal continuously during the measurement time.

5.2 Input impedance

The input port of the measuring receivers shall be unbalanced. For receiver control settings within the CISPR indication range, the nominal input impedance shall be 50 Ω with a VSWR not to exceed the values in Table 5.

Table 5 – VSWR requirements for receiver input impedance

Frequency range	RF attenuation dB	VSWR
9 kHz to 1 GHz	0	2,0 to 1
9 kHz to 1 GHz	≥ 10	1,2 to 1
1 GHz to 18 GHz	0	3,0 to 1
1 GHz to 18 GHz	≥ 10	2,0 to 1

Symmetric input impedance in the frequency range 9 kHz to 30 MHz: a balanced input transformer is to be used for symmetric (that is, ungrounded) measurements. (The preferred input impedance is 600 Ω for the frequency range 9 kHz to 150 kHz.) Symmetric input impedance may be incorporated either in the relevant symmetrical artificial network required to couple to the receiver or, optionally, in the measuring receiver itself.

5.3 Fundamental characteristics

5.3.1 Bandwidth

For all types of broadband disturbance, the actual value of the bandwidth shall be stated when the disturbance level is quoted and the bandwidth is within the values in Table 6.

Table 6 – Bandwidth requirements for measuring receivers with peak detector

Frequency range	Bandwidth B_6	Reference BW
9 kHz to 150 kHz (Band A)	100 Hz to 300 Hz ^a	200 Hz (B_6)
0,15 MHz to 30 MHz (Band B)	8 kHz to 10 kHz ^a	9 kHz (B_6)
30 MHz to 1 000 MHz (Bands C and D)	100 kHz to 500 kHz ^a	120 kHz (B_6)
1 GHz to 18 GHz (Band E)	300 kHz to 2 MHz ^a	1 MHz ^b (B_{imp})
^a Since the response of a peak measuring receiver to non-overlapping pulses is proportional to its impulse bandwidth, either the actual bandwidth is quoted in the result or the level may be quoted as "in a 1 MHz bandwidth", calculated by dividing the measured value by the impulse bandwidth in MHz (see 3.6). For other types of broadband disturbance, this procedure may introduce an error. Therefore, data measured with the reference bandwidth shall take precedence.		
^b The bandwidth selected shall be defined as the impulse bandwidth of the measuring receiver with a tolerance of $\pm 10\%$.		

5.3.2 Charge and discharge time constants ratio

In order to achieve a meter reading within 10 % of the true value of the peak at a repetition rate of 1 Hz, the ratio of discharge time constant to charge time constant shall be equal to or greater than the following values:

- a) $1,89 \times 10^4$ in the frequency range 9 kHz to 150 kHz;
- b) $1,25 \times 10^6$ in the frequency range 150 kHz to 30 MHz;
- c) $1,67 \times 10^7$ in the frequency range 30 MHz to 1 000 MHz;
- d) $1,34 \times 10^8$ in the frequency range 1 GHz to 18 GHz.

If the test receiver has a peak-hold capability, the hold time shall be adjustable to values between 30 ms and 3 s.

NOTE For receivers that use peak hold (and forced discharge after the hold time) or digital peak detection techniques, the requirement on the charge/discharge time constants ratio is not relevant. A maximum-hold function of the display may be used for signals with time-varying amplitudes.

If a spectrum analyzer is used for peak measurements, the video bandwidth (B_{video}) shall be set to a value greater than or equal to the resolution bandwidth (B_{resol}). For peak measurements, the result can be read from the spectrum analyzer display with the detector operating either in the linear or logarithmic mode.

5.3.3 Overload factor

For peak measuring receivers, the overload factor does not need to be as high as it is for other types of measuring receivers. For most direct-reading detectors, the overload factor shall be slightly larger than unity. The overload factor shall be adequate for the time-constants used (see 5.3.2).

5.4 Sine-wave voltage accuracy

The accuracy of sine-wave voltage measurement shall be better than ± 2 dB ($\pm 2,5$ dB above 1 GHz) when the instrument measures a sine-wave signal using a 50 Ω resistive source impedance.

5.5 Response to pulses

Up to 1 000 MHz, the response of the measuring receiver to pulses with impulse area $1,4/B_{imp}$ mVs (where B_{imp} is in Hz) e.m.f. at 50 Ω source impedance shall be equal to the response to an unmodulated sine-wave signal at the tuned frequency having an e.m.f. with rms value of 2 mV [66 dB(μ V)]. The source impedances of both the pulse generator and the

signal generator shall be the same. The pulses shall have a uniform spectrum according to Table 2. A tolerance of $\pm 1,5$ dB is permitted in the sine-wave voltage level, and this is a requirement for all pulse repetition frequencies for which no overlapping pulses occur at the output of the IF amplifier.

NOTE 1 Annexes B and C describe methods for determining the output characteristics of pulse generators for use in testing for the requirements of this subclause.

NOTE 2 At a repetition rate of 25 Hz for Band A and 100 Hz for the other bands, the relationship between the indications of a peak measuring receiver and a quasi-peak measuring receiver with the preferred bandwidth are given in Table 7.

Table 7 – Relative pulse response of peak and quasi-peak measuring receivers for the same bandwidth (frequency range 9 kHz to 1 000 MHz)

Frequency	A_{imp} mVs	B_{imp} Hz	Ratio peak/quasi-peak (dB) for pulse repetition rate	
			25 Hz	100 Hz
Band A	$6,67 \times 10^{-3}$	$0,21 \times 10^3$	6,1	–
Band B	$0,148 \times 10^{-3}$	$9,45 \times 10^3$	–	6,6
Bands C and D	$0,011 \times 10^{-3}$	$126,0 \times 10^3$	–	12,0

NOTE 1 The pulse response is based on the use of the reference bandwidth only (see Table 6).

NOTE 2 The values in this table result from the nominal specification of the detector weighting functions. Therefore, verification by a calibration laboratory is not required.

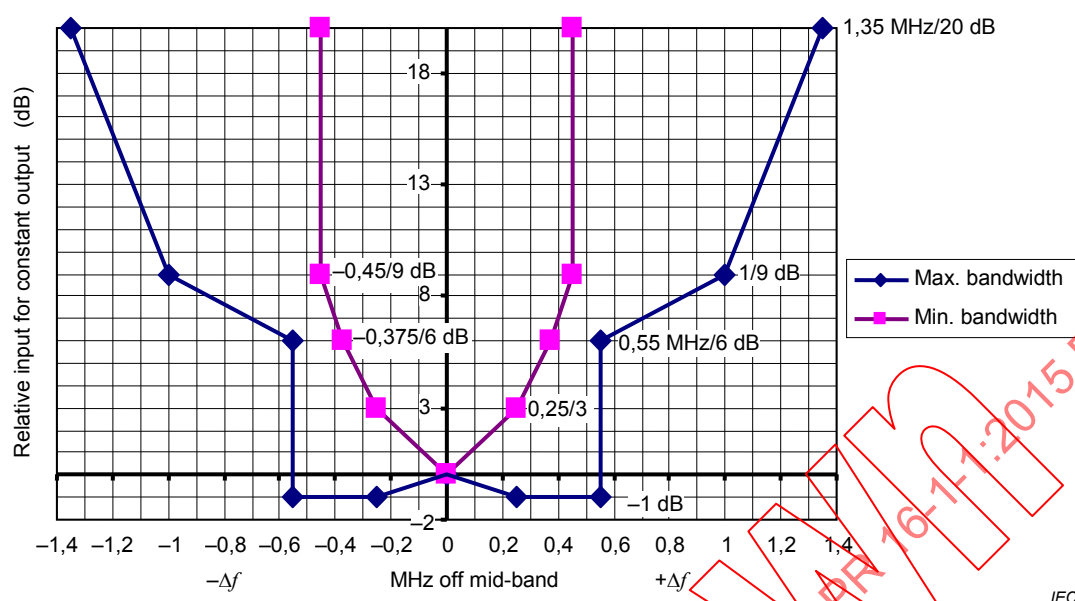
Above 1 GHz, the required impulse area is defined using a pulse-modulated carrier at the frequency of test, since pulse generators with a uniform spectrum up to 18 GHz are not feasible. See E.6.

5.6 Selectivity

Since the bandwidth requirements stated in 5.3.1 allow variations from the bandwidths shown in Figures 5, 6 and 7, these selectivity curves apply to peak measuring receivers in regard to shape only, and the frequency axis shall be scaled accordingly. For example, $B_6/2$ corresponds to 100 Hz in Figure 5.

The requirements in 4.5.2, 4.5.3 and 4.5.4 apply.

The curve representing the overall selectivity of the measuring receiver reference bandwidth for Band E shall lie within the limits of Figure 9.



NOTE 1 The limits for the impulse bandwidth cannot be shown in the diagram, as the related filter attenuation depends on the type of the filter. Therefore bounds for the 6-dB and the 9-dB bandwidths have been given for orientation.

NOTE 2 The limits for the overall selectivity have been derived from equipment being in use at the time of introduction of the selectivity requirement.

Figure 1 – Limits for the overall selectivity – Pass band (Band E)

5.7 Intermodulation effects, receiver noise, and screening

For the frequency range below 1 GHz, the requirements stated in 4.6, 4.7 and 4.8 apply. Subclauses 4.7 and 4.8.2 apply also for Band E.

In addition, the following applies for Band E.

- Requirements for intermodulation effects are under consideration.
- Preselection filter for Band E: when measuring low level spurious signals in the presence of a strong fundamental signal for certain equipment-under-test, insert a filter at the measuring receiver's input (internally or externally) which provides adequate attenuation at the fundamental frequency to protect the input circuits of the receiver from overload and damage and to prevent the generation of harmonic and intermodulation signals.
- Several filters may be required to deal with more than one fundamental frequency.

NOTE 30 dB filter attenuation at the fundamental frequency of the equipment-under-test is normally adequate.

NOTE 2 Several filters may be required to deal with more than one fundamental frequency.

Requirements for screening effectiveness, that is, the immunity to high ambient radiated disturbances, are under consideration.

6 Measuring receivers with average detector for the frequency range 9 kHz to 18 GHz

6.1 General

Average measuring receivers are generally not used for the measurement of impulsive disturbance. This type of receiver has a detector designed to indicate the average value of the envelope of the signal passed through the pre-detector stages. The average detector is used

to measure narrowband signals to overcome problems associated with either modulation content or the presence of broadband noise.

Spectrum analyzers and FFT-based measuring instruments that meet the requirements of this clause can be used for compliance measurements. For emission measurements, FFT-based measuring instruments shall sample and evaluate the signal continuously during the measurement time.

6.2 Input impedance

The input port of the measuring receiver shall be unbalanced. For receiver control settings within the CISPR indication range, the input impedance shall be nominally 50 Ω with a VSWR not to exceed the values stated in Table 5.

Symmetric (balanced) input impedance in the frequency range of 9 kHz to 150 kHz: use a balanced input transformer for symmetrical (that is, ungrounded) measurements. (The preferred input impedance for the frequency range of 9 kHz to 150 kHz is 600 Ω). Symmetric input impedance may be incorporated either in the relevant symmetrical artificial network required to couple to the receiver or, optionally, in the measuring receiver itself.

6.3 Fundamental characteristics

6.3.1 Bandwidth

The bandwidths shall lie within the values shown in Table 8.

Table 8 – Bandwidth requirements for measuring receivers with average detector

Frequency range	Bandwidth B_6	Reference BW
9 kHz to 150 kHz (Band A)	100 Hz to 300 Hz ^a	200 Hz (B_6)
150 kHz to 30 MHz (Band B)	8 kHz to 10 kHz ^a	9 kHz (B_6)
30 MHz to 1 000 MHz (Bands C and D)	100 kHz to 500 kHz ^a	120 kHz (B_6)
1 GHz to 18 GHz (Band E)	300 kHz to 2 MHz ^a	1 MHz ^b (B_{imp})
^a The subject of bandwidth is discussed in E.1. If a bandwidth other than the reference BW is used, this bandwidth shall be stated when the disturbance level is reported.		
^b The bandwidth selected shall be defined as in Table 6.		

6.3.2 Overload factor

For receivers with average detectors, the overload factor for circuits preceding the detector at a pulse repetition rate of n Hz shall be B_{imp}/n , with B_{imp} in Hz.

The receiver shall not overload for pulse rates equal to or greater than 25 Hz for Band A, 500 Hz for Band B, and 5 000 Hz for Bands C and D.

NOTE With this type of receiver, in general, it is not possible to provide a sufficient overload factor to prevent non-linear operation of the receiver at very low pulse rates (the response to a single pulse is not defined).

6.4 Sine-wave voltage accuracy

The accuracy of sine-wave voltage measurement shall be better than ± 2 dB ($\pm 2,5$ dB above 1 GHz) when the receiver measures a sine-wave signal with 50 Ω resistive source impedance.

6.5 Response to pulses

6.5.1 General

NOTE Annexes B and C describe methods for determining the output characteristics of pulse generators for use in testing the requirements of this clause in the frequency range below 1 GHz.

6.5.2 Amplitude relationship

Up to 1 000 MHz, the average detector is defined as follows (linear average): the response of the measuring receiver to pulses of repetition rate n Hz and impulse area of $1,4/n$ mVs e.m.f. at $50\ \Omega$ source impedance, shall be equal to the response to an unmodulated sine-wave signal at the tuned frequency having an e.m.f. with rms value of 2 mV [66 dB(μ V)]. The source impedances of both the pulse generator and the signal generator shall be the same. The pulses shall have a uniform spectrum according to data shown in Table 2. ~~The value of n shall be 25 Hz for Band A, 500 Hz for Band B, and 5 000 Hz for Bands C and D. A tolerance of $\pm 2,5$ dB/ $\pm 0,5$ dB $\pm 1,5$ dB/ $\pm 1,5$ dB is permitted on the sine-wave voltage level.~~

NOTE 1 At repetition frequencies of 25 Hz, 100 Hz, 500 Hz, 1 000 Hz and 5 000 Hz, the relationship between the indications of an average and a quasi-peak measuring receiver of the same bandwidth, assuming adequate overload factors and a constant output level, is given in Table 9.

Table 9 – Relative pulse response of average and quasi peak measuring receivers for the same bandwidth ~~(frequency range 9 kHz to 1 GHz)~~

Frequency range of measuring receiver	Ratio quasi-peak/average indications (dB) for pulse repetition rate				
	25 Hz	100 Hz	500 Hz	1 000 Hz	5 000 Hz
9 kHz to 150 kHz (Band A)	12,4				
0,15 MHz to 30 MHz (Band B)		(32,9)	22,9	(17,4)	
30 MHz to 1 000 MHz (Bands C and D)				(38,1)	26,3
NOTE 1 The pulse response is based on the use of the reference bandwidth only (see Table 8).					
NOTE 2 Values in parentheses are for information only.					
NOTE 3 The values in this table result from the nominal specification of the detector weighting functions. Therefore, verification by a calibration laboratory is not required.					

Above 1 GHz (Band E), two modes of the average (weighting) detector are defined – linear and logarithmic:

For the linear average detector, the response of the measuring receiver to pulses of repetition rate n Hz and impulse area of $1,4/n$ mVs e.m.f. at $50\ \Omega$ source impedance shall be equal to the response of an unmodulated sine-wave signal at the tuned frequency having an e.m.f. of rms value of 2 mV [66 dB(μ V)]. The pulse shall be defined as a pulse-modulated carrier. The value of n shall be 50 000 Hz. A tolerance of $\pm 1,5$ dB is permitted on the sine-wave voltage level.

For the logarithmic average detector, the response of the measuring receiver to pulses of repetition rate 333 kHz (inverse of period 3 μ s) and impulse area of 6,7 nVs e.m.f. at $50\ \Omega$ source impedance shall be equal to the response of an unmodulated sine-wave signal at the tuned frequency having an e.m.f. with rms value of 2 mV [66 dB(μ V)]. A tolerance of ± 4 dB is allowed on the sine-wave voltage level (the 10 % tolerance of the bandwidth causes a possible variation of approximately $\pm 2,5$ dB).

For further details, see E.6.

NOTE 2 Average detection can be achieved with spectrum analyzers operated with a video bandwidth $B_{\text{video}} \ll B_{\text{resol}}$ in order to achieve proper averaging based on the repetition frequency of the measured signal. For measurements based on a reduction of the video

bandwidth, ensure the scanning time is sufficiently long to allow the video filter to respond correctly.

NOTE 2 For average (weighted) measurements in the linear mode, the result will correspond to the average level of the measured signal. If the logarithmic mode is used, the result will correspond to the average of the logarithmic values of the measured signal. Thus, for a square-wave signal taking alternatively the values 20 dB(μV) and 60 dB(μV), the level obtained in the logarithmic mode is 40 dB(μV), whereas in the linear mode, the level of 54,1 dB(μV) represents the true average value of the signal.

6.5.3 Variation with repetition frequency

The response to repetitive pulses of a measuring receiver equipped with a linear average detector shall be such that, for a constant indication on the measuring receiver, the relationship between amplitude and repetition frequency is in accordance with the following rule:

Amplitude proportional to (repetition frequency)⁻¹

A tolerance of +3 dB to –1 dB is allowed in the frequency range from the lowest useable repetition frequency to a frequency equal to $B_3/2$, as determined from overload considerations.

NOTE 1 The theoretical pulse response curves of quasi-peak and average detector receivers, combined on an absolute scale, are shown in Figure 4. The response to repeated pulses of the measuring receiver equipped with a logarithmic average detector (above 1 GHz) is influenced by the noise level between the pulses. Using the following values:

- $L_{\log Av}$ is the level indicated by the logarithmic average detector;
- T_P is the pulse duration;
- L_P is the pulse level in dB(μV);
- T_N is the duration of the noise level;
- L_N is noise level in dB(μV);

then the following approximate relationship applies:

$$L_{\log Av} = \frac{T_P L_P + T_N L_N}{T_P + T_N} \quad (7)$$

EXAMPLE If the pulse level L_P is 85 dB(μV) and the noise level L_N is 8 dB(μV), $T_P = 1/B_{imp} = 1 \mu s$, the pulse rate n is 100 000 Hz, then $T_N \approx 9 \mu s$. From this equation, $L_{\log Av} = 15,7$ dB(μV). In reality, $L_{\log Av}$ is higher because T_P is higher, because the pulse signal at the IF output does not drop to noise level immediately after 1 μs.

NOTE 2 A tolerance is under consideration.

6.5.4 Response to intermittent, unsteady and drifting narrowband disturbances

The response to intermittent, unsteady and drifting narrowband disturbances shall be such that the measurement result is equivalent to the peak reading of a meter with a time constant of 160 ms for Bands A and B and of 100 ms for Bands C and D, as depicted in Figure 11. The time constant is as defined in A.3.2. This can be accomplished by a meter-simulating network following the envelope detector of the receiver. The peak reading may be taken, for example, by continuous monitoring of the meter output using an A/D converter and a microprocessor, as shown in Figure 10.

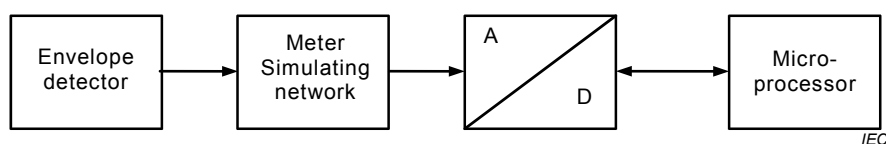


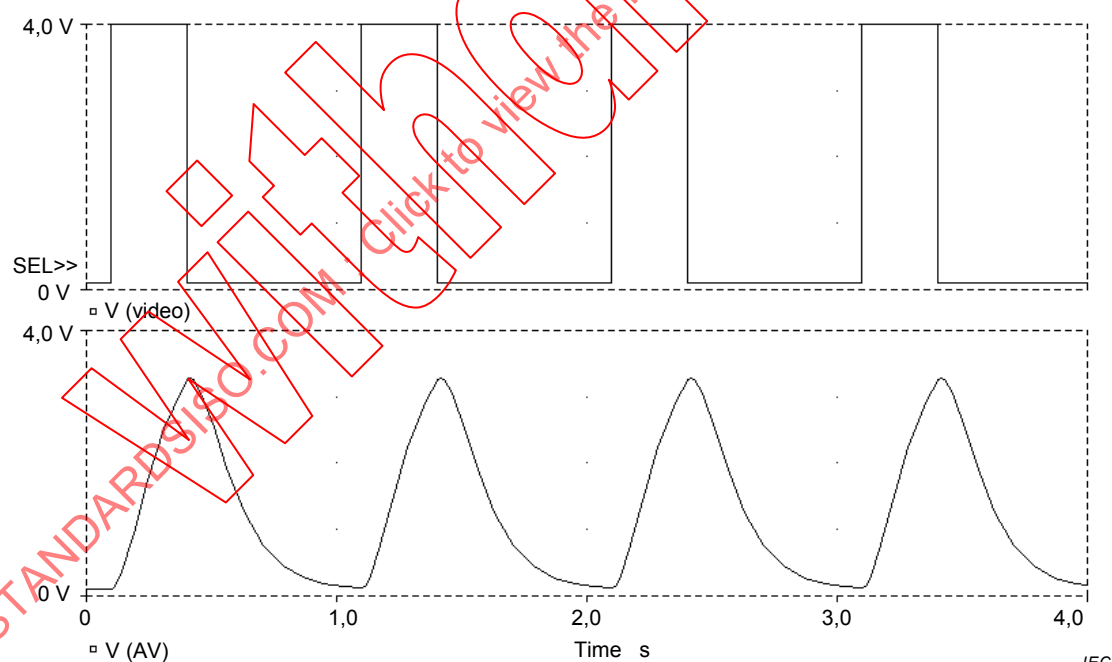
Figure 10 – Block diagram of an average detector

For Band E, the meter time constant for the linear average detector is 100 ms. For the logarithmic average detector, the requirement is under consideration.

It is deduced from the above requirement that an average measuring receiver shall yield the maximum reading listed in Table 10 for a radio frequency sine-wave input signal modulated with repeated rectangular pulses having the duration and period indicated in the table. A tolerance of $\pm 1,0$ dB is allowed for this requirement.

Table 10 – Maximum reading of average measuring receivers for a pulse-modulated sine-wave input in comparison with the response to a continuous sine wave having the same amplitude

Repeated rectangular pulses for modulation	Band A/B receiver $T_M = 0,16$ s	Band C/D receiver $T_M = 0,1$ s
Duration = T_M Period = 1,6 s	0,353 (= -9,0 dB)	0,353 (= -9,0 dB)
NOTE In Band E, this applies for the linear average detector only.		



NOTE 1 The response shown is caused by an intermittent narrowband signal with a duration of 0,3 s and a repetition frequency of 1 Hz, when a time constant of 100 ms is used. If the time constant is 160 ms, the peaks at the output of the meter-simulating network will be lower.

NOTE 2 The response to intermittent narrowband disturbances ~~may~~ can also be defined for the logarithmic average detector operating with a certain video bandwidth, for example, 10 Hz, and the maximum hold function of the spectrum display.

Figure 11 – Screenshot showing response of the meter-simulating network to an intermittent narrowband signal

6.6 Selectivity

For receivers with a bandwidth of 200 Hz (for the frequency range 9 kHz to 150 kHz) or a bandwidth of 9 kHz (for frequency range 0,15 MHz to 30 MHz) the overall selectivity shall be within the limits shown in Figure 5 and 6, respectively. For receivers with a bandwidth of 120 kHz (for the frequency range 30 MHz to 1 000 MHz), the overall selectivity shall be within the limits shown in Figure 7. For receivers having other bandwidths, Figures 5, 6 and 7 describe the shape only and the frequency axis shall be scaled accordingly. The curve representing the overall selectivity of the measuring receiver reference bandwidth for Band E shall lie within the limits of Figure 9.

The requirements of 4.5.2, 4.5.3 and 4.5.4 apply.

NOTE For the measurement of equipment that requires higher selectivity at the transition between 130 kHz and 150 kHz (for example, mains signaling equipment as defined in EN 50065-1 [18]²), a high-pass filter may be added in front of the measuring receiver to achieve the following combined selectivity of CISPR measuring receiver and high-pass filter:

Frequency kHz	Relative attenuation dB
150	≤ 1
146	≤ 6
145	≥ 6
140	≥ 34
130	≥ 81

The measuring receiver in conjunction with the high-pass filter should meet the requirements of this standard.

6.7 Intermodulation effects, receiver noise, and screening

The requirements in 5.7 shall apply.

7 Measuring receivers with rms-average detector for the frequency range 9 kHz to 18 GHz

7.1 General

RMS-average weighting receivers employ a weighting detector that is a combination of the rms detector (for pulse repetition frequencies above a corner frequency f_c) and the average detector (for pulse repetition frequencies below the corner frequency f_c), thus achieving a pulse response curve with the following characteristics: 10 dB/decade above the corner frequency and 20 dB/decade below the corner frequency.

Spectrum analyzers and FFT-based measuring instruments that meet the requirements of this clause can be used for compliance measurements. For emission measurements, FFT-based measuring instruments shall sample and evaluate the signal continuously during the measurement time.

7.2 Input impedance

The input circuit of measuring receivers shall be unbalanced. For receiver control settings within the CISPR indication range, the input impedance shall be nominally 50 Ω with a VSWR not to exceed the values in Table 11.

² Figures in square brackets refer to the Bibliography.

Table 11 – VSWR requirements of input impedance

Frequency range	RF Attenuation dB	VSWR
9 kHz to 1 GHz	0	2,0 to 1
9 kHz to 1 GHz	10	1,2 to 1
1 GHz to 18 GHz	0	3,0 to 1
1 GHz to 18 GHz	10	2,0 to 1

Symmetric input impedance in the frequency range 9 kHz to 30 MHz: to permit symmetrical measurements, a balanced input transformer is used. The preferred input impedance for the frequency range 9 kHz to 150 kHz is 600 Ω . This symmetric input impedance may be incorporated either in the relevant symmetrical artificial network necessary to couple to the receiver or optionally in the measuring receiver.

7.3 Fundamental characteristics

7.3.1 Bandwidth

The bandwidths shall lie within the values of Table 12.

Table 12 – Bandwidth requirements for measuring receivers with rms-average detector

Frequency range	Bandwidth
9 kHz to 150 kHz (Band A)	200 Hz (B_6)
150 kHz to 30 MHz (Band B)	9 kHz (B_6)
30 MHz to 1 000 MHz (Bands C and D)	120 kHz (B_6)
1 GHz to 18 GHz (Band E)	1 MHz (B_{imp})
NOTE The chosen value in band E is defined as the impulse bandwidth of the measuring receiver with a tolerance of $\pm 10\%$.	

7.3.2 Overload factor

Above the corner frequency f_c , specified below, the overload factor for circuits preceding the detector at a pulse repetition rate of n Hz shall be $1,27(B_3/n)^{1/2}$, with B_3 in Hz. Below the corner frequency the overload factor at a pulse repetition rate of n Hz shall be above the value $1,27(B_3/f_c)^{1/2} \times (f_c/n)$.

NOTE 1 "Corner frequency" is the pulse repetition frequency above which the rms-average detector behaves like an rms detector and below which the rms-average detector has the slope of a linear average detector.

The minimum pulse repetition rate without overload shall conform to the values given in Table 13.

Table 13 – Minimum pulse repetition rate without overload

Frequency range of measuring receiver	Corner frequency f_c kHz	Minimum pulse repetition rate Hz	Ratio peak/rms -average indications dB
9 kHz to 150 kHz (Band A)	0,01	5	19
0,15 MHz to 30 MHz (Band B)	0,01	5	35,5
30 MHz to 1 000 MHz (Bands C and D)	0,1	31,6	40,6
1 GHz to 18 GHz (Band E)	1	316	40

NOTE 2 With this type of detector it will not, in general, be possible to provide sufficient overload factor to prevent non-linear operation of the instrument at very low pulse repetition rates for short pulses in Bands C/D and E (the response to a short single pulse is only theoretically defined in these bands).

NOTE 3 Annex A describes the calculation for the overload factor for the rms detector. Annex B describes the determination of the pulse generator spectrum. Annex C describes the accurate measurement of the output levels of nanosecond pulse generators.

NOTE 4 For Band E, the test ~~may~~ can be made with a pulse-modulated sine-wave signal, with an occupied bandwidth of e.g. 2 MHz. E.6 gives the specification of an applicable test signal.

7.4 Sine-wave voltage accuracy

The accuracy of sine-wave voltage measurement shall be better than ± 2 dB ($\pm 2,5$ dB above 1 GHz) when the receiver measures a sine-wave signal with a $50\ \Omega$ resistive source impedance.

7.5 Response to pulses

7.5.1 Construction details

The detector function can be represented by an rms detector that continuously determines rms values during periods of time equal to the reciprocal of the corner frequency f_c . These rms values are then passed through a second order low-pass filter that corresponds to the critically damped indication that is specified for the quasi-peak detector, the time constant of which is defined up to 1 GHz. For Band E, the time constant is 100 ms. In case of variation with time, the maximum output of the low-pass filter is the measurement result.

NOTE Annexes B, C and E describe methods for determining the output characteristics of pulse generators for use in testing the requirements of this clause.

7.5.2 Amplitude relationship

The response of the measuring receiver for Band A to pulses of impulse area $278 \times (B_3)^{-1/2}$ μ Vs e.m.f. at a $50\ \Omega$ source impedance which have a uniform spectrum up to at least the highest tuneable frequency of Band A, and repeated at a frequency of 25 Hz, shall for all frequencies of tuning, be equal to the response to an unmodulated sine-wave signal at the tuned frequency having an e.m.f. of 2 mV [66 dB(μ V)] rms. For the measuring receivers for Bands B, C, D and E, the corresponding values are $44 \times (B_3)^{-1/2}$ μ Vs and 1 000 Hz. The source impedances of the pulse generator and the signal generator shall both be the same. A tolerance of $\pm 1,5$ dB is permitted in the sine-wave voltage levels prescribed above.

NOTE Annex A describes the calculation for the pulse response of the rms detector. At a repetition frequency of 25 Hz and 100 Hz (i.e. the quasi-peak detector reference pulse repetition frequency), respectively, the relationship between the indications of an rms-average and a quasi-peak measuring receiver of the same bandwidth is given in Table 14.

When external preamplifiers are used, refer to Annex J for applicable requirements.

Table 14 – Relative pulse response of rms-average and quasi-peak measuring receivers

Frequency range of measuring receiver	Pulse repetition rate Hz	Ratio quasi-peak/rms-average indications dB
9 kHz to 150 kHz (Band A)	25	4,2
0,15 MHz to 30 MHz (Band B)	100	14,3
30 MHz to 1 000 MHz (Bands C and D)	100	20,1

NOTE The values in this table result from the nominal specification of the detector weighting functions. Therefore, verification by a calibration laboratory is not required.

7.5.3 Variation with repetition frequency

The response of the measuring receiver to repeated pulses shall be such that, for a constant indication on the measuring receiver, the relationship between amplitude and repetition frequency above the corner frequency f_c shall be in accordance with the following rule:

amplitude proportional to (repetition frequency) $^{-1/2}$.

Below the corner frequency f_c the relationship shall be in accordance with the following rule:

amplitude proportional to (repetition frequency) $^{-1}$.

The response curve for a particular receiver shall lie between the limits in Table 15.

Table 15 – Pulse response of rms-average measuring receiver

Repetition frequency Hz	Relative equivalent level of pulse in dB			
	Band A	Band B	Bands C and D	Band E
100 k	-	-	$(-20 \pm 2,0)$	$-20 \pm 2,0$
10 k	-	-	$-10 \pm 1,0$	$-10 \pm 1,0$
1 000	-	0 (ref.)	0 (ref.)	0 (ref.)
316	-	$+5 \pm 0,5$	$+5 \pm 0,5$	$+10 \pm 1,0$
100	$-6 \pm 0,6$	$+10 \pm 1,0$	$+10 \pm 1,0$	$(+20 \pm 2,0)$
31,6	-	$+15 \pm 1,5$	$+20 \pm 2,0$	
25	0 (ref.)	$+16 \pm 1,6$		
10	$+4 \pm 0,4$	$+20 \pm 2,0$		
5	$+9 \pm 0,7$	$+25 \pm 2,3$		
1	-	-		

NOTE 1 Values in brackets are for information only.

NOTE 2 The values at 5 Hz for Bands A and B take into account the effect of the meter time constant.

7.5.4 Response to intermittent, unsteady and drifting narrowband disturbances

The response to intermittent, unsteady and drifting narrowband disturbances shall be such that the measurement result is equivalent to the peak reading of a meter with a time constant of 160 ms for Bands A and B and of 100 ms for Bands C, D and E. This can be accomplished by the meter-simulating network (analog or digital) to which the rms values described in 7.5.1 are used as input.

It is deduced from the above requirement that an rms-average measuring receiver shall yield the maximum reading listed in Table 9 for a radio frequency sine-wave input signal modulated with repeated rectangular pulses having the duration and period indicated in Table 16. A tolerance of $\pm 1,0$ dB is allowed for this requirement.

Table 16 – Maximum reading of rms-average measuring receivers for a pulse-modulated sine-wave input in comparison with the response to a continuous sine wave having the same amplitude

Repeated rectangular pulses for modulation	Band A/B receiver $T_M = 0,16 \text{ s}$	Band C/D/E receiver $T_M = 0,1 \text{ s}$
Duration = T_M Period = 1,6 s	0,398 (= –7,9 dB)	0,353 (= –9,0 dB)
NOTE The value for the Band A/B receiver can vary by about $\pm 0,5 \text{ dB}$ due to varying overlapping of the 160 ms pulse duration with the 100 ms rms integration time duration.		

7.6 Selectivity

The selectivity curves for the rms-average weighting receiver shall be equal to those of Figures 5, 6 and 7, for Bands A, B, C and D. For the Band E receiver, the selectivity curve is given in Figure 9.

The requirements of 4.5.2, 4.5.3 and 4.5.4 apply. For Band E receivers, requirements are under consideration.

7.7 Intermodulation effects, receiver noise, and screening

For the frequency range below 1 GHz, the requirements of 4.6, 4.7 and 4.8 apply. Subclauses 4.7 and 4.8.2 also apply for Band E.

For Band E, the following applies:

- requirements for intermodulation effects are under consideration.
- preselection filter: when measuring weak spurious signals in the presence of a strong fundamental signal from certain equipment under test, a filter shall be provided at the input of the measuring receiver to ensure adequate attenuation at the fundamental frequency to protect the input circuits of the receiver from overload and damage, and to prevent the generation of harmonic and intermodulation signals.

NOTE 1 30 dB filter attenuation at the fundamental frequency of the equipment under test is normally adequate.

NOTE 2 A number of such filters may be required to deal with more than one fundamental frequency.

Requirements for screening effectiveness, i.e. the immunity to high ambient radiated disturbances, are under consideration.

8 Measuring receivers for the frequency range 1 GHz to 18 GHz with amplitude probability distribution (APD) measuring function

APD of disturbance is defined as the cumulative distribution of the “probability of time that the amplitude of disturbance exceeds a specified level”.

APD can be measured at the output of the envelope detector or the succeeding circuits of an RF measuring receiver or a spectrum analyzer. The amplitude of disturbance should be expressed in terms of the corresponding field strength or voltage at the receiver input. Usually, an APD measurement is carried out at a fixed frequency.

The APD measuring function will be an additional function of the measuring apparatus and may be attached to, or incorporated in the measuring instrument.

The APD measuring function can be implemented using the following methods. One approach uses comparators and counters (Figure G.1). The equipment determines the probabilities of

exceeding a set of pre-assigned amplitude (i.e. voltage) levels. The number of levels equals the number of comparators. Another possible method involves the use of an analog-to-digital converter, a logic circuit, and memory (Figure G.2). The equipment can also provide the APD figure for a set of pre-assigned amplitude levels. The number of levels depends on the resolution of the analog-to-digital converter (e.g. 256 levels for an 8-bit converter).

APD measurements using the aforementioned function are applicable to products or product families if their potential to cause interference to digital communication systems is to be determined (see 4.7 of CISPR 16-3:2010/CISPR 16-3:2010/AMD1:2012, for background material on amplitude probability distribution, APD, specifications).

The following specifications apply to the APD measuring function. A rationale for these specifications is provided in Annex G.

- **Specifications**

- a) The dynamic range of the amplitude shall be greater than 60 dB.
- b) The amplitude accuracy, including threshold level setting error, shall be better than $\pm 2,7$ dB.
- c) The maximum measurable time of a disturbance shall be longer than or equal to 2 min. The intermittent measurement can be used if the dead time is less than 1 % of the total measurement time.
- d) The minimum measurable probability shall be 10^{-7} .
- e) The APD measuring function shall be capable of assigning at least two amplitude levels. The probabilities corresponding to all pre-assigned levels shall be measured simultaneously. The resolution of the pre-assigned amplitude levels shall be 0,25 dB at a minimum or better.
- f) The sampling rate shall be greater than or equal to 10 million samples per second when using a resolution bandwidth of 1 MHz.

- **Recommended specification**

- g) Amplitude resolution of the APD display should be less than 0,25 dB for APD measuring equipment with an A/D converter.

NOTE APD measurements may also be applicable in the frequency range below 1 GHz.

9 Disturbance analyzers

9.1 General

Disturbance analyzers are used for the automatic assessment of amplitude, rate and duration of discontinuous disturbances (clicks).

A 'click' has the following characteristics:

- a) the QP amplitude exceeds the quasi-peak limit of continuous disturbance,
- b) the duration is not longer than 200 ms, and
- c) the spacing from a preceding or subsequent disturbance is equal to or more than 200 ms.

A series of short pulses shall be treated as a click when its duration, measured from the start of the first to the end of the last pulse, is not longer than 200 ms and conditions a) and c) are fulfilled.

The time parameters are determined from the signal that exceeds the IF reference level of the measuring receiver.

NOTE 1 Definition and assessment of clicks are in compliance with CISPR 14-1.

NOTE 2 Current analyzers are designed for use with a quasi-peak measuring receiver of the type that works with a limited internal signal level. As a result, such analyzers may not interface correctly with all receivers.

9.2 Fundamental characteristics

- a) The analyzer shall be equipped with a channel to measure the duration and spacing of discontinuous disturbances; the input of this channel shall be connected to the IF output of the measuring receiver. For these measurements, only the part of the disturbance has to be considered which exceeds the IF reference level of the receiver. The accuracy of duration measurements shall be not worse than $\pm 5\%$.

NOTE 1 The IF reference level is the corresponding value in the IF output of the measuring receiver to an unmodulated sinusoidal signal, which produces a quasi-peak indication equal to the limit for continuous disturbances.

- b) The analyzer shall be equipped with a channel to assess the quasi-peak amplitude of a disturbance.
- c) The amplitude in the quasi-peak channel shall be measured 250 ms after the last falling edge in the IF channel.
- d) The combination of both channels shall comply in all respects with the requirements of 4.2.
- e) The analyzer shall be capable of indicating the following information:
- the number of clicks of duration equal to or less than 200 ms;
 - the duration of the test in minutes;
 - the click rate;
 - the incidence of disturbances other than clicks which exceed the QP limit of continuous disturbance.

NOTE 2 An example of a disturbance analyzer is shown in the form of a block diagram in Figure 12.

- f) For validation of the fundamental characteristics the analyzer has to pass the performance check with all the waveforms (test pulses) in Table 14.

Figure 13 presents in a graphical form the waveforms listed in Table 17.

Figure F.1 presents in a graphical form all the waveforms listed in Table F.1 for the performance check of the exceptions from the definitions of a click according to 4.2.3 of CISPR 14-1:2005.

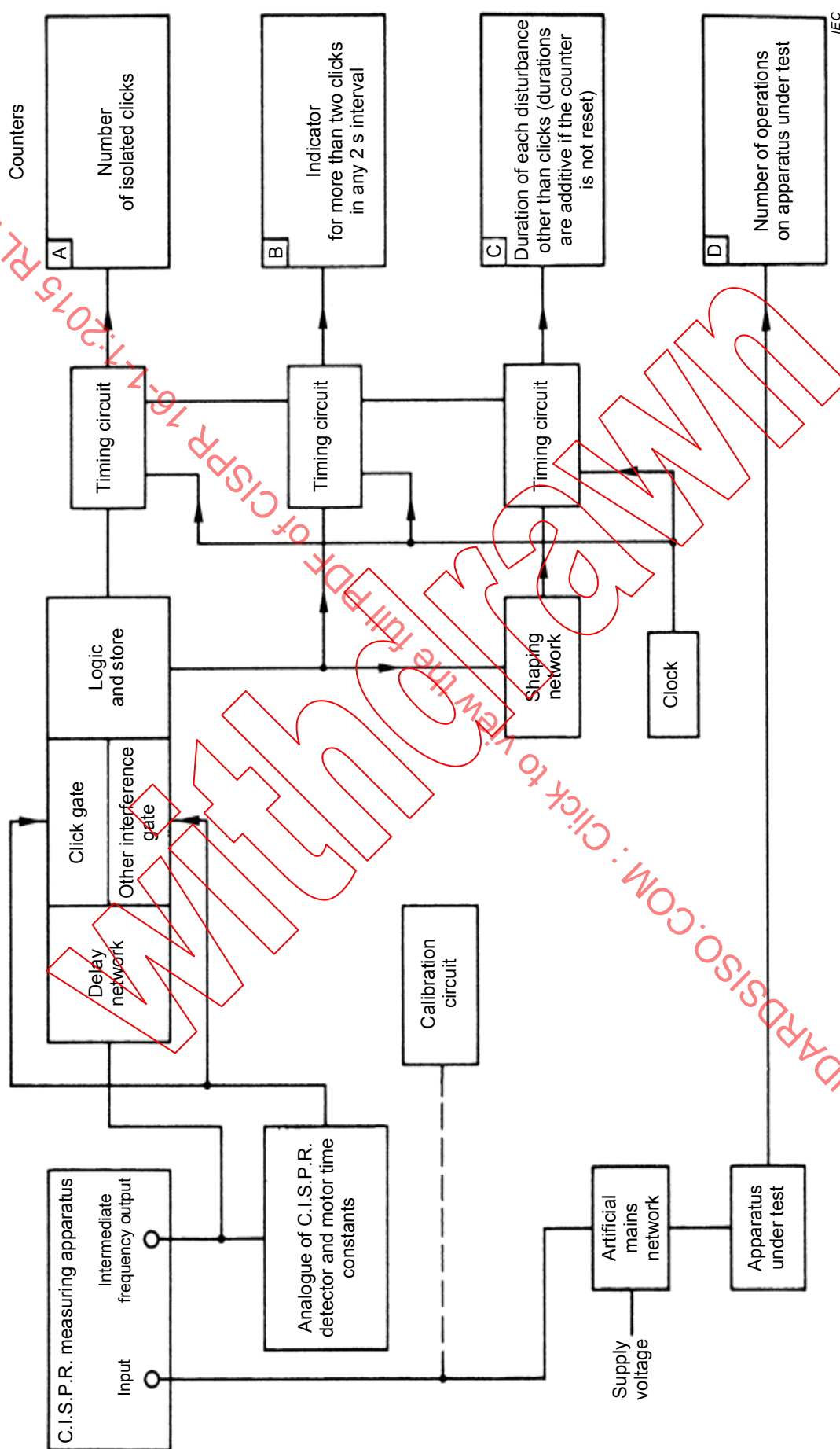


Figure 12 – Example of a disturbance analyzer

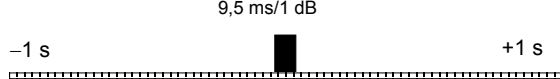
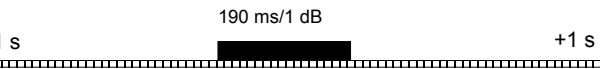
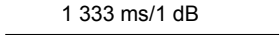
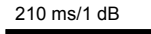
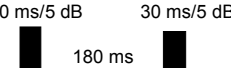
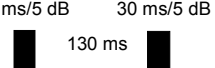
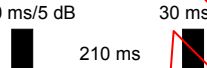
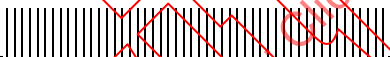
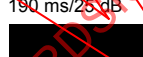
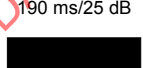
Test No.	Test signal	Evaluation by the analyzer
1	 0,11ms/1 dB	1 click
2	 9,5 ms/1 dB -1 s +1 s	1 click
3	 190 ms/1 dB -1 s +1 s Background: noise or CISPR pulses, 200 Hz: -2,5 dB (QP)	1 click
4	 1 333 ms/1 dB	Other than click
5	 210 ms/1 dB	Other than click
6	 30 ms/5 dB 180 ms 30 ms/5 dB	Other than click
7	 30 ms/5 dB 130 ms 30 ms/5 dB	1 click
8	 30 ms/5 dB 210 ms 30 ms/5 dB	2 clicks
9	 Min. 21 pulses/0,11 ms/periodicity 10 ms/1 dB	Other than click
10	 265 ms 30 ms/25 dB 30 ms/-2,5 dB	1 click
11	 190 ms/25 dB Band B: 1 034 ms/Band C: under consideration	2 clicks
12	 190 ms/25 dB Band B: 1 166 ms/Band C: under consideration 30 ms/-2,5 dB/2 dB IF	1 click

Figure 13 – A graphical presentation of test signals used in the test of the analyzer for the performance check against the definition of a click according to Table 14

**Table 17 – Disturbance analyzer performance test –
Test signals used for the check against the definition of a click (1 of 4)**

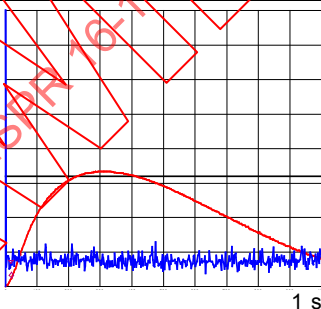
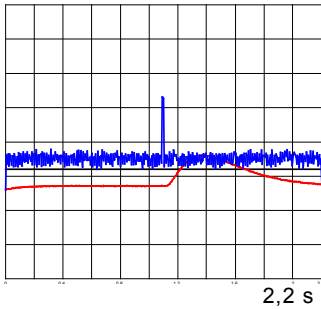
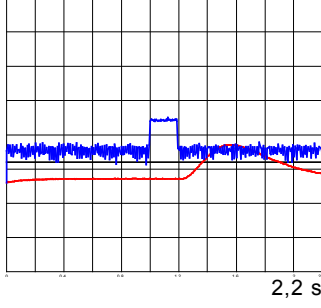
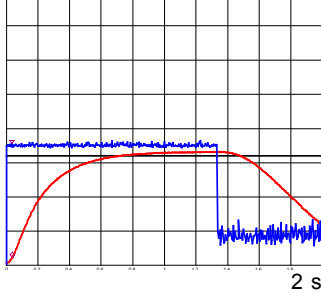
Test No.	Test signal parameters							Graphical presentation of the test signal measured in the IF-output and the associated QP signal relative to the reference indication of the measurement receiver
	1		2		3	4	5	
	QP amplitude of impulses adjusted individually relative to QP reference indication of the measurement receiver dB		Duration of impulses ^f adjusted in the intermediate frequency output of the measurement receiver ms		Separation of impulses or periodicity (IF-output) ms	Evaluation by the analyzer		
	Pulse 1	Pulse 2	Pulse 1	Pulse 2				
1	1		0,11			1 click		
2 ^a	1		9,5			1 click		
3 ^a	1		190			1 click		
4	1		1 333 ^b			Other than click		

Table 17 (2 of 4)

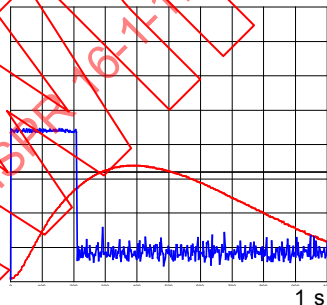
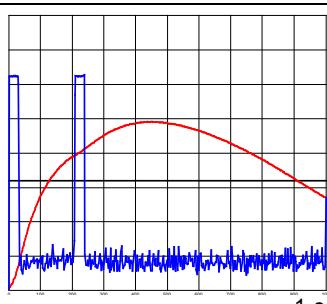
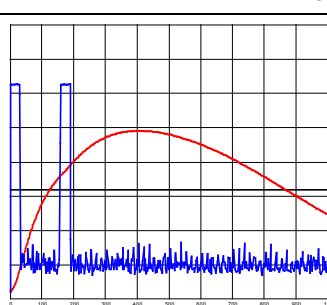
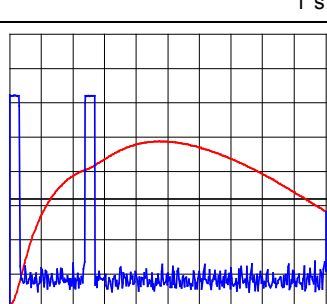
Test No.	Test signal parameters					Evaluation by the analyzer	Graphical presentation of the test signal measured in the IF-output and the associated QP signal relative to the reference indication of the measurement receiver
	1		2		3		
	QP amplitude of impulses adjusted individually relative to QP reference indication of the measurement receiver dB		Duration of impulses t adjusted in the intermediate frequency output of the measurement receiver ms		Separation of impulses or periodicity (IF-output) ms		
	Pulse 1	Pulse 2	Pulse 1	Pulse 2			
5	1		210			Other than click (210 ms)	
6	5	5	30	30	180	Other than click (240 ms)	
7	5	5	30	30	130	1 click	
8	5	5	30	30	210	2 clicks	

Table 17 (3 of 4)

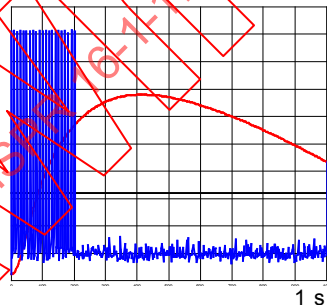
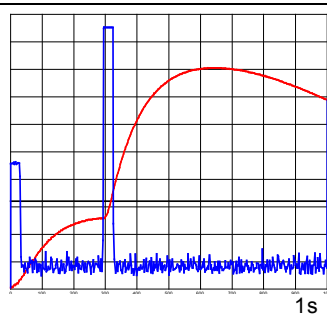
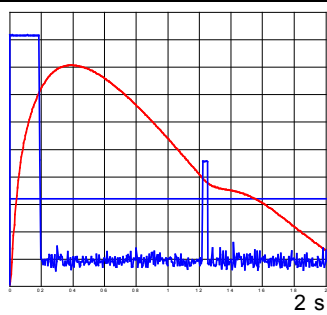
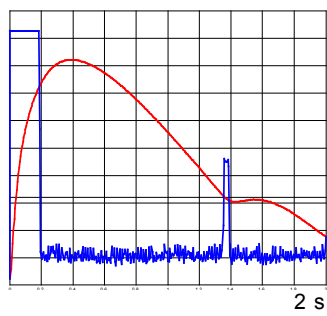
Test No.	Test signal parameters					Evaluation by the analyzer	Graphical presentation of the test signal measured in the IF-output and the associated QP signal relative to the reference indication of the measurement receiver
	1		2		3		
	QP amplitude of impulses adjusted individually relative to QP reference indication of the measurement receiver dB		Duration of impulses ^f adjusted in the intermediate frequency output of the measurement receiver ms		Separation of impulses or periodicity (IF-output) ms		
	Pulse 1	Pulse 2	Pulse 1	Pulse 2			
9	1		0,11		Periodicity 10, minimum 21 pulses	Other than click	
10	-2,5	25	30	30	265	1 click	
11	25	-2,5 ^c	190	30	1 034 ^e	2 clicks ^d	
12	25	-2,5 ^c	190	30	1 166 ^e	1 click	

Table 17 (4 of 4)

a	To be performed with background noise consisting of 200 Hz CISPR pulses at a level 2,5 dB below the quasi-peak threshold level. These pulses should be present commencing at least 1 s before the test pulse and lasting until at least 1 s after the test pulse.
Observations:	
1)	The graphical representation is done with peak measurements of a very short hold time (<1 ms) of the test receiver which show the 200-Hz pulse. When the pulse-modulated sine wave arrives, the 200-Hz-pulse is no longer visible (as seen in the graph for test no. 3) but still present during the event of the click disturbance
2)	The very narrow responses at the origin in the graphs are due to a firmware imperfection.
b	The 1,333 s impulse checks the threshold of the analyzer for impulses, which are only 1 dB above the quasi-peak threshold level.
c	These lower levels shall be set such that the intermediate frequency threshold is exceeded but the quasi-peak threshold is not exceeded
d	If these two pulses are measured as separate disturbances, only one click will be registered.
e	The correspondent values for the frequency range above 30 MHz are under consideration and will be revised after further investigations.
f	The rise times of the pulses shall not be longer than 40 μ s.

9.3 Test method for the validation of the performance check for the click analyzer

9.3.1 Basic requirements

The disturbance analyzer is connected to the quasi-peak measuring receiver and tuned to a convenient frequency.

A CW signal and a pulsed CW signal both at the tuned frequency of the receiver are required. A signal generated by CISPR pulse generator, as defined in Annex B, with a 200 Hz PRF covering the receiver bandwidth at the tuned frequency is also required for test numbers 2 and 3.

The pulsed CW signal source shall provide two independently variable pulses. The rise time of the pulses shall not be longer than 40 μ s. The pulse duration shall be variable between 110 μ s and 1,3 s and the amplitudes variable over a 44 dB range. Any background noise of the pulsed CW signal source shall be at least 20 dB below the reference level used in step a) in the test measured on the receiver's quasi-peak meter.

The test procedure is as follows:

- The CW signal is connected to the input of the measuring receiver used in conjunction with the disturbance analyzer. The amplitude of the CW signal is adjusted to bring the meter indication to the reference (zero) point on the meter scale of the measuring receiver equal to a value identical to the QP-limit for continuous disturbance. The receiver RF sensitivity (attenuator) control is adjusted to a level above the receiver noise but below the limit for continuous disturbance used as threshold in the IF channel. The corresponding level of the CW signal at the IF output of the receiver constitutes the IF reference level.
- The pulsed CW signal is connected to the input of the measuring receiver. For test numbers 2 and 3, the signal from the CISPR pulse generator is added to the pulsed CW signal. The parameters of the signal are given in Table 14. The amplitudes of the pulses shown in column 1 of Table 14 are adjusted individually relative to the indication of the limit (QP) for continuous disturbance used as threshold in the IF channel. The levels shall be relative to the respective RF and IF reference levels established in the previous paragraph.

9.3.2 Additional requirements

The test method is identical to the one described in 9.3.1a). The parameters of the signal are given in Table F.1.

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Annex A (normative)

Determination of response to repeated pulses of quasi-peak and rms-average measuring receivers (See 3.6, 4.4.2, 7.3.2 and 7.5.1)

A.1 General

This annex sets out the data for the numerical calculation, and the procedure for establishing the curve of response to repeated pulses. The assumptions inherent in the method are also stated. The calculation is divided into three successive stages.

NOTE The text on the rms detector in this annex deals with the rms measuring receiver in theory and applies to the rms-average measuring receiver above the corner frequency f_c as defined in Clause 7.

A.2 Response of the pre-detector stages

The pulse response of these stages is, in general, determined solely by the IF stages that define the overall selectivity of the receiver.

It is common practice to consider that this selectivity can be obtained by an assembly of two critically-coupled tuned transformers arranged in cascade so as to produce the desired passband at the –6 dB points. Any other equivalent arrangement can be reduced to the above for purposes of calculation. The practical symmetry of this passband permits the use of the equivalent low-pass filter for calculating the envelope of the pulse response. The error resulting from this approximation is negligible.

The envelope of the pulse response is written:

$$A(t) = 4\omega_0 G e^{-\omega_0 t} (\sin \omega_0 t - \omega_0 t \cos \omega_0 t) \quad (\text{A.1})$$

where

G is the overall gain at tuned frequency;

ω_0 is the angular frequency of value $(\pi/\sqrt{2}) B_6$.

The envelope of the response of two critically-coupled tuned transformers to an impulse area $\nu\tau$ is, from the previous equation:

$$A(t) = (\nu\tau) 4\omega_0 G e^{-\omega_0 t} (\sin \omega_0 t - \omega_0 t \cos \omega_0 t) \quad (\text{A.2})$$

The corresponding selectivity curve of the equivalent low-pass filter may be written, for $\tau \ll 1/\omega_0$:

$$F(f) = G \times \frac{2\omega_0^2}{\left[(\omega_0 + j\omega)^2 + \omega_0^2 \right]^2} \quad (\text{A.3})$$

where $\omega = 2\pi f$.

The bandwidths B_3 and B_6 will be:

$$B_3 = \frac{\left[\sqrt{2} \times \sqrt[4]{(\sqrt{2}-1)} \right] \omega_0}{\pi} = 0,361 \omega_0 \quad (\text{A.4})$$

$$B_6 = \frac{\sqrt{2} \times \omega_0}{\pi} = 0,450 \omega_0 \quad (\text{A.5})$$

The effective bandwidth of a receiver, comprising an idealized rectangular filter giving the same rms value of response as an actual receiver, is equal to the power bandwidth Δf defined as:

$$\Delta f = \left(\frac{1}{F_0^2} \right) \int_{-\infty}^{+\infty} F^2(f) df \quad (\text{A.6})$$

where

$F(f)$ is the selectivity curve;

F_0 is the maximum value of $F(f)$ (assuming a single peak selectivity curve).

The power bandwidth is then, for $F_0 = 1$

$$\Delta f = \int_{-\infty}^{+\infty} F^2(f) df \quad (\text{A.7})$$

Taking $F(f)$ from Equation (A.3) and putting $G = 1$, we have:

$$\Delta f = \int_0^{\infty} 2 \left\{ \frac{2\omega_0^2}{[(\omega_0 + f\omega)^2 + \omega_0^2]^4} \right\} df \quad (\text{A.8})$$

this leads to:

$$\Delta f = 0,265 \sqrt{2} \times \omega_0 = 0,375 \omega_0 \quad (\text{A.9})$$

thus:

$$B_3 = 0,963 \Delta f \quad (\text{A.10})$$

A.3 Response of the quasi-peak voltmeter detector to output of preceding stages

A.3.1 General

The calculation is made on the assumption that the connection of the detector circuits to the output of the last IF stages does not affect either the amplitude or the shape of the signal therefrom. In other words, the output impedance of this stage is regarded as negligible compared with the input impedance of the detector.

Any detector may be reduced to the form (actual or equivalent) of a non-linear element (for example a diode) in association with a resistance (total forward resistance S) and followed by a circuit consisting of a capacitance C in shunt with a discharge resistance R .

The electrical charge time constant T_C is related to the product $S \times C$, while the electrical discharge time constant T_D is given by the product $R \times C$.

The relationship between T_C and the product $S \times C$ will be established by obtaining, in a time $t = T_C$, an indicated voltage of 0,63 times the final steady value when a constant amplitude RF signal is suddenly applied.

The voltage U across the capacitor is related to the amplitude A of the RF signal applied to the detector by the equation:

$$\frac{dU}{dt} + UI(RC) = \frac{A(\sin \theta - \theta \cos \theta)}{\pi \times S \times C} \quad (\text{A.11})$$

where θ is the conduction angle ($U = A \cos \theta$).

This equation cannot be directly integrated. A value for the product $S \times C$, which, for the time constants chosen satisfies the above conditions, is found by methods of approximation, for example:

in Band A:	T_C	=	45 ms
	T_D	=	500 ms
	$2,81 S \times C$	=	1 ms
in Band B:	T_C	=	1 ms
	T_D	=	160 ms
	$3,95 S \times C$	=	1 ms
in Bands C and D:	T_C	=	1 ms
	T_D	=	550 ms
	$4,07 S \times C$	=	1 ms

By inserting the value thus obtained in Equation (A.11), this may be solved for either an isolated pulse or repeated pulses (again by methods of approximation) by introducing, in place of the constant amplitude A , the function $A(t)$ given by Equations (A.1) and (A.2).

This case of repeated pulses can be solved practically only by arbitrarily assuming a level for the output voltage of the detector at the start of each pulse, by determining the increment ΔU of this voltage caused by the pulse, and then finding the spacing which shall exist between two successive pulses in order to repeat the assumed initial conditions.

A.3.2 Response of the indicating instrument to the signal from the detector

The only simplifying, but perfectly legitimate, assumption is that the rising portion of the output voltage of the detector is instantaneous.

The following characteristic equation then has to be solved:

$$\frac{d^2 \alpha}{dt^2} + \left(\frac{2}{T_M} \frac{d\alpha}{dt} \right) + \frac{1}{T_M^2} \alpha = \left(\frac{1}{T_M^2} \right) e^{-t/T_D} \quad (\text{A.12})$$

where

$\alpha(t)$ is the instrument deflection;

T_D is the electrical discharge time constant of the quasi-peak voltmeter;

T_M is the mechanical time constant of the critically damped indicating instrument.

The solution of the problem is relatively simple for the two extremes of the response curve; on the one hand, for pulses sufficiently separated for the starting point to be zero and thus known, and on the other, for pulses having a sufficiently high repetition rate for the inertia of the instrument to prevent it following the fluctuations faithfully. For the intermediate cases, the calculation becomes more complicated. At the start of each pulse, the instrument deflection is varying and it is necessary to find a solution that takes account of the initial position and velocity.

A.4 Response of rms detector to output voltage of preceding stages

A.4.1 Output voltage and amplitude relationship

By definition, the output voltage of the rms detector is given by:

$$U_{\text{rms}} = \left[n \int_0^{+\infty} \frac{A^2(t)}{2} dt \right]^{1/2} \quad (\text{A.13})$$

where n is the pulse repetition frequency in Hz.

The output may also be deduced from the frequency response curve as:

$$U_{\text{rms}} = \left[n \int_{-\infty}^{+\infty} \frac{2v\tau \times F^2(f)}{2} df \right]^{1/2} \quad (\text{A.14})$$

where $v\tau$ is the area of pulse having a uniform frequency spectrum.

This gives:

$$U_{\text{rms}} = \left[\sqrt{2} \times v\tau \times \sqrt{n} \int_{-\infty}^{+\infty} F^2(f) df \right]^{1/2} \quad (\text{A.15})$$

Which, from Equation (A.7), gives:

$$U_{\text{rms}} = \sqrt{2} \times v\tau \times \sqrt{n} \times \sqrt{\Delta f} \quad (\text{A.16})$$

From Equation (A.16), the amplitude relationship may be deduced by taking:

$$U_{\text{rms}} = 2 \text{ mV, when } n = 100 \text{ Hz}$$

thus:

$$v\tau = \frac{100\sqrt{2}}{\sqrt{\Delta f}} \mu Vs \quad (\text{A.17})$$

or from Equation (A.10):

$$v\tau = \frac{139}{\sqrt{B_3}} \mu Vs \quad (\text{A.18})$$

A.4.2 Calculation of overload factor

The overload factor corresponding to a pulse repetition frequency of n Hz is calculated as follows.

From Equation (A.16):

$$U_{\text{rms}} = (v\tau) \times (2n\Delta f)^{1/2}$$

From Equations (A.1) and (A.2), and for $G = 1$:

$$A(t)_{\text{peak}} = 0,944 \times v\tau \times \omega_0$$

Thus the overload factor:

$$\frac{A(t)_{\text{peak}}}{\sqrt{2} \times U_{\text{rms}}} = 1,28 \left(\frac{B_3}{n} \right)^{1/2} \quad (\text{A.19})$$

A.5 Relationship between indication of rms meter and quasi-peak meter

The amplitude relationship for the rms meter that states the value of pulse $(v\tau)_{\text{rms}}$ for the case of 100 Hz, which is equivalent to a sine-wave signal of 2 mV, is from Equation (A.18):

$$(v\tau)_{\text{rms}} = \frac{139}{\sqrt{B_3}} \mu Vs$$

For the selectivity characteristic quoted in Equation (A.3), this corresponds to:

$$(v\tau)_{\text{rms}} = \frac{155}{\sqrt{B_6}} \mu Vs$$

when reference is made to the bandwidth at 6 dB.

For the quasi-peak receiver, the value of pulse $(v\tau)_{\text{qp}}$, which is equivalent to a sine-wave signal of 2 mV, is as follows:

for the frequency range 0,15 MHz to 30 MHz:

$$(\nu\tau)_{qp} = 0,316 \mu\text{Vs}$$

for the frequency range 30 MHz to 1 000 MHz:

$$(\nu\tau)_{qp} = 0,044 \mu\text{Vs}$$

Thus for measuring receivers having band-pass characteristics according to Equation (A.3) and a bandwidth at 6 dB equal to the nominal bandwidths prescribed in Clauses 4, 5, 6 and 7 the following relationships for $(\nu\tau)_{rms}/(\nu\tau)_{qp}$ exist:

for the frequency range 0,15 MHz to 30 MHz:

$$\frac{(\nu\tau)_{rms}}{(\nu\tau)_{qp}} = 14,3 \text{ dB}$$

for the frequency range 30 MHz to 1 000 MHz:

$$\frac{(\nu\tau)_{rms}}{(\nu\tau)_{qp}} = 20,1 \text{ dB}$$

These relationships are valid for a pulse repetition frequency of 100 Hz. At other repetition frequencies, it is necessary to use the corresponding pulse response curves.

Annex B (normative)

Determination of pulse generator spectrum (See 4.4, 5.5, 6.5, 7.5)

B.1 Pulse generator

B.1.1 General

For checking compliance with the requirements of this standard, a pulse generator is needed. Compliance with the requirements of 4.4, 4.6, 5.5, 6.5 and 7.5 may be tested using the pulse generator technique.

For each frequency band of the measuring receiver under test, the generator used shall be capable of producing pulses with the impulse area specified and over the range of repetition frequencies given in Table B.1. The impulse area should be known within $\pm 0,5$ dB and the repetition frequency to within about 1 %.

Table B.1 – Pulse generator characteristics

Frequency band of receiver under test MHz	Impulse area μVs	Repetition frequency Hz
0,09 to 0,15	13,5	1, 2, 5, 10, 25, 60, 100
0,15 to 30	0,316	1, 2, 10, 20, 100, 1 000
30 to 300	0,044	1, 2, 10, 20, 100, 1 000
300 to 1 000	(see Note)	1, 2, 10, 20, 100, 1 000
NOTE The generator should be capable of producing pulses of adequate impulse area with a spectrum up to 1 000 MHz as uniform as possible.		

B.1.2 The spectrum of the generated pulses

The spectrum is defined by a curve that represents as a function of the tuned frequency of the receiver under test, the law of variation of the equivalent voltage at the input of a measuring apparatus having a constant bandwidth.

The spectrum should be substantially constant up to the upper limit of the frequency band of the receiver under test. The spectrum may be regarded as satisfactorily uniform if, within this band, the variation of the spectrum amplitude is not greater than 2 dB relative to its value for the lower frequencies within the band. The impulse area at the measurement frequency shall be known to within $\pm 0,5$ dB.

For checking compliance with the requirements of 4.6, the spectrum above the upper limit of the frequency band shall be limited (10 dB down at twice the upper frequency). This is necessary to standardize the severity of the test since the inter-modulation products of all components of the spectrum will contribute to the response.

B.2 General method of measurement

Methods for the accurate determination of the absolute value of the spectrum amplitude of pulses are given in Annex C.

For measurement of the variation of the spectrum amplitude with frequency, the following method may be used.

The pulse generator is connected to the input of an RF receiver followed by an oscilloscope connected so as to indicate the RF pulse at the output of the receiver.

At each frequency of tuning of the receiver, the following are measured:

- a) the bandwidth, B_6 Hz, of the receiver at the –6 dB points,
- b) the rms value, E_0 , of the output from a standard signal generator having the same impedance as the pulse generator and tuned to the mid-band of the receiver and producing on the oscilloscope a deflection equal in amplitude to the peak of the RF pulses.

The relative spectrum amplitude at each frequency is taken to be:

$$S_r(f) = \frac{E_0}{B_6}$$

The measurement is repeated for various test frequencies in the band under consideration.

The spectrum of the pulse generator is given by the curve relating $S_r(f)$ to the measurement frequency.

The receiver used should be linear for the peak levels of the signals used.

The suppression of parasitic responses, in particular the image frequency and IF responses, should be at least 40 dB.

The measurements may be made with a receiver conforming to the present specification, using the quasi-peak indicator in place of the oscilloscope, provided that the repetition frequency of the pulses is kept constant throughout the series of measurements.

Annex C (normative)

Accurate measurements of the output of nanosecond pulse generators (See 4.4, 5.5, 6.5, 7.5)

C.1 Measurement of impulse area (A_{imp})

C.1.1 General

Theoretical and practical investigations have shown that, when applied with reasonable care, accurate methods of measurement include those given in C.1.2 to C.1.5.

C.1.2 Area method

The pulses to be measured are fed through a narrow band filter whose passband is centred at frequency f having a symmetrical amplitude characteristic, and an asymmetrical phase characteristic (in conjunction with a filter, an amplifier may be used provided it is operated in its linear range).

The total area under the envelope $A(t, f)$ of the output from the band-pass filter (taking into account the sign of different parts of it) is measured, so as to evaluate the integral in the equation:

$$2(A_{\text{imp}}) = S(f) = \int_{-\infty}^{+\infty} A(t, f) dt \quad (\text{C.1})$$

where

$S(f)$ is the spectral intensity; and

$A(t, f)$ is the magnitude of the envelope due to a single isolated pulse (expressed in terms of equivalent input sine-wave voltage).

In applying this equation, the intermediate-frequency amplifier of a low-frequency receiver or a disturbance-measuring receiver is used together with a series of frequency converters to tune across the spectrum of the pulse. The output of the final intermediate-frequency amplifier is taken directly to an oscilloscope for the area measurement.

In a variation of this method for pulses of duration much shorter than the period of the frequency (f), the impulse area can be measured directly as an integrated area by means of a suitable oscilloscope (for example, for nanosecond pulses, a sampling oscilloscope is required), the integration taking into account the sign of different parts of the area.

C.1.3 Standard transmission line method

A transmission line of length corresponding to propagation time τ and charged to a voltage V_0 is discharged into a load resistance equal to the characteristic impedance of the line. The transmission line is considered to consist of the actual line as well as the charged section of the line contained in the switch housing. It has been found that spectral intensity, $S(f)$, has the value $2V_0\tau$ in the low-frequency portion of the spectrum of the resulting pulse in which the amplitude is constant with frequency, this amplitude being independent of the existence of certain stray impedances between the line and the load resistor (e.g. inductance or resistance) or of finite switching time.

C.1.4 Harmonic measurement

This method may be used for pulse generators producing a sequence of pulses with sufficiently high and stable repetition frequency.

When the pulse repetition frequency F exceeds the values of the bandwidth of the measuring receiver, the latter may select one line from the pulse spectrum. In this case, the impulse area may be determined as follows:

$$A_{\text{imp}} = \frac{V_K}{2F} = \frac{V\sqrt{2}}{2F} \quad (\text{C.2})$$

where $V_K = V\sqrt{2}$ is the peak value of the k -th harmonic.

The pulse generator may then be used to calibrate the pulse response characteristics of a measuring receiver in which the bandwidth is sufficiently wide to accept many harmonic components (approximately 10 or more within the 6 dB bandwidth).

C.1.5 Energy method

Another method compares the power produced by a thermal source (resistor) with that produced by the pulse generator. However, the accuracy obtained with this method is somewhat less than with the three methods mentioned above. This method may be useful at frequencies of the order of 1 000 MHz.

C.2 Pulse generator spectrum

C.2.1 To determine compliance with 4.4.1, 5.5, 6.5.2 and 7.5.2, the impulse area shall be known with an error not greater than $\pm 0,5$ dB.

C.2.2 The pulse repetition frequency shall be known with an error not greater than 1 %.

C.2.3 For determining compliance with 4.4.2, 5.5, 6.5.4 and 7.5.3, the impulse area shall not depend on their repetition frequency.

C.2.4 For determining compliance with 4.4, 5.5, 6.5 and 7.5, the generator frequency spectrum should be uniform over the passband of the measuring receiver. This requirement is considered fulfilled in the following cases:

- if variation of the frequency spectrum is substantially linear with respect to frequency within the frequency passband of the receiver, and the spectrum irregularity does not exceed 0,5 dB within the receiver passband measured at the -6 dB points;
- if the frequency spectrum is smoothly tapered on both sides from the tuning frequency of the receiver, and if the spectrum width at the -6 dB points is at least five times greater than the receiver passband at that level.

In both cases, the impulse area is assumed to be equal to its value at the tuning frequency.

Annex D

(normative)

Influence of the quasi-peak measuring receiver characteristics on its pulse response

(See 4.4.2)

The level of the pulse response curve for high repetition frequencies depends essentially on the magnitude of the bandwidth. On the other hand, for low repetition frequencies, the time constants play the more important role. No tolerance has been stated for these time constants, but it is suggested for guidance that a value of 20 % is considered reasonable.

It is also at very low repetition frequencies that the effect of lack of overload factors will be most noticeable. The values required for the overload factors are those necessary for the accurate measurement of an isolated pulse using the bandwidth and the time constants prescribed.

Examination of the pulse response-curve at the two ends of the range of the indicating instrument provides a check on possible non-linear behaviour of the detector. The most critical repetition frequencies in this respect are most probably in the neighbourhood of 20 Hz to 100 Hz.

Annex E (normative)

Response of average and peak measuring receivers (See 6.3.1)

E.1 Response of pre-detector stages

It is shown in [19] and [20] that the area under the envelope of the impulse response curve of a narrowband circuit having a symmetrical frequency characteristic is independent of the bandwidth, and is given by:

$$\int_{-\infty}^{+\infty} A(t) dt = 2\nu\tau G_0 \quad (\text{E.1})$$

where ν and τ are the amplitude and duration of a rectangular pulse for which $B_{\text{imp}} \tau \ll 1$ and G_0 is the gain of the circuit at the centre frequency.

This theorem is valid only in the case of a non-oscillating envelope. The oscillatory envelope is characteristic of double-tuned circuits, and unless a phase sensitive detector is used, it may be necessary to compensate by calibration the error introduced by the oscillatory response. In the case of critical coupling, the second peak of the envelope is about 8,3 % of the first one.

NOTE The response of the pre-detector stages as defined in A.2 is oscillatory. Therefore, the calibration error introduced by the oscillatory response ~~should be~~ is compensated with a biased tolerance of +2,5 dB/–0,5 dB in 6.5.2.

As long as pulses do not overlap in the output of the IF amplifier, the average value is proportional to the pulse repetition rate, n :

Therefore, the average voltage is equal to $2\nu\tau G_0 n$.

In view of Equation (E.1), it is not considered meaningful to define an effective bandwidth for an average measuring receiver.

E.2 Overload factor

For calculation of overload factor and for use in connection with peak measuring receivers, it is useful to define a quantity known as the effective impulse bandwidth of the pre-detector circuit as follows:

$$B_{\text{imp}} = \frac{A(t)_{\text{max}}}{2G_0} \quad (\text{E.2})$$

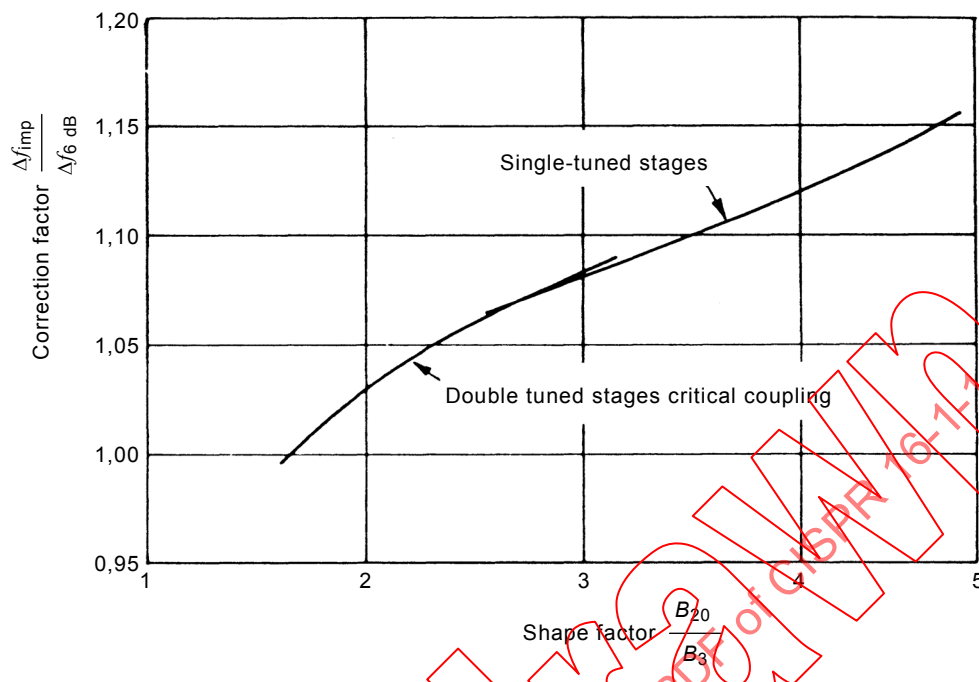
where $A(t)_{\text{max}}$ is the peak envelope output of the intermediate-frequency stages with a unit impulse applied.

From the work leading to Equation (A.19), we have:

$$B_{\text{imp}} = \left(\frac{0,944}{2} \right) \omega_0 = 1,05B_6 \text{ or } 1,31B_3 \quad (\text{E.3})$$

where B_6 and B_3 are defined in 3.6.

For other types of tuned circuits, the ratio of B_{imp} to B_6 may be estimated from Figure E.1 if the ratio of B_{20} to B_3 is known, where B_{20} is the bandwidth at 20 dB.



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Figure E.1 – Correction factor for estimating the ratio B_{imp}/B_6 for other tuned circuits

E.3 Relationship between indication of an average and a quasi-peak measuring receiver

At a repetition rate of n Hz, the value of impulse area required to produce a response on an average measuring receiver equivalent to the response to an unmodulated sine-wave signal at the tuned frequency of rms value 2 mV from a signal generator having the same output impedance as the pulse generator is:

$$\nu\tau = \frac{1,4}{n} \text{ mVs} \quad (\text{E.4})$$

At a repetition rate of 100 Hz, $\nu\tau$ is 14 μVs .

Therefore, from A.5 the ratio of $(\nu\tau)_{\text{ave}}$ to $(\nu\tau)_{\text{qp}}$ to produce the same indication will be:

for the frequency range 0,15 MHz to 30 MHz:

$$\frac{(\nu\tau)_{\text{ave}}}{(\nu\tau)_{\text{qp}}} = 32,9 \text{ dB}$$

for the frequency range 30 MHz to 1 000 MHz:

$$\frac{(\nu\tau)_{\text{ave}}}{(\nu\tau)_{\text{qp}}} = 50,1 \text{ dB}$$

The above assumes adequate overload factor at the repetition rate in question, and that the bandwidths in use correspond respectively to those in Clause 4. At a repetition rate of 1 000 Hz, the corresponding ratios will be 17,4 dB and 38,1 dB.

E.4 Peak measuring receivers

Where a direct-reading meter is used in the receiver, the requirement for time constants can be determined from the curve in Figure E.2, which shows the percentage of the reading referred to the true peak in function of a parameter and which includes the time constants ratio, the bandwidth B_6 and the pulse repetition rate. In using this curve, it should be noted that:

$$\frac{R_C}{R_D} = \frac{1}{4} \left(\frac{T_C}{T_D} \right) \quad (\text{E.5})$$

where T_C and T_D are respectively the charge and discharge time constants.

For example, if it is desired to have the receiver read at least 90 % of true peak at a repetition rate of 1 Hz, it would be necessary to have a discharge-time constant to charge time constant ratio of:

$1,25 \times 10^6$ in the frequency range 0,15 MHz to 30 MHz;

$1,67 \times 10^7$ in the frequency range 30 MHz to 1 000 MHz.

E.5 Relationship between indication of a peak and a quasi-peak measuring receiver

The value of impulse area, A_{imp} , required to produce a response on a peak measuring receiver equivalent to the response to an unmodulated sine-wave signal at the tuned frequency of rms value 2 mV is:

$$\frac{1,4}{B_{\text{imp}}} \text{ mVs (with } B_{\text{imp}} \text{ in Hz)} \quad (\text{E.6})$$

From the 6 dB bandwidths specified in Table H.1, the B_{imp} values are obtained as $1,05B_6$ (see E.2). These values and the corresponding A_{imp} values required for a peak meter are shown in Table E.1.

Table E.1 – B_{imp} and A_{imp} values for a peak measuring receiver

Frequency	$A_{\text{imp,peak}}$ mVs	B_{imp} Hz
Band A	$6,67 \times 10^{-3}$	$0,21 \times 10^3$
Band B	$0,148 \times 10^{-3}$	$9,45 \times 10^3$
Bands C and D	$0,011 \times 10^{-3}$	126×10^3

Therefore, using the values given as a) in Table 1 for $A_{\text{imp, qp}}$, the ratio of $A_{\text{imp, qp}}$ to $A_{\text{imp, peak}}$ to produce the same indication is:

- For Band A 6,1 at 25 Hz pulse repetition frequency;
- For Band B 6,6 at 100 Hz pulse repetition frequency;
- For Bands C and D 12,0 at 100 Hz pulse repetition frequency.

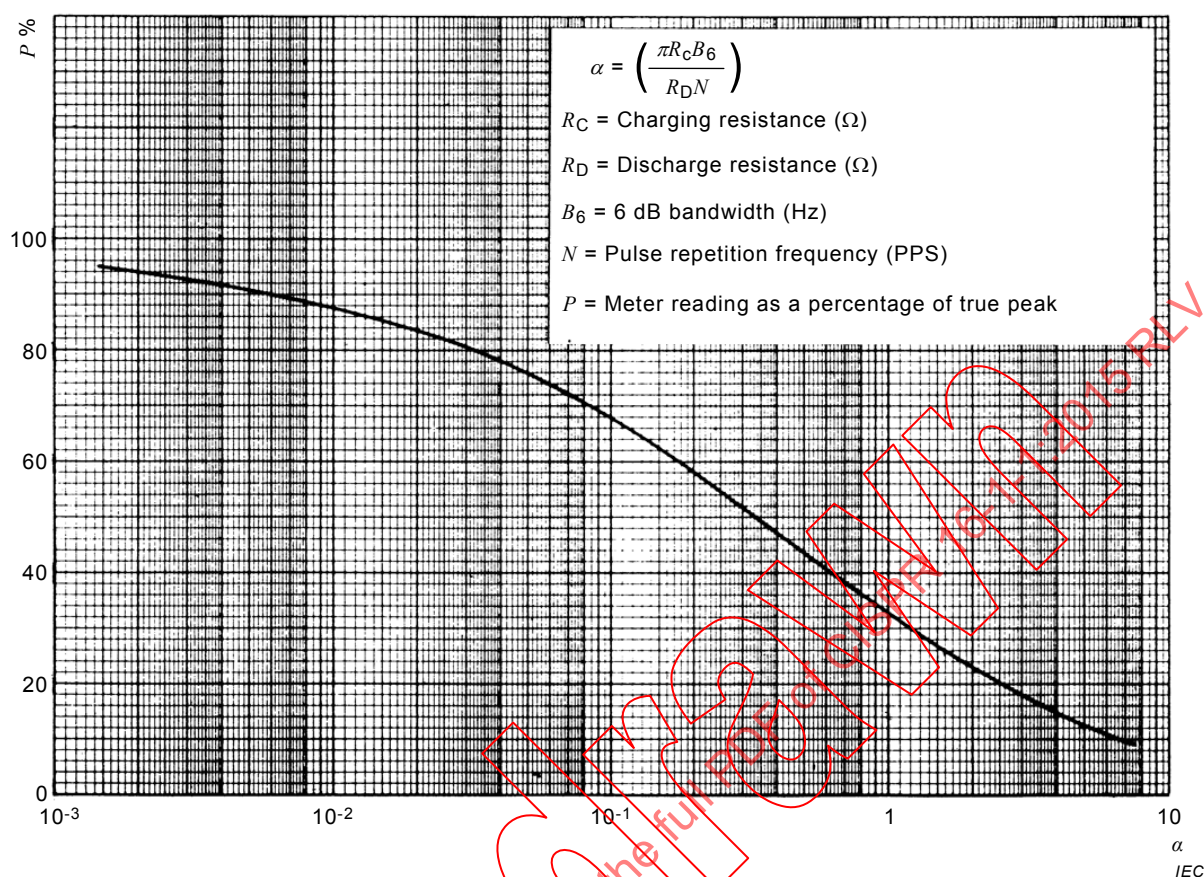


Figure E.2 – Pulse rectification coefficient P

E.6 Test of measuring receiver response above 1 GHz to pulses

Pulse generators with a uniform spectrum up to 18 GHz are not feasible. To test the response of measuring receivers above 1 GHz to pulses and to verify the amplitude relationship of various types of measuring receivers, it is practical to use a pulse-modulated carrier tuned to the receive frequency. The pulse width shall be less than or equal to $(1/3 B_{\text{imp}})$. The accuracy of the impulse width is important for the precise generation of a certain impulse area as required in the relevant subclause. In addition to a measurement of the pulse duration using an oscilloscope, the pulse duration of a rectangular pulse can be verified by the distance between the minima on the spectrum display (see Figure E.3 for a sample waveform).

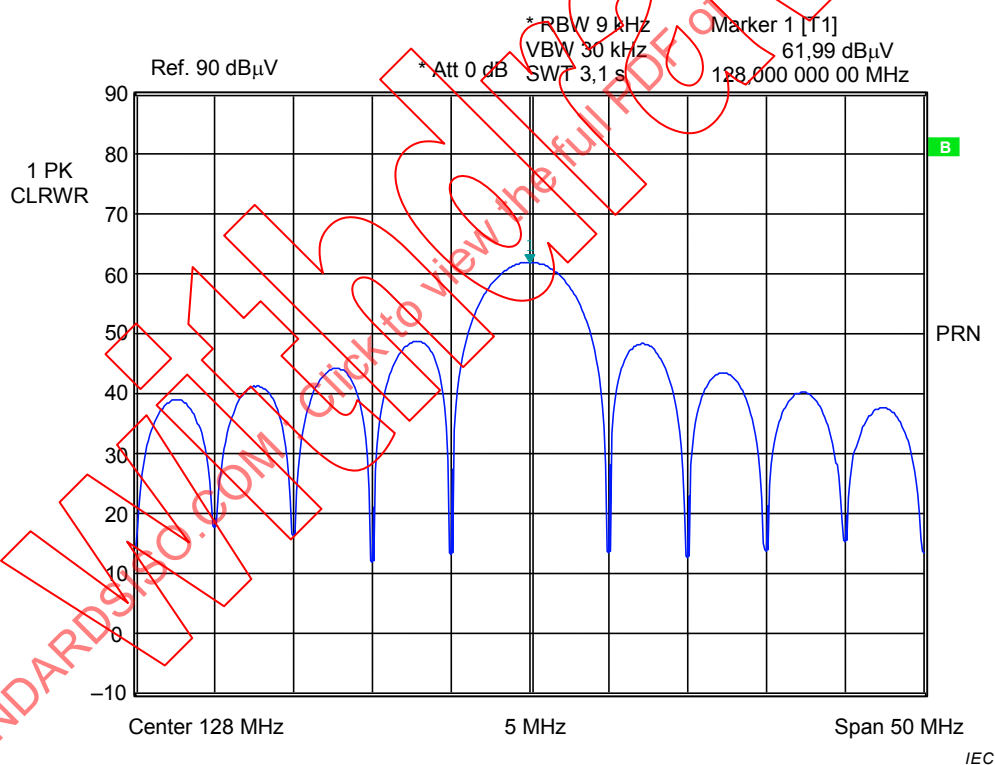
For the measuring receiver with a peak detector with a bandwidth B_{imp} of 1 MHz, an impulse area (e.m.f.) of $1,4/B_{\text{imp}}$ mVs is required, that is, 1,4 nVs for a response equal to that of an unmodulated sine-wave signal tuned to the receive frequency having an e.m.f. with rms value of 2 mV [66 dB(μ V)]. A pulse-modulated carrier having the required impulse area can be generated with the various pulse widths as shown in Table E.2.

Table E.2 – Carrier level for pulse-modulated signal of 1,4 nVs

Pulse width w_p/ns	Carrier level (e.m.f.) $L_{\text{carrier}}/\text{dB}(\mu\text{V})$
100	86
200	80

For a measuring receiver with a linear average detector, the impulse area (e.m.f.) equal to an unmodulated sine-wave signal at the receive frequency having an e.m.f. with rms value of 2 mV [66 dB(μV)] shall be $1,4/n$ mVs (n being the pulse repetition rate). For $n = 50\,000$, the impulse area is 28 nVs, that is, 26 dB higher than for the peak measuring receiver with a B_{imp} of 1 MHz.

For a measuring receiver with an rms detector, the impulse area (e.m.f.) equal to an unmodulated sine-wave signal at the receive frequency having an e.m.f. with rms value of 2 mV [66 dB(μV)] shall be $44(B_3^{-1/2})$ μVs for pulse repetition rate of 1 kHz. For an impulse bandwidth B_{imp} of 1 MHz, the corresponding B_3 is 700 kHz. Therefore, the required impulse area is 52,6 nVs, that is, 31,5 dB higher than for the peak measuring receiver with a B_{imp} of 1 MHz.

**Figure E.3 – Example (spectrum screenshot) of a pulse-modulated signal with a pulse width of 200 ns**

E.7 Measurement of the impulse bandwidth of a measuring receiver

E.7.1 General

The impulse bandwidth B_{imp} of a measuring receiver is defined as the peak value U_p (measured by the receiver) divided by the pulse spectral density D of the test pulse:

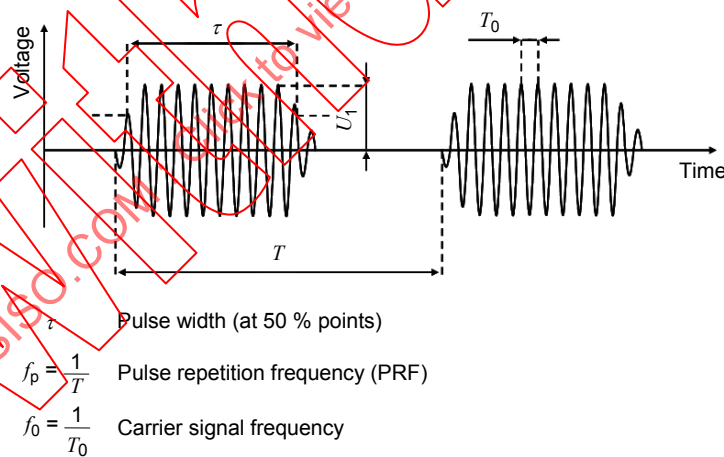
$$B_{\text{imp}} = \frac{U_p}{D} \quad (\text{E.7})$$

If U_p is measured in μV and D is given in $\mu\text{V}/\text{MHz}$, then B_{imp} will result in units of MHz. Both quantities, U_p and D , are assumed to be calibrated in rms values of an unmodulated sine wave signal, which is the case for CISPR measuring receivers.

The pulse spectral density D will frequently not be available as a precise reference quantity. In order to reduce the uncertainty of the impulse bandwidth measurement, Methods 1 and 2 are using two measurements. Under certain circumstances, the selectivity curve of a measuring receiver can also be used to calculate B_{imp} (as described in method 3), since B_{imp} is the “voltage bandwidth” of the measuring receiver (not to be confused with the power bandwidth or equivalent noise bandwidth, which determines the rms value of Gaussian noise when using the rms detector of the measuring receiver). B_{imp} is determined by the selectivity curve of the IF filter, the (possibly non-linear) phase response of the filter and the video bandwidth of the receiver. It is wider than B_6 , but there is no general factor for the relationship between B_{imp} and B_6 or B_3 of the receiver.

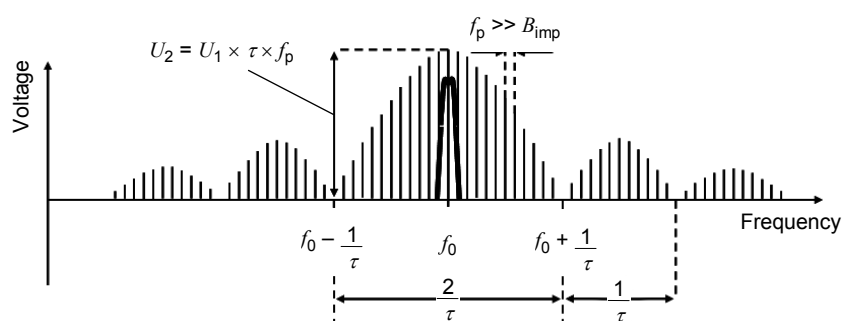
E.7.2 Method 1: Measurement by comparison of the responses of B_{imp} to two pulses with identical amplitude and width but with low and high pulse repetition frequencies (prf)

This method applies a pulse-modulated RF signal, with short pulse duration as shown in Figure E.4 and two different prfs. With the high prf ($f_p \gg B_{\text{imp}}$), the receiver can be tuned to the carrier frequency as shown in Figure E.5 and with the low prf f_p ($f_p \ll B_{\text{imp}}$), the spectrum will appear as a broadband signal as in Figure E.6. with a pulse spectral density of $D = U_1 \times \tau$. The pulse shape (amplitude U_1 and duration τ) has to be independent of the prf. For $B_{\text{imp}} = 1 \text{ MHz}$, f_{p1} could be selected to be 30 MHz and f_{p2} could be 30 kHz.



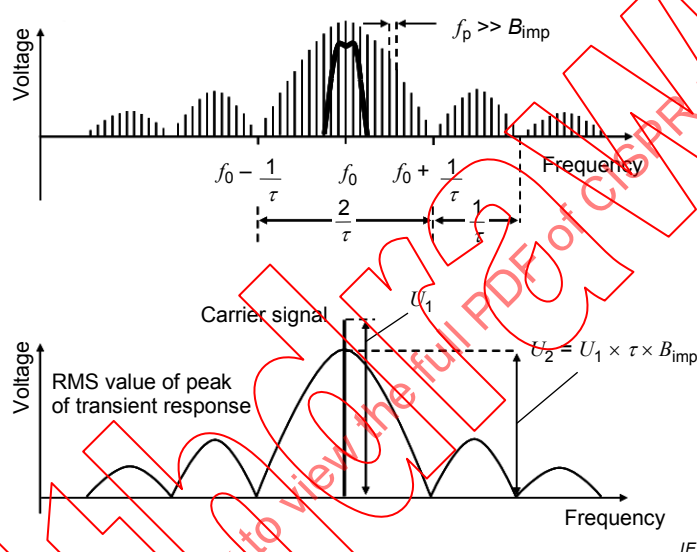
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Figure E.4 – Pulse-modulated RF signal applied to a measuring receiver



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Figure E.5 – Filtering with a B_{imp} much smaller than the prf



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Figure E.6 – Filtering with a B_{imp} much wider than the prf

With the first measurement, the rms amplitude U_2 can be expected as $U_2 = U_1 \times \tau \times f_{p1}$. Low measurement uncertainty can be achieved by a high signal-to-noise ratio. But care shall be taken to avoid overload. With the second measurement, the maximum response of the rms value of the peak to the transient can be expected as $U_p = U_1 \times \tau \times B_{\text{imp}}$. If the product $U_1 \times \tau$ is perfectly equal in both measurements, then B_{imp} can be calculated from the two measurement results as shown in Figure E.7 using Equation (E.2):

$$B_{\text{imp}} = f_{p1} \times \frac{U_p}{U_2} \quad (\text{E.8})$$

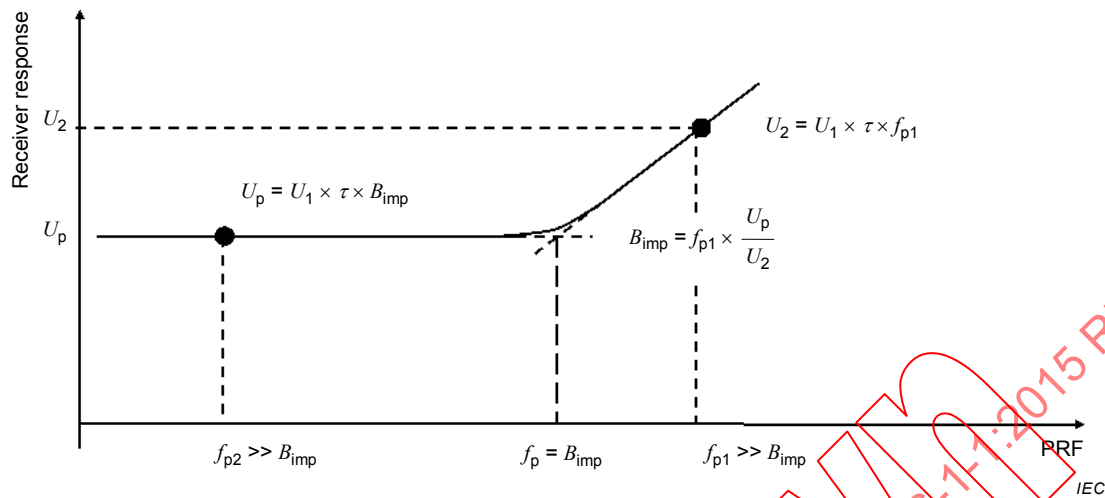


Figure E.7 – Calculation of the impulse bandwidth

E.7.3 Method 2: Measurement by comparison of the response of B_{imp} to an impulsive signal with the response of a narrow bandwidth to the same signal

If a pulse generator that retains a constant amplitude, independent of the selected prf, is not available, method 2 can be applied with a relatively low prf. It is based on the same principle as method 1, measurement. However, instead of using a high prf signal, the second measurement is made with a filter much narrower than the prf. The method is also described in C.1.5.

This method determines the pulse spectral density D using the equation $D = U_k / f_p$, where U_k is the measured voltage of one spectral line (i.e. the carrier frequency, if the signal is a pulse-modulated carrier, or the center line at the receive frequency, at which B_{imp} is to be measured) and f_p is the prf. Again, f_p shall be much higher than the narrow bandwidth and much lower than the B_{imp} to be measured, i.e. $B_{\text{narrow}} \ll f_p \ll B_{\text{imp}}$. Example settings could be $B_{\text{narrow}} = 9 \text{ kHz}$, $f_p = 100 \text{ kHz}$ for $B_{\text{imp}} = 1 \text{ MHz}$. The method requires a comparison of the responses of the narrowband filter and of the filter to be measured by applying an unmodulated sinewave signal to both filters and deriving a correction factor c for the calculation of D ($c = U_2 / U_1$, with U_2 being the value for the wide filter and U_1 being the value for the narrow filter). Therefore $D = c \times U_k / f_p$. When D is determined, U_p is measured with the peak detector and B_{imp} can be calculated using Equation (E.2).

E.7.4 Method 3: Integration of the normalized linear selectivity function

This method has the advantage of high precision and is applicable for filters with a perfectly linear selectivity function (e.g. digital filters, or per specification by the manufacturer) and where the video bandwidth is much wider (e.g. 10 times) than the impulse bandwidth ($B_{\text{video}} \gg B_{\text{imp}}$).

In this case, the impulse bandwidth of a measuring receiver is defined as the area of the normalized linear selectivity function $U(f)$, with $1/U_{\text{max}}$ as the normalization factor:

$$B_{\text{imp}} = \frac{1}{U_{\text{max}}} \int_{-\infty}^{+\infty} U(f) df \quad (\text{E.9})$$

Measuring receivers with high-resolution digital frequency displays can be tuned in N steps of Δf to measure the selectivity function $U(f_n)$. Measurements between the 60 dB points with 100 steps ($N = 101$) are usually sufficient for a correct bandwidth measurement. Analogous, a swept receiver can be set up such that its start and stop frequencies coincide with the 60 dB points of the filter curve and a sweep is taken to obtain the amplitude values. The test signal

will be a CW signal to trace out the filter shape of the filter under investigation. In this case, the impulse bandwidth can be measured and calculated using

$$B_{\text{imp}} = \frac{1}{U_{\text{max}}} \sum_{n=1}^N [U(f_n) + U(f_{n+1})] \times \frac{\Delta f}{2} \quad (\text{E.10})$$

Figure E.8 depicts an example of a normalized linear 1 MHz selectivity function.

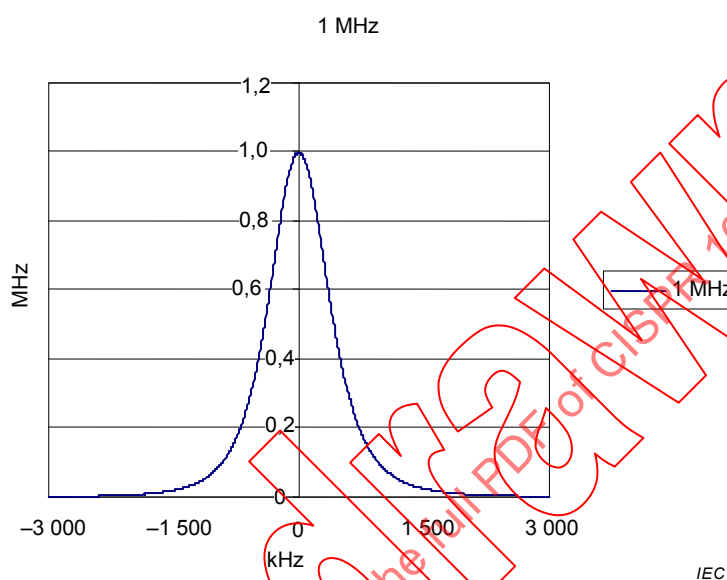


Figure E.8 – Example of a normalized linear selectivity function

Annex F

(normative)

Performance check of the exceptions from the definitions of a click according to 4.2.3 of CISPR 14-1:2005

For the application of the exceptions given in CISPR 14-1, the disturbance analyzer shall provide the following additional information (refer to Table F.1 for test details):

- a) the number of clicks of duration equal to or less than 10 ms;
- b) the number of clicks of duration greater than 10 ms but equal to or less than 20 ms;
- c) the number of clicks of duration greater than 20 ms but equal to or less than 200 ms;
- d) the duration of each registered disturbance the amplitude of which exceeds the QP level limit for continuous disturbance;
- e) an indication that the appliance failed the test, if it is clear that it produces disturbances other than clicks not corresponding to the definition of a click and to which none of the exceptions can be applied;
- f) the time interval from the start of the test to the occurrence of disturbances; mentioned under e);
- g) the total duration of disturbances other than clicks the QP level limit of which exceeds the limit for continuous disturbance;
- h) the click rate.

Table F.1 – Disturbance analyzer test signals ^a (1 of 5)

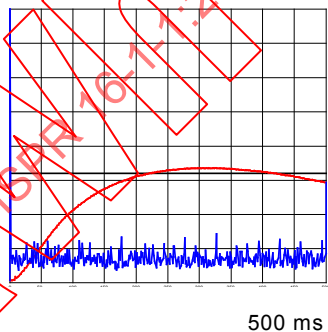
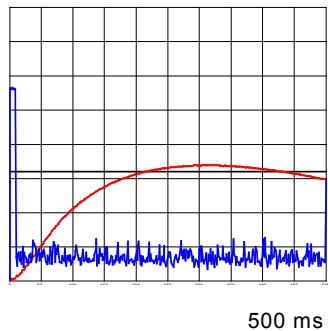
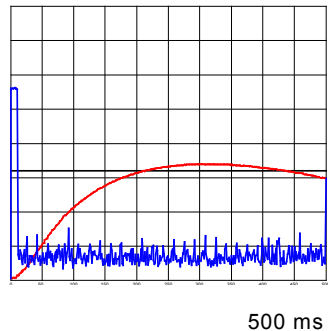
Test No.	Test signal parameters					Graphical presentation of the test signal measured in the IF output and the associated QP signal relative to the reference indication of the measurement receiver
	1		2		3	
	QP Amplitude of impulses adjusted individually relative to QP reference indication of the measurement receiver dB		Duration of impulses ^b adjusted in the intermediate frequency output of the measurement receiver ms		Separation of impulses or periodicity (IF-output) ms	
	Pulse 1	Pulse 2	Pulse 1	Pulse 2		
1	1		0,11			1 click ≤10 ms 
2	1		9,5			1 click ≤10 ms 
3	1		10,5			1 click >10 ms, ≤20 ms 

Table F.1 (2 of 5)

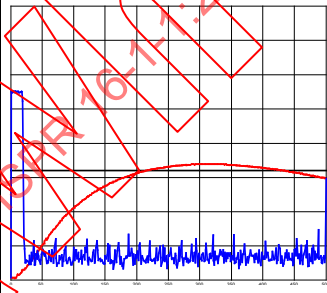
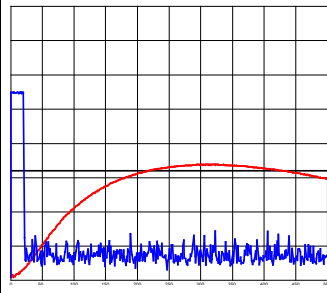
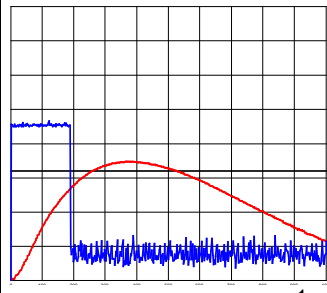
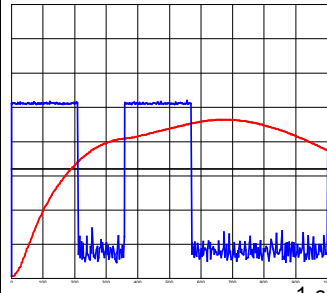
Test No.	Test signal parameters					Graphical presentation of the test signal measured in the IF output and the associated QP signal relative to the reference indication of the measurement receiver
	1		2		3	
	QP Amplitude of impulses adjusted individually relative to QP reference indication of the measurement receiver dB		Duration of impulses ^b adjusted in the intermediate frequency output of the measurement receiver ms		Separation of impulses or periodicity (IF-output) ms	
	Pulse 1	Pulse 2	Pulse 1	Pulse 2		
4	1		19			1 click >10 ms, ≤20 ms 
5	1		21			1 click >20 ms 
6	1		190			1 click >20 ms 
7	5	5	210	210	150	IF only once per program cycle or per minimum observation time: counted as 1 click >20 ms (See E2 and Note 1 of this table, 600 ms rule) 
						OTHERWISE Continuous disturbance (570 ms)

Table F.1 (3 of 5)

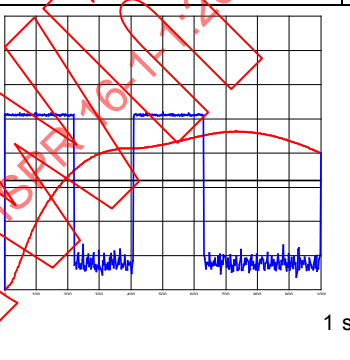
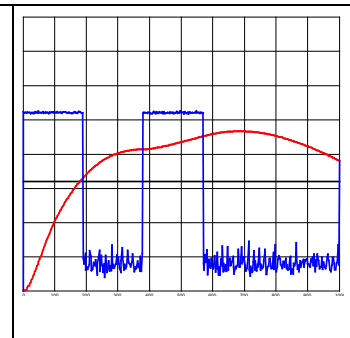
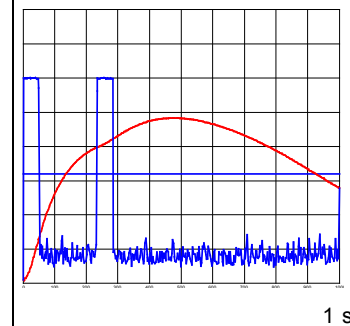
Test No.	Test signal parameters					Graphical presentation of the test signal measured in the IF output and the associated QP signal relative to the reference indication of the measurement receiver
	1		2		3	
	QP Amplitude of impulses adjusted individually relative to QP reference indication of the measurement receiver		Duration of impulses ^b adjusted in the intermediate frequency output of the measurement receiver		Separation of impulses or periodicity (IF-output)	
	dB		ms		ms	
	Pulse 1	Pulse 2	Pulse 1	Pulse 2		
8	5	5	220	220	190	FAIL Continuous disturbance (See E2 and Note 1 of this table: no exception is applicable because the total duration is 630 ms > 600 ms) 
9	5	5	190	190	190	IF the final click rate is less than 5: 2 clicks >20 ms (See E4 and Note 1 of this table; refrigerator rule; also see Note 2 of this table) 
						OTHERWISE IF only once per program cycle or once during the minimum observation time: counted as 1 click >20 ms (see E2 and Note 1 of this table) OTHERWISE Fail: continuous disturbance (570 ms)
10	5	5	50	50	185	IF the final click rate is less than 5: 2 clicks >20 ms (See E4 and Note 1 of this table; also see Note 2 of this table) 

Table F.1 (4 of 5)

Test No.	Test signal parameters				
	1	2	3	4	5
	QP Amplitude of impulses adjusted individually relative to QP reference indication of the measurement receiver dB	Duration of impulses ^b adjusted in the intermediate frequency output of the measurement receiver ms	Separation of impulses or periodicity (IF-output) ms	Evaluation by the analyzer	Graphical presentation of the test signal measured in the IF output and the associated QP signal relative to the reference indication of the measurement receiver
	Pulse 1	Pulse 2	Pulse 1	Pulse 2	
					OTHERWISE IF not more than once per program cycle or during the minimum observation time: counted as 1 click < 600 ms (See E2 and Note 1 of this table, $2 \times 285 \text{ ms} > 20 \text{ ms}$) OTHERWISE fail: continuous disturbance (285 ms)
11	20	20	15	5	1 × Pulse 1 + 9 × Pulse 2, repeated until 40 clicks are registered, where the separation between each impulse is 13 s 36 clicks < 10 ms 4 clicks > 10 ms, ≤ 20 ms ≥ 90 % of the clicks < 10 ms PASS (see E3, Note 1 and Note 3 of this table; a measurement of the click amplitudes is <u>not</u> required.)
12	20	20	15	5	1 × Pulse 1 + 8 × Pulse 2, repeated until 40 clicks are registered, where the separation between each impulse is 13 s 35 clicks ≤ 10 ms 5 clicks > 10 ms, ≤ 20 ms < 90 % of the clicks ≤ 10 ms (see E3, Note 1 and Note 3 of this table. No exception is applicable. After application of upper quartile method the final result will be "FAIL" because the click amplitudes are too high.)

Table F.1 (5 of 5)

CISPR 14-1:2005, 4.2.3, contains the following exceptions:

- E1 – “Individual switching operations”
This exception can be evaluated only by the operator, not automatically by the disturbance analyzer. It is mentioned here to avoid confusion with the numbering of the exceptions for users of both this standard and CISPR 14-1.
- E2 – “Combination of clicks in a time frame less than 600 ms” (“600 ms rule”)
In program-controlled appliances, a combination of clicks in a time frame less than 600 ms is allowed once per selected program cycle. For other appliances such a combination of clicks is allowed once during the minimum observation time. This is also valid for thermostatically controlled three-phase switches, causing three disturbances sequentially in each of the three phases and the neutral. The combination of clicks is considered as one click.
- E3 – “Instantaneous switching”
Appliances which fulfil the following conditions:
 - the click rate is not more than 5,
 - none of the caused clicks has a duration longer than 20 ms, and
 - 90 % of the caused clicks have a duration less than 10 ms,
 shall be deemed to comply with the limits, independent of the amplitude of the clicks. If one of these conditions is not satisfied then the limits for discontinuous disturbance apply.
- E4 – “Separation of clicks less than 200 ms” (refrigerator rule)
For appliances which have a click rate less than 5, any two disturbances each having a maximum duration of 200 ms, shall be evaluated as two clicks even when the separation between the disturbances is less than 200 ms. In this case, for instance observed with refrigerators, such a configuration has to be evaluated as two clicks and not as a continuous disturbance.

NOTE 1 The analyzer has to apply exception E2 only if E4 is not applicable.

NOTE 2 The check wave forms 11 and 12 can pass the test only in case exception E3 can be applied, as the following calculation shows:

- Including the click at “0” seconds for the check waveforms 11 and 12, the required 40 clicks are counted after $13 \text{ s} \times 39 = 507 \text{ s}$, i.e. 8,45 min. The click rate is $40 / 8,45 = 4,734$ (less than 5 as required – here all depends on whether 90 % are $\leq 10 \text{ ms}$ or not).

NOTE 3 The relaxation of the limit for the clicks according to CISPR 14-1 is: $20 \times \log(30 / 4,734) = 16,04 \text{ [dB]}$. Therefore the check waveforms 11 and 12 (amplitude 20 dB over the limit) never can pass the upper quartile check according to CISPR 14-1:2005, which means that no more than 25 % of the clicks are allowed to exceed the click limit.

^a Test signals used for the performance check with the evaluation of the exceptions from the definition of a click according to CISPR 14-1:2005, 4.2.3.

^b The rise times of the pulses shall not be longer than 40 μs .

Test No	Test signal	Evaluation by the analyzer
1	0,11 m/1 dB	1 click ≤10 ms
2	9,5 ms/1 dB	1 click ≤10 ms
3	10,5 ms/1 dB	1 click >10 ms, ≤20 ms
4	19 ms/1 dB	1 click > 10 ms, ≤20 ms
5	21 ms/1 dB	1 click >20 ms
6	190 ms/1 dB	1 click >20 ms
7	210 ms/5 dB 150 ms 210 ms/5 dB	1 click ≤600 ms (DUT programme-controlled)
8	220 ms/5 dB 190 ms 220 ms/5 dB	Continuous ≥600 ms
9	190 ms/5 dB 190 ms 190 ms/5 dB	1 click ≤600 ms (counted as 2 clicks refrigerator rule)
10	50 ms/5 dB 185 ms 50 ms/5 dB	for N < 5 - 2 clicks for N ≥ 5 - continuous, or 1 click ≤600 ms for programme controlled DUT
11	15 ms/20 dB 13 s 13 s 13 s 13 s 13 s 13 s 13 s 13 s 13 s 9 pulses/5 ms/20 dB repeated up to 40 counted clicks	36 clicks ≤10 ms 4 clicks >10 ms, ≤20 ms
12	15 ms/20 dB 13 s 13 s 13 s 13 s 13 s 13 s 13 s 8 pulses/5 ms/20 dB repeated up to 40 counted clicks	35 clicks <10 ms 5 clicks >10 ms, ≤20 ms

Figure F.1 – A graphical presentation of the test signals used for the performance check of the analyzer with the additional requirements according to Table F.1

Annex G (informative)

Rationale for the specifications of the APD measuring function

The specifications are based on the following definitions and considerations:

a) Dynamic range of the amplitude

The dynamic range of the amplitude is defined as the range necessary to obtain the APD. The upper limit of the dynamic range shall be greater than the peak level of disturbance to be measured and the lower limit shall be lower than the level of disturbance limit specified by the product committees.

According to CISPR 11, the peak limit for group 2, class B, for ISM equipment is set at 110 dB(μV/m), and the weighted limit is specified as 60 dB(μV/m). Therefore, a dynamic range of greater than 60 dB is proposed, with a 10 dB margin.

b) Sampling rate

Ideally, the APD of disturbances is measured using the equivalent bandwidth of the radio service to be protected. However, the spectrum analyzer's resolution bandwidth is specified as 1 MHz for the frequency range above 1 GHz. The sampling rate shall therefore be greater than 10 million samples per second.

c) Maximum measurable time

CISPR 11 specifies the maximum hold time as a 2 min period for peak measurements of microwave cooking appliances above 1 GHz. Therefore, the measurable time for an APD measurement shall be 2 min minimum. Because the size of the counter or memory is limited, continuous measurements may be difficult for long measurement periods. Therefore, intermittent measurements are allowed under the condition that the dead time is less than 1 % of the total measurement time.

d) Minimum measurable probability

About 100 occurrences may be necessary to obtain a meaningful result. Therefore, the minimum measurable probability is calculated as follows:

assuming 2 min for the measuring time and a 10-million-samples-per-second sampling rate, the probability is determined as:

$$100/(120 \times 10 \times 10^6) \pm 10^{-7}$$

e) Display of APD measurement data

The amplitude resolution for the display of APD results depends on the dynamic range and the resolution of the A/D converter. For example, the resolution of the display comes to less than 0,25 dB (± 60 dB/256) when an 8-bit A/D converter is applied to a dynamic range of 60 dB.

Figures G.1 and G.2 show block diagrams of implementations of the APD measurement function.

An example of an APD measurement result is depicted in Figure G.3.

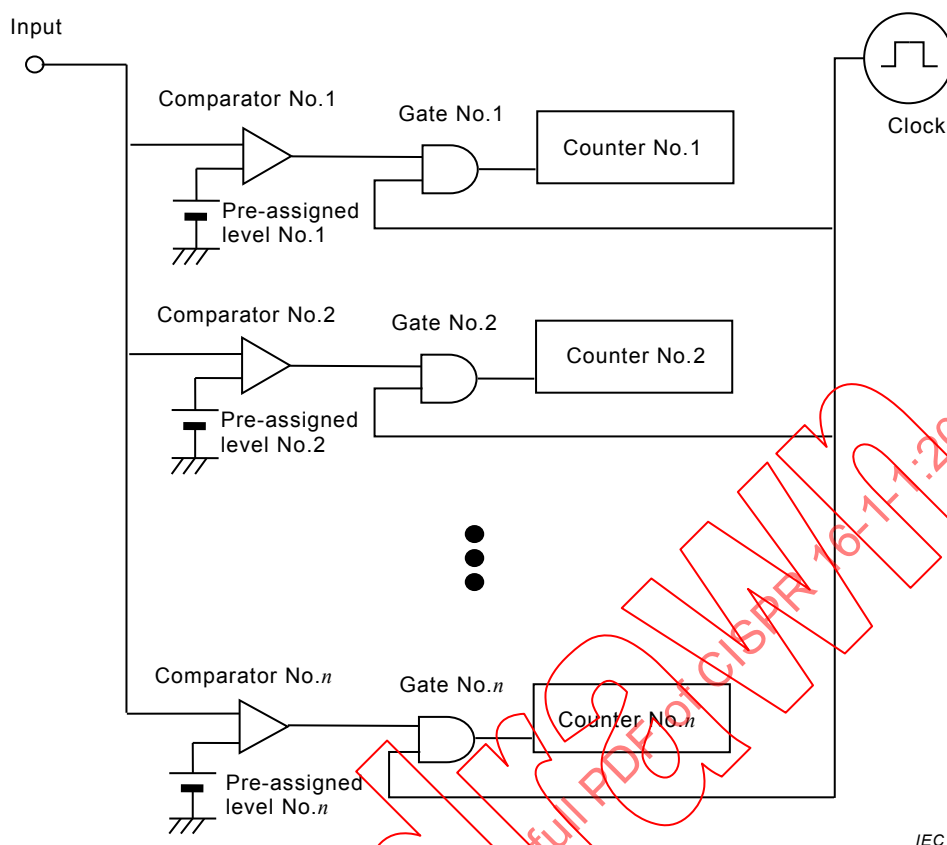


Figure G.1 – Block diagram of APD measurement circuit without A/D converter

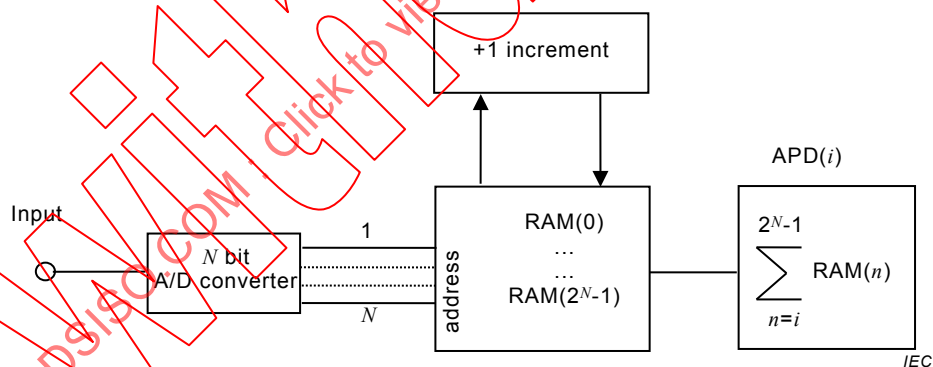


Figure G.2 – Block diagram of APD measurement circuit with A/D converter

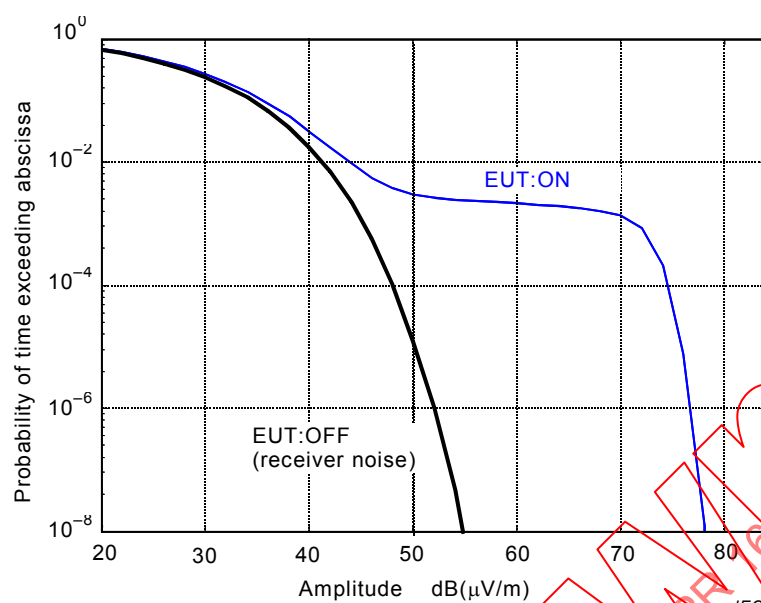


Figure G.3 – Example of display of APD measurement

Annex H (informative)

Characteristics of a quasi-peak measuring receiver

Table H.1 provides specifications of a quasi-peak measuring receiver. These specifications describe the overall characteristics of such an instrument and do not describe the specification of individual components and subassemblies of the instrument. The responses to pulses as specified in 4.4 are calculated on the basis of the measuring receivers having the following fundamental characteristics.

Table H.1 – Characteristics of quasi-peak measuring receivers

Characteristics	Frequency band		
	Band A 9 kHz to 150 kHz	Band B 0,15 MHz to 30 MHz	Bands C and D 30 MHz to 1 000 MHz
Bandwidth at the –6 dB points, B_6 in kHz	0,20	9	120
Detector electrical charge time constant, in ms	45	1	1
Detector electrical discharge time constant, in ms	500	160	550
Mechanical time constant of critically damped indicating instrument, in ms	160	160	100
Overload factor of circuits preceding the detector, in dB	24	30	43,5
Overload factor of the d.c. amplifier between detector and indicating instrument, in dB	6	12	6
NOTE 1 The definition of mechanical time constant (see 3.8) assumes that the indicating instrument is linear, i.e. equal increments of current produce equal increments of deflection. An indicating instrument having a different relation between current and deflection ~~may~~ can be used provided that the instrument satisfies the requirements of this subclause. In an electronic instrument, the mechanical time-constant ~~may~~ can be simulated by a circuit. NOTE 2 No tolerance is given for the electrical and mechanical time constants. The actual values used in a specific receiver are determined by the design to meet the requirements in 4.4.			

Annex I (informative)

Example of EMI receiver and swept spectrum analyzer architecture

This annex provides a brief description of the main differences between “EMI receivers” and “swept spectrum analyzers”, as far as this standard is concerned. Figure I.1 illustrates an example of the architecture of both types of instruments. The parts shaded in grey are typically implemented in test instrumentation to achieve compliance with specifications called out in this standard.

NOTE Additional background information is currently in preparation for CISPR 16-3.

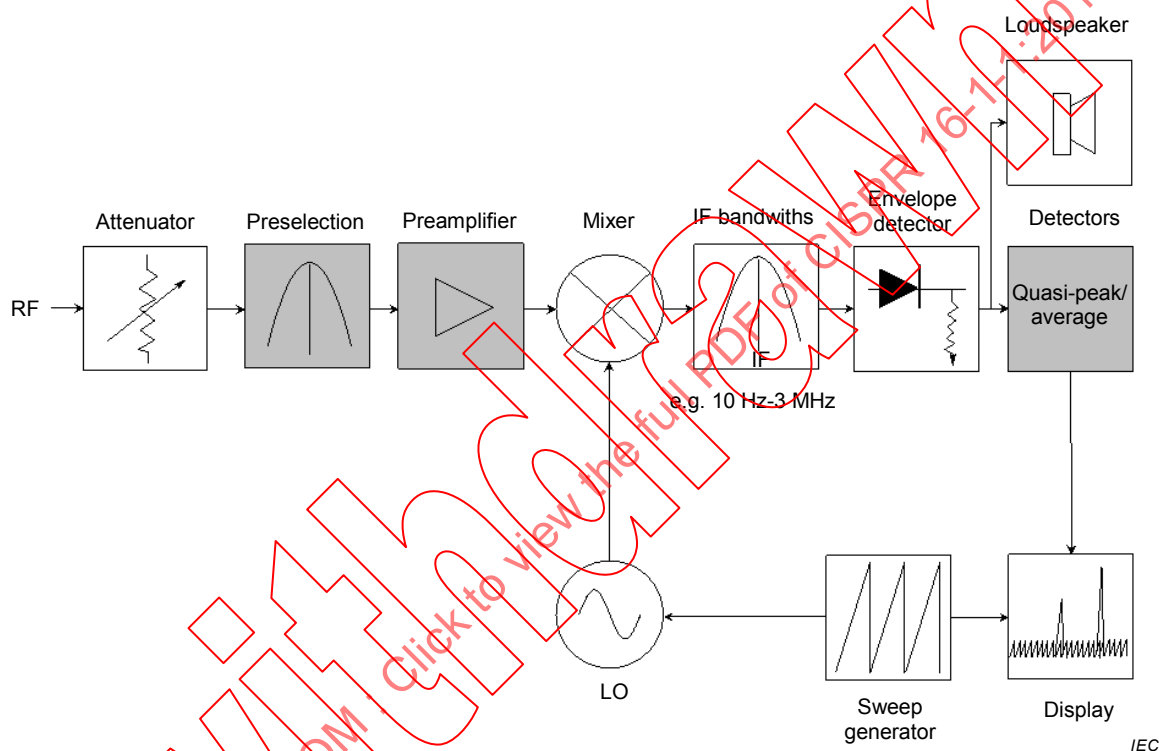


Figure I.1 – Example block diagram of EMI receiver consisting of swept spectrum analyzer with added preselector, preamplifier and quasi-peak/average detector

The main differences between the two instrument types are described below.

- a) Swept spectrum analyzers are scanning instruments, which tune their local oscillator (LO) frequency continuously to cover the selected frequency range of interest. Some EMI receivers perform a stepped sweep, i.e. the instrument is tuned to fixed frequencies, in defined frequency step sizes, to cover the frequency range of interest. The amplitude at each tuning frequency is measured and retained for further processing or display.
- b) Most swept spectrum analyzers do not have preselection (i.e. filtering at the input) built into the instrument before the first frequency conversion stage. This usually results in an inadequate dynamic range for measurements of low repetition frequency pulses with quasi-peak detection and thus may lead to erroneous measurement results under these circumstances.
- c) Swept spectrum analyzers with preselection are commercially available. This type of instruments may meet all requirements called out in this standard and, in case of full compliance with this standard, can be used without any restrictions to perform emission measurements in accordance with CISPR 16-2 series.

- d) The specifications applicable to spectrum analyzers without preselection in regard to quasi-peak detection are less stringent and their use is conditional on the signals to be measured.
- e) Spectrum analyzers may not have a built-in preamplifier. EMI receivers tend to have a preamplifier built in after the preselection stage.
- f) The frequency selectivity criteria, defined in 4.5, may not be met by swept spectrum analyzers. Typically swept spectrum analyzers use Gaussian shaped filters that may not meet these requirements. This standard requires swept spectrum analyzers to meet the stated specifications in 4.5.
- g) Swept spectrum analyzers may not have a quasi-peak detector built in. This standard requires spectrum analyzers to meet the stated specifications in 4.4 for quasi-peak detection. However, the documented requirements for pulse repetition frequencies are not applicable to swept spectrum analyzers without preselection.
- h) Swept spectrum analyzers may not have the proper response to intermittent, unsteady and drifting narrowband disturbances as described in 6.5.4. This standard requires spectrum analyzers to meet the stated specifications in 6.5.4.

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Annex J (normative)

Requirements when using an external preamplifier with a measuring receiver

J.1 General

Using an external preamplifier at the input of a measuring receiver shall be considered carefully as, while it improves system sensitivity, it may invalidate the system's compliance with the overload requirements of this standard. Further, an external preamplifier may invalidate the usability of a spectrum analyzer without preselection for the measurement of impulsive signals with pulse repetition frequencies down to 20 Hz using the quasi-peak detector as specified in 4.4.2.

Therefore the operator of a measuring system that includes an external preamplifier shall determine the limitations of the system and shall apply linearity checks for the test system. Automated measurement results with external preamplifiers need to be verified using a final manual linearity check. The information given in this annex provides guidance for the user of emission measurement systems.

J.2 Considerations for optimum emission measurement system design

Internally, measuring receivers are designed to achieve optimum sensitivity while avoiding overload. Built-in preselection in the measuring receiver avoids overload by impulsive signals. In spite of preselection, measuring receivers usually have no linearity reserve for quasi-peak measurements of a single pulse above the specified indication range. Missing preselection in measuring receivers causes problems with quasi-peak detection of impulsive signals with low PRF.

The use of an external broadband preamplifier shall be considered only after all other possible measures for improving the system sensitivity have been exhausted, e.g. using measuring receivers with built-in preamplifiers, using antennas of sufficient gain, or using low loss connecting cables. An external preamplifier need only be added when the disturbance limit and all of the emissions expected and emissions to be measured are very close to the system noise level, e.g. for compliance with Class 5 radiated disturbance limits of CISPR 25 [14]. If high emission signals or high ambients are expected, external preamplifiers are not recommended.

From experience, external preamplifiers are not needed for radiated disturbance measurements to Class B limits of CISPR 11, CISPR 22 [13] and CISPR 32 [15], either at 3 m or at 10 m measurement distance, when measuring receivers with built-in preamplifiers including preselection and low-loss antenna cables are used. The same situation applies for radiated disturbance measurements to CISPR 14-1, CISPR 15 [1], and the generic emission standards, as well as for disturbance power measurements.

External preamplifiers are not recommended for conducted disturbance measurements below 30 MHz; their use may cause harmonics in the presence of high-level disturbance at frequencies below 150 kHz, where many emission standards do not specify disturbance limits.

If an external preamplifier is added for improved sensitivity, the following needs to be considered:

- a) preamplifiers have a wide bandwidth, i.e. they are susceptible to overload by impulsive signals and high level narrowband signals;

- b) preamplifiers may produce intermodulation products and harmonics; this is especially important when measurements are made on an OATS and/or in the presence of radio transmission equipment;
- c) preamplifiers increase the signal level at the receiver input and thus may overload the receiver input stages, a condition which cannot be avoided entirely by the receiver's built-in preselection;
- d) the gain in sensitivity will be less than the gain in signal level, thus limiting the dynamic range of the preamplifier/receiver combination;

NOTE 1 The gain in sensitivity is understood as the difference between the noise figure without preamplifier and the system noise figure with preamplifier.

- e) for maximum sensitivity in the frequency range above 1 GHz, the preamplifier is mounted/connected directly to the measurement antenna;
- f) use of an external preamplifier requires that an accurate gain versus frequency characterization be accounted for in the measurement result;
- g) the uncertainty of the gain as a function of temperature and aging, as well as the additional mismatch uncertainty between the preamplifier output port and the receiver input port, shall be included in the uncertainty budget for the measurement; the input impedance shall, as far as possible, comply with the requirements for the measuring receiver and shall be included in the uncertainty budget;
- h) for CISPR Band E, a system consisting of an external preamplifier and a measuring receiver shall be designed such that it cannot be overloaded by signals of lower frequency bands, and/or by any signal whose out-of-band or spurious signals are to be measured; e.g. the ISM signal of a microwave oven shall not drive the system into overload.

The gain in sensitivity is determined using the following quantities and equations:

$$F = \frac{P_{ie}}{kT_0 B} \text{ and,} \quad (J.1)$$

$$\text{for an amplifier, } F = \frac{P_o}{gkT_0 B} \quad (J.2)$$

where

- F is the noise factor, with $10 \lg F$ = noise figure (often denoted by the symbol NF);
- P_{ie} is the equivalent noise input power;
- P_o is the noise output power;
- g is calculated from the gain, $G = 10 \lg g$, respectively $g = 10^{G/10}$;
- k is Boltzmann's constant = $1,38 \times 10^{-23}$ Ws/K and $kT_0 = 4 \times 10^{-21}$ W/Hz;
- T_0 is the absolute reference room temperature (293 K);
- B is the noise bandwidth (e.g. of the measuring receiver).

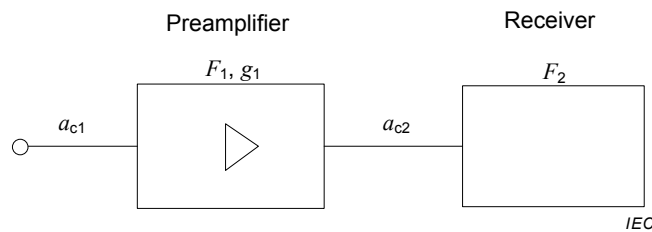


Figure J.1 – Receiver with preamplifier

In Figure J.1, assuming that the cable attenuation $a_{c2} = 0$ dB, then

$$10 \lg F_{\text{tot}} = a_{c1} + 10 \lg \left(F_1 + \frac{F_2 - 1}{g_1} \right) \quad (\text{J.3})$$

where F_{tot} is the noise factor of the system at the input cable with a_{c1}

If $a_{c2} \neq 0$ dB, then the preamplifier gain factor g_1 in Equation (J.3) has to be replaced by $10(G_1 - a_{c2})/10$. Cable attenuation $a_{c1} = 0$ dB is achieved by mounting and/or connecting the preamplifier directly to the antenna. If $a_{c1} \neq 0$ dB, then the cable attenuation a_{c1} adds to the system noise figure as shown by Equation (J.3).

State-of-the-art preamplifiers typically have noise figures of 3 dB or less, corresponding to a noise factor of $F_1 = 2$. Receivers with built-in preamplifiers typically have noise figures around 8 dB, corresponding to a noise factor $F_2 = 6,3$. This high noise factor is due to attenuation caused by preselection and other internal insertion losses of the receiver. Receivers without built-in preamplifiers typically have noise figures around 15 dB, corresponding to a noise factor $F_2 = 31,6$.

NOTE 2 The noise figure $10 \lg F_2$ of a measuring receiver can be determined from the indicated noise level using

$$10 \lg F_2 = V_{\text{Nav}} + 67 - 10 \lg B_N - w_{\text{Nav}}$$

where

V_{Nav} is the receiver noise floor with linear average detection, in dB(μV);

B_N is the noise bandwidth of the measuring receiver, in Hz;

w_{Nav} is the noise weighting factor for linear average detection, in dB.

EXAMPLE If $V_{\text{Nav}} = -10,7$ dB(μV), $B_N = 85$ kHz (for $B_6 = 120$ kHz), and $w_{\text{Nav}} = -1$ dB, then the noise figure $10 \lg F_2 = 8$ dB.

The quantity w_{Nav} is the difference between the indications of the linear average detector and the r.m.s. detector for Gaussian noise [21]; values for quasi-peak detection w_{Nqp} are approximately 4 dB for Band B, and 6 dB for Bands C/D; for peak detection w_{Npk} is up to 12 dB, depending on measurement time.

The noise bandwidth B_N is close to the 3 dB bandwidth B_3 of the measuring receiver. A rough approximation is given by $B_N = 1,1 B_3$. See [21] for details about specific filter implementations.

Considering a given preamplifier noise figure of 3 dB, it will be acceptable to achieve a system noise figure $10 \lg F_{\text{tot}} = 4$ dB, corresponding to a noise factor of 2,51. This requires that $(F_2 - 1)/g_1 = 0,51$, or $g_1 = (F_2 - 1)/0,51$.

- For receivers with a built-in preamplifier, the resulting gain is $g_1 = 10,39$, or $G_1 = 10,2$ dB.

- For receivers without a built-in preamplifier, the resulting gain is $g_1 = 60$, or $G_1 = 17,8$ dB.

For a receiver without a built-in preamplifier, as described above, an external preamplifier with a noise figure of 3 dB and a gain of 10 dB will give a system noise figure of 7 dB.

From the preceding examples, it can be seen that an improvement in sensitivity of 4 dB requires a signal gain of around 10 dB for a receiver with a built-in preamplifier. For a receiver without a built-in preamplifier, an improvement in sensitivity of 11 dB requires a signal gain of almost 18 dB, and an improvement of 8 dB requires a signal gain of 10 dB. It is evident that a system noise figure of 3,5 dB cannot easily be achieved with a preamplifier noise figure of 3 dB, because an excessive preamplifier gain would be necessary. Refer to Table J.1 for example noise figures.

Because it will severely limit the system's linearity performance, it is not advisable to use preamplifiers with a gain of 30 dB or more.

Table J.1 – Examples of preamplifier and measuring receiver data and resulting system noise figures

Preamplifier				Measuring receiver		System
Noise factor	Noise figure	Gain factor	Gain	Noise factor	Noise figure	Noise figure
F_1	$10 \lg F_1$	g_1	G_1	F_2	$10 \lg F_2$	$10 \lg F_{\text{tot}}$
	dB		dB		dB	dB
2	3	10,4	10,2	6,3	8	4
2	3	10	10	31,6	15	7
2	3	60	17,8	31,6	15	4

J.3 Linearity specifications and precautions in measurement

The dynamic range of preamplifiers is defined by the 1 dB compression point, 3 dB compression point, and saturation point. To avoid distortion caused by the input signal, the signal should ideally stay below the 1 dB compression point during the entire measurement time.

An example screenshot of the transfer function of an amplifier is shown in Figure J.2. The response of such an amplifier using a sinusoidal signal in time domain and frequency domain is shown in Figure J.3. The numbers on the axes in Figures J.2, J.3 and J.4 are generic in nature (quantization values) and do not represent specific units.

Figure J.3 shows that the sinusoidal signal is distorted in time domain, which is due to the nonlinear effects of the preamplifier. The frequency domain display shows that the level is decreased at 100 MHz, and that further harmonics exist. A corresponding simulation for a broadband pulse is shown in Figure J.4.

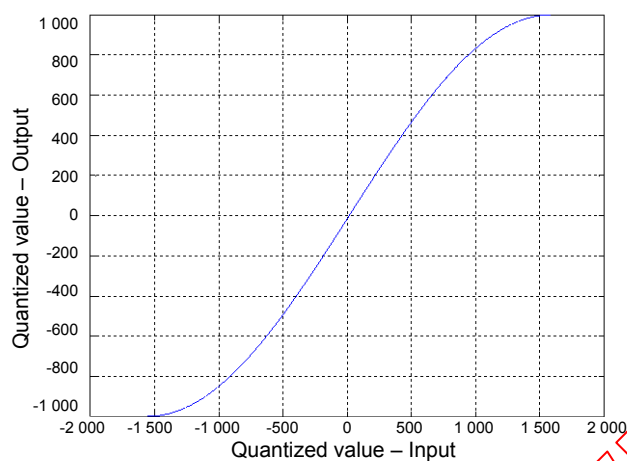
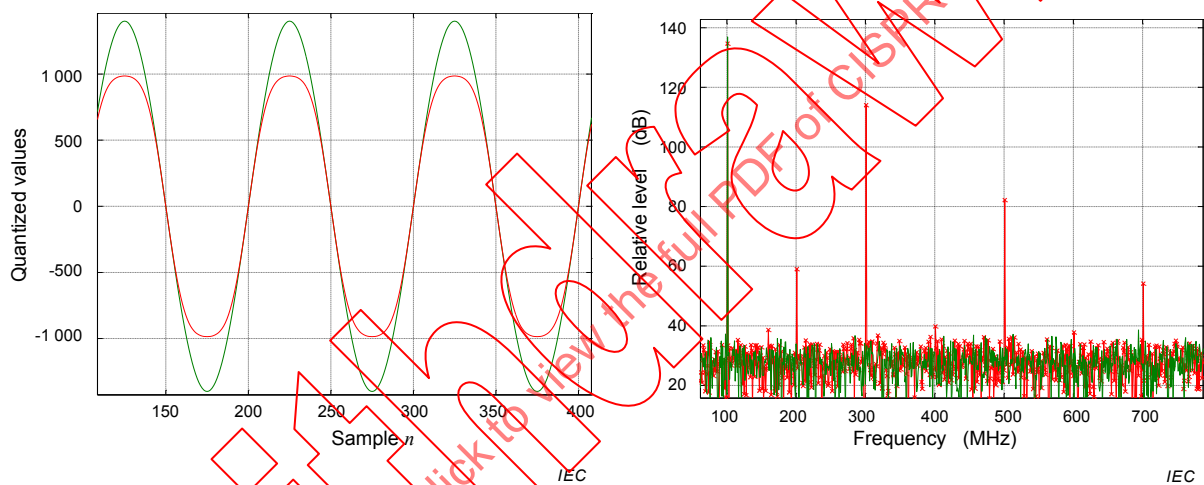
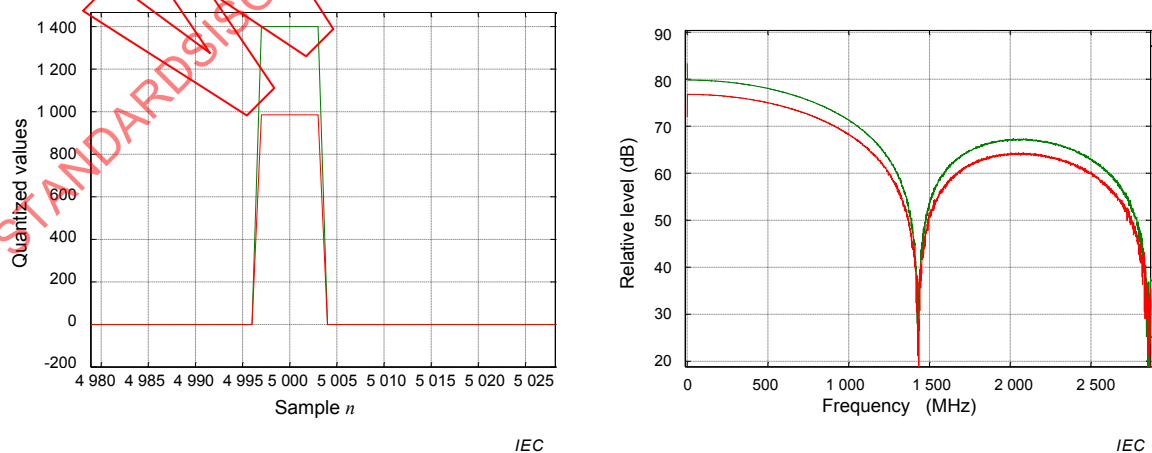


Figure J.2 – Transfer function of an amplifier



Green = normalized input signal; red = output signal

Figure J.3 – Response for a sinusoidal signal



Green = normalized input signal; red = output signal

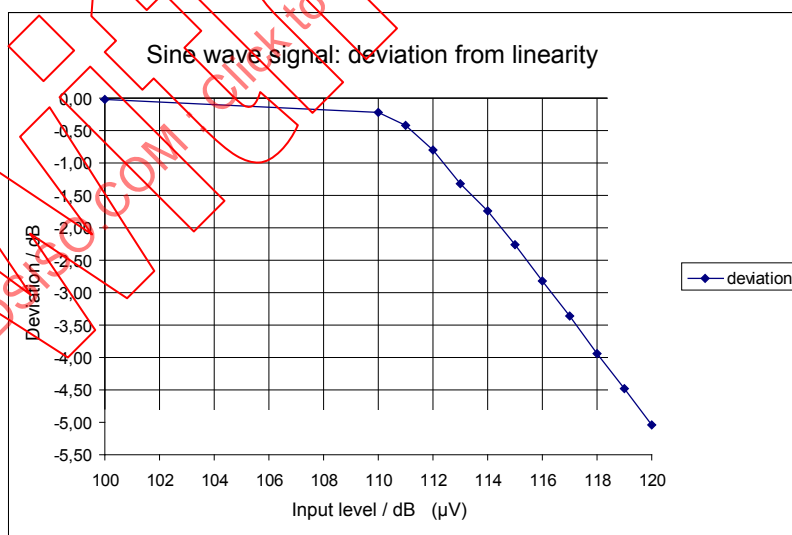
Figure J.4 – Response for an impulse

Comparing Figures J.3 and J.4, it can be seen that the saturation level in the time domain is exactly the same. However in the frequency domain the effects of saturation of the external preamplifier are different. For the impulsive signal, the amplitude level is decreased, invalidating the measurement result. For sinusoidal signals, the amplitude of the fundamental is decreased, while further harmonics are generated by the nonlinear effect of the external preamplifier; the measurement result is also invalidated.

The performance of the system, i.e. system noise level and overload capability, will depend on the characteristics of both the preamplifier and the measuring receiver. For narrowband signals, generally the 1 dB compression point of the preamplifier output exceeds the 1 dB compression point of the measuring receiver input. Preselection of the measuring receiver will improve system linearity for the measurement of broadband impulsive signals. Therefore, two types of systems are taken into consideration: systems with, and without, preselection at the measuring receiver input.

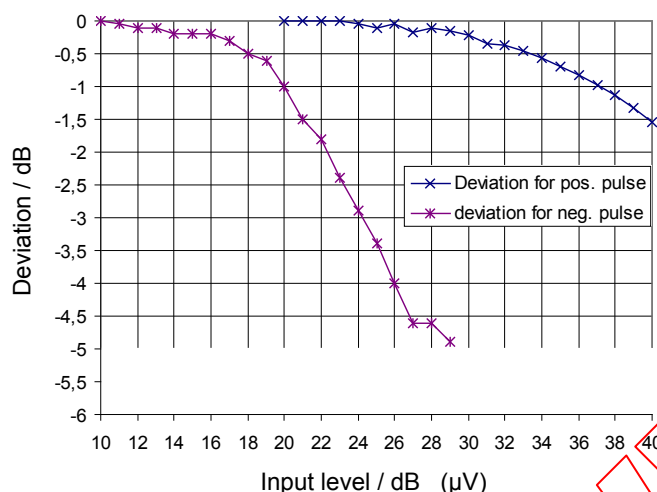
A broadband overload detector, which is effective at the input of some measuring receivers without preselection, is used to detect signal levels at the 1 dB compression point of the first mixer, to alert the user of linearity problems. The overload detector can also be used as an indicator to assure valid measurement results. Similar overload detection is recommended for wideband FFT based measuring systems to avoid over-range of the wideband A/D converter (see J.4).

Further precautions for measurements include a prediction of the available overload factor for the measurement of impulsive disturbances. Apart from gain versus frequency and noise figure, the 1 dB compression point of the preamplifier and the complete system, consisting of preamplifier and measuring receiver, shall be specified. For CISPR Bands C/D, the relationship between the 1 dB compression point for sine wave signals and the peak value of the broadband CISPR pulse signal with a bandwidth of 2 GHz gives a bandwidth factor F_{bw} of 85 dB [$F_{bw} = 20 \lg(2\,000/0,12)$]. Figures J.5 and J.6 show the deviations from linearity of a preamplifier with a 1 dB compression point of 112 dB(μ V), for an unmodulated sine wave and impulsive signals.



IEC

Figure J.5 – Deviation from linear gain for an unmodulated sine wave (example)



NOTE Using $F_{\text{BW}} = 85 \text{ dB}$, the peak value of the positive pulse signal with a PRF of 100 Hz is at around $37 \text{ dB}(\mu\text{V}) + 12 \text{ dB} + 85 \text{ dB} = 134 \text{ dB}(\mu\text{V})$, i.e. around 22 dB above the 1 dB compression point of Figure J.5. 12 dB is the quasi peak weighting factor, i.e. the difference between peak and quasi peak for a PRF of 100 Hz.

Figure J.6 – Deviation from linear gain for a broadband impulsive signal as measured with the quasi-peak detector (example)

The flatness of the deviation curve for positive pulses in Figure J.6 is misleading, because the amplifier nonlinearity is masked by the amplifier's own intermodulation products. This effect can be demonstrated using a band-stop filter with a notch depth of greater than 40 dB (band-stop filter as specified in 4.6) at the input of the preamplifier. For an acceptable operation (error contribution less than 1 dB by intermodulation), the notch depth shall remain at least 20 dB during the intermodulation test. The value of 20 dB is obtained with quasi-peak measurements at a PRF of 100 Hz; the PRF of 100 Hz is a compromise.

Ideally the 20 dB notch depth would be needed for quasi-peak measurements at all PRFs. This is shown in Figure J.7 for the preamplifier used above with 10 dB gain, where the 20 dB depth is retained as long as the peak level of the input signal is less than $37 \text{ dB}(\mu\text{V})$, and the peak level of the output signal is less than $46 \text{ dB}(\mu\text{V})$ (blue curve). For a PRF of 100 Hz, a peak level of $37 \text{ dB}(\mu\text{V})$ corresponds to a quasi-peak level of $25 \text{ dB}(\mu\text{V})$. Thus while the 1 dB compression point for the broadband impulsive signal in Figure J.6 “positive pulse” looks like being at $37 \text{ dB}(\mu\text{V})$ quasi-peak, the preamplifier is already overloaded. The input signal should be at least 12 dB lower, i.e. at $25 \text{ dB}(\mu\text{V})$ quasi-peak, to avoid excessive intermodulation.

In Figure J.6 the “positive pulse” also shows that a simple overload test with a switchable 10 dB attenuator at the preamplifier input may not properly indicate the overload in case of impulsive signals, because the output level can still follow the input level, while the preamplifier input signal is up to 20 dB above the 1 dB compression point. The simple test may work for sine wave signals. A better characterization of the system with respect to impulsive signals is obtained using the band-stop filter intermodulation test. If the band-stop filter intermodulation test is not available, the 1 dB compression point of the preamplifier, referred to its input, should be used to characterize the system.

NOTE The band-stop filter intermodulation test is intended to characterize the system, e.g. done by the system provider. It would be impractical to use a band-stop filter test in each EMC test lab during an emission test.

Note that during the band-stop filter intermodulation test, it shall be assured that the measuring receiver used as an indicator at the output of the preamplifier is not overloaded. Figure J.8 shows that the notch depth result from a CISPR intermodulation test of a measuring receiver with preselection still exceeds 30 dB with an input signal (quasi peak) of $55 \text{ dB}(\mu\text{V})$, which corresponds to an input level (quasi peak) of $45 \text{ dB}(\mu\text{V})$ to a 10 dB preamplifier. Using a measuring receiver with built-in broadband preamplifier may not show

the linearity of the external preamplifier correctly, due to overload of the measuring receiver, as shown in Figure J.9 and J.10, whereas with preselection the output will be linear.

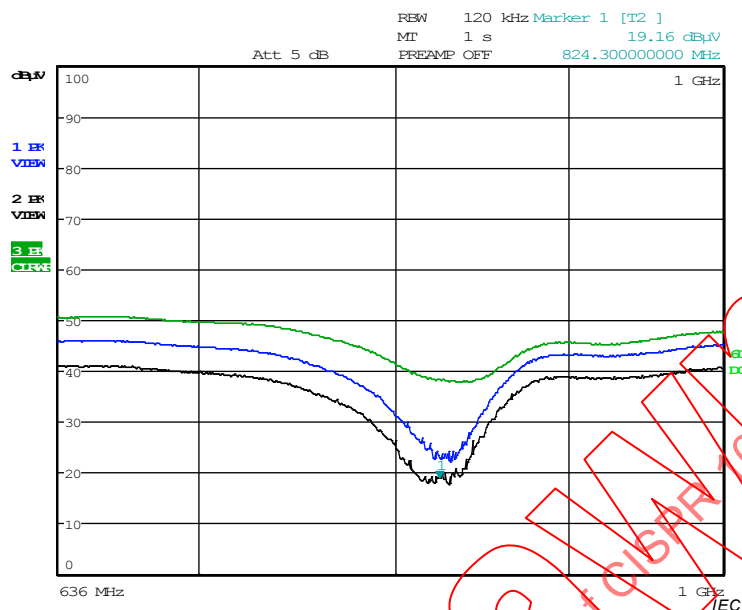


Figure J.7 – Screenshot of a band-stop filter test for a preamplifier at around 818 MHz

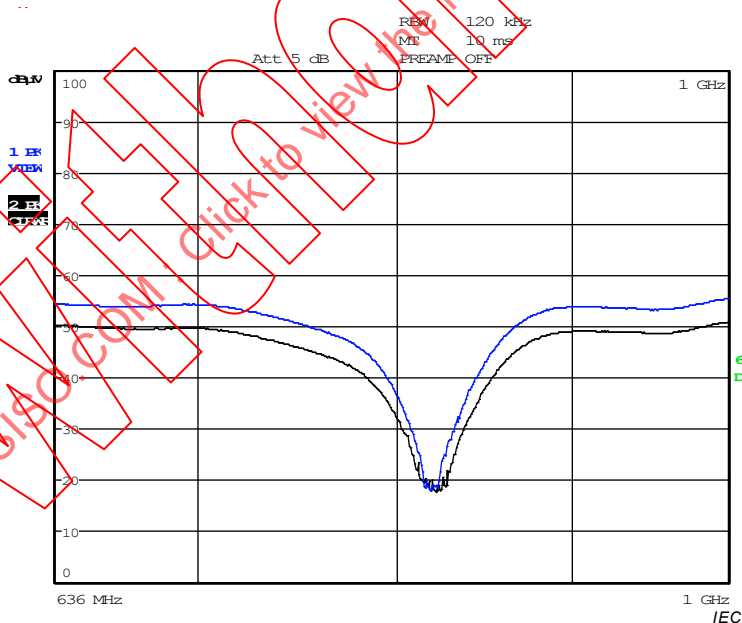


Figure J.8 – Band-stop filter test result with the measuring receiver at 818 MHz

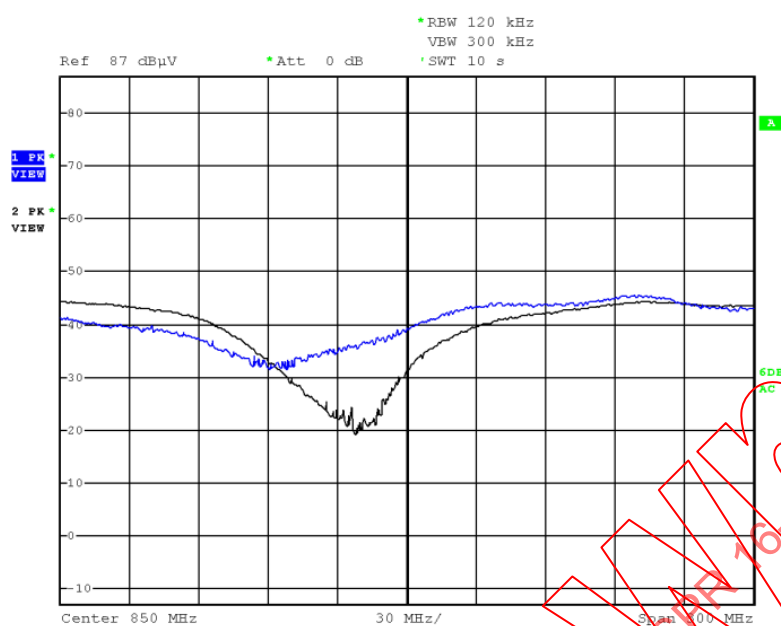
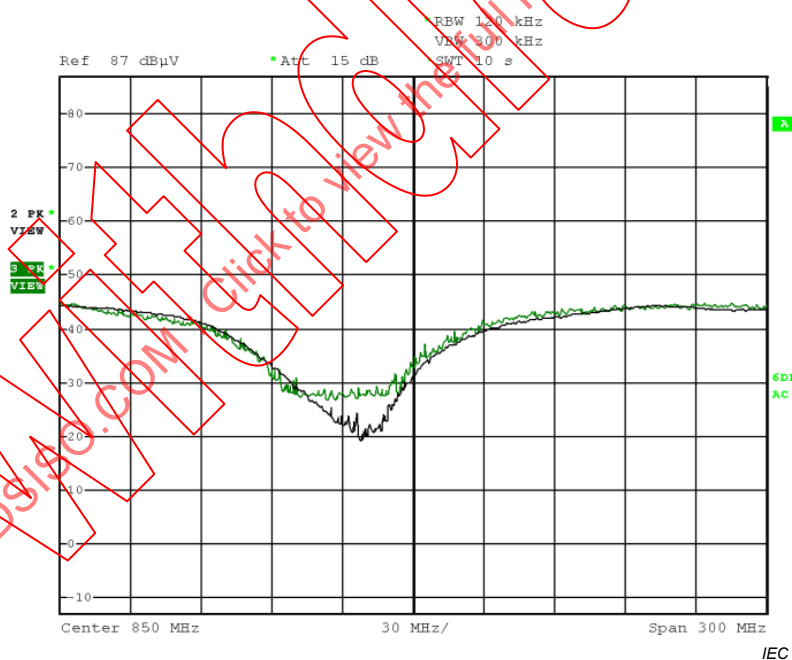


Figure J.9 – Band-stop filter test results for the same 10 dB preamplifier but a different receiver with preselection (black) and without preselection (blue)



NOTE A 15 dB attenuator between external preamplifier and receiver was used to avoid overload of the receiver without preselection; however the receiver's noise level then hides the notch.

Figure J.10 – Band-stop filter test results for the same 10 dB preamplifier but with the receiver of Figure J.9 with preselection (black) and without preselection (green)

When an external broadband preamplifier is used with a measuring receiver, the user cannot expect proper weighting of broadband impulsive signals by such a measuring system using average, rms-average and quasi-peak detection at low pulse repetition frequencies. Therefore, the user shall determine the operating range between noise level and the 1 dB compression point for broadband impulsive signals for the peak detector of the measurement

system. This determination allows a prediction of the lowest PRF for proper weighting of broadband impulsive signals using each individual detector.

Figure J.11 shows the weighting functions of the detectors specified in CISPR 16-1-1 for CISPR Bands C/D, and an example 'Noise' line to illustrate the operating range between noise level and 1 dB compression point. In the example, the peak detector noise level is 15 dB below the 1 dB compression point. For the quasi-peak detector, the noise level is approximately 5 dB lower, i.e. the operating range is approximately 5 dB wider. For the rms-average and average detectors, the noise level is approximately 10 dB lower, which increases the operating range to about 25 dB in the example.

To draw the noise line shown in Figure J.11, the peak level V_p is used from the band-stop filter test in Figure J.7 and the average detector noise level V_{Nav} determined. The difference $V_p - V_{Nav}$ marks the crossing of the "Noise" line with the "Average" line. For the 10 dB preamplifier above, $V_p = 37 \text{ dB}(\mu\text{V})$, $V_{Nav} = -14 \text{ dB}(\mu\text{V})$ for a noise figure of 4 dB and $V_p - V_{Nav} = 51 \text{ dB}$. The noise line in Figure J.11 is drawn from an example where $V_p - V_{Nav} = 27 \text{ dB}$.

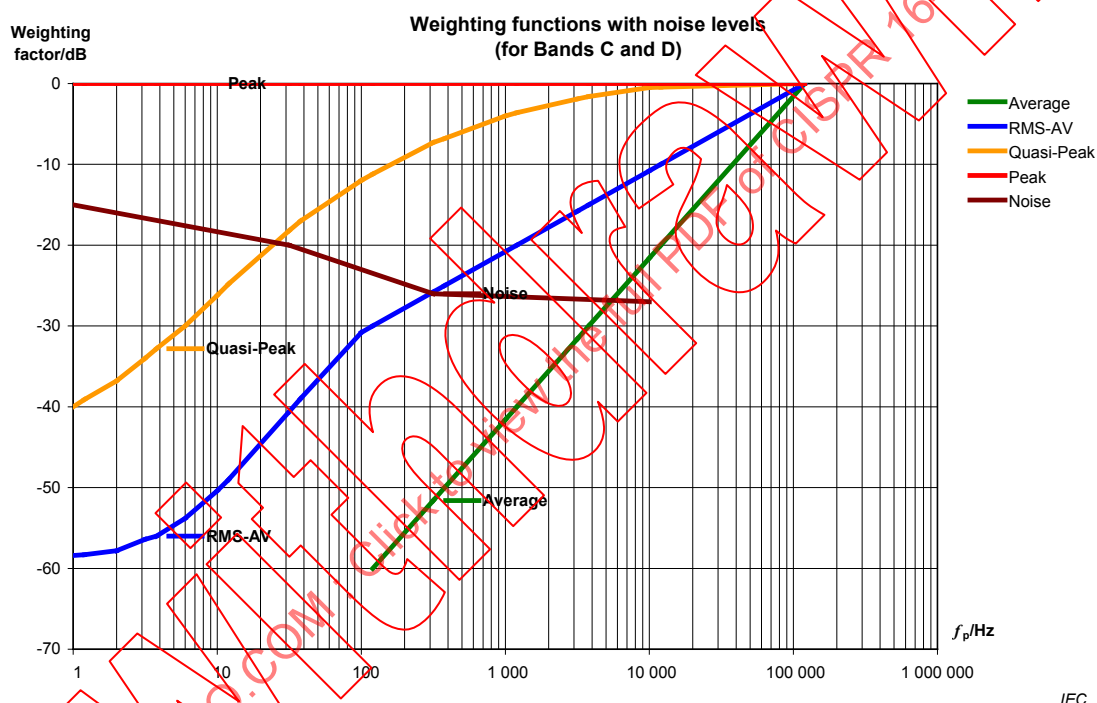


Figure J.11 – Weighting functions of the various CISPR detectors with a noise curve to illustrate the remaining operating ranges for broadband impulsive signals (example)

From Figure J.11, the critical PRF can be seen at which the impulsive signal level, with peak level at the 1 dB compression point, is equal to the noise level. However for an accurate measurement, the signal level needs to be approximately 6 dB above the noise level (the actual value depends on the PRF). As a consequence, in this example quasi-peak measurements can be carried out above a PRF of about 60 Hz. For the rms-average and average detectors, the critical PRFs are near 1 kHz and 10 kHz, respectively. For practical measurements, a linearity check is recommended using the weighting factor at the critical PRF. For this example, the linearity check is as follows:

- For the quasi-peak measurement: the critical PRF of 60 Hz is exceeded if the difference between peak and quasi-peak values is less than 15 dB.
- For the rms-average and average measurements: the critical PRFs of 1 kHz and 10 kHz are exceeded if the difference between peak and rms-average or average detector results are less than 20 dB.

However, if the measurements are made close to the noise level, the differences might be reduced by the noise level, which will give the impression of PRFs higher than actual.

J.4 Detecting the overload of an external preamplifier in a wideband FFT based measuring system

Detecting whether the preamplifier is in the linear range during the measurement can be performed for sinusoidal as well as impulsive signals, by taking the maximum of the preamplifier output signal then comparing it with a given threshold level corresponding to the 1 dB compression point. The maximum (positive) and minimum (negative) voltage of the signal in the time domain shall be sampled continuously during the measurement time and compared to that threshold level. The 1 dB compression point is defined for a sinusoidal signal yielding an output 1 dB lower than expected, as shown in Figure J.5.

During a measurement, a measuring apparatus that digitizes the signal of the output of the external preamplifier can be used to detect whether an over-range has occurred. For the preceding example, a threshold level of a normalized value in Figure J.2 'Input' of about 900 would be appropriate to avoid nonlinear effects. The threshold level should be identified by the system manufacturer depending on the application. For example, the measurement of harmonics of intentional radiators requires a better linearity (lower threshold) than the measurement of impulsive disturbance. A measuring apparatus that digitizes the input signal shall fulfil the following requirements, to allow a correct decision:

- a) continuous (gapless) acquisition during the measurement time;
- b) selectable threshold level;
- c) broadband acquisition of the entire measurement band, e.g. up to 1 GHz.

Typical instruments that fulfil such requirements include broadband FFT-based measurement instruments with over-range detection, as described in CISPR TR 16-3, and oscilloscopes in single-shot trigger mode. Over-range detection is used to avoid exceeding the operating range of the wideband A/D converter.

Annex K (normative)

Calibration requirements for measuring receivers

K.1 General

When performing EMI measurements it is essential to use measuring equipment that meets the specifications called out in this standard such that the expected measurement instrumentation uncertainty for conducted and radiated disturbance measurements as well as disturbance power measurements can be achieved. In addition, the results of these measurements shall be traceable (see 3.17) to national or internationally accepted standards. These requirements can be met by selecting measuring equipment that is correctly calibrated. The calibration requirements described in this annex are only applicable to the test instrumentation (i.e. EMI receivers and spectrum analysers) covered in this standard.

The EMC test laboratory is responsible for the selection and use of adequate measuring equipment as well as the purchase of accredited (or otherwise deemed appropriate) calibration services. A clear understanding of the calibration requirements related to measuring equipment is essential to determine the necessary specifics of calibration service in the purchasing process and to review the obtained service upon receipt of the equipment back from the calibration laboratory, before it is placed back into service at the test laboratory.

K.2 Calibration and verification

Calibration is defined as a set of operations that establishes, by reference to standards, the relationship that exists, under specified conditions, between an indication of an instrument under calibration and a result of a measurement using the corresponding traceable reference standard. Applied to the measuring receiver this means that a calibration procedure consisting of various steps is used to determine the actual values of various calibration parameters through measurements under specified environmental conditions, using measuring equipment that was calibrated by an accredited (or otherwise deemed appropriate) calibration laboratory. The results of these calibration measurements are used to determine if the instrument under calibration meets the specifications published by the manufacturer.

The calibration process itself does not necessarily require the instrument under calibration to be adjusted. However, adjustments may be required if the calibration process determines that the instrument does not meet the manufacturer's specifications. The goal of the instrument calibration process is the determination of compliance of a measuring receiver under calibration with its published specifications in a traceable manner (see 3.17).

"Verification" should not be confused with "intermediate checks" (also called confidence checks); the latter consists of a set of operations aimed at providing evidence of the proper functioning of a test instrument. An intermediate check of a measuring receiver can differ considerably from the calibration process because the purpose of these two activities is entirely different.

K.3 Calibration and verification specifics

Calibration of a measuring receiver requires a specific process that defines the various measurements to determine if the receiver meets its specifications. In general, this calibration process has also been used by the receiver manufacturer to establish the receiver specifications. Therefore, only the manufacturer's calibration process or verification process in accordance with this standard shall be applied by a calibration laboratory or test laboratory performing its own calibrations to determine whether the receiver meets its specifications at

the time of calibration or the requirements called out in this standard. This requirement applies to measuring receivers only.

If a process different from the manufacturer's calibration process or verification process in accordance with this standard is used, it shall be verifiably validated and it shall be stated in the calibration certificate that the process used deviates from the calibration process defined by the manufacturer. For ancillary equipment such as AMNs, AANs, absorbing clamps and antennas, the calibration procedures documented in other relevant parts of CISPR 16 shall be applied.

The calibration process for measuring receivers also defines the following essential parameters that shall be used for proper calibration:

- a) the specific set-up of the receiver under calibration for each measurement in the calibration process (e.g. in the case of an EMI receiver or spectrum analyzer the tuning frequency, attenuator setting, resolution bandwidth setting, and other parameters, for each measurement to be performed);
- b) the required test set-up for the measurement of a specific parameter (e.g. the use of power splitters for ratio measurements and any other required measuring equipment);
- c) the required accuracy of measuring equipment used to perform the measurements of the calibration process (e.g. required amplitude accuracy and frequency accuracy);
- d) the actual number of measurements to be performed and their sequence. For many types of measuring receiver this sequence is mandatory and cannot be changed because the measurements of some parameters require the measurements of previous calibration parameters to be completed. In addition, it is possible that the interpretation of a test result for a calibration parameter is dependent on the test result of a previous measurement in the calibration sequence;
- e) the required environmental conditions (e.g. required ambient temperature and relative humidity), if deemed necessary by the manufacturer.

Only if the manufacturer's calibration process is used can the results of the calibration measurements be compared to the published specifications. Consequently, the calibration laboratory or the test laboratory performing its own calibrations (also called internal calibrations) should use the manufacturer's calibration process for a specific measuring receiver. If an alternative process is used, it shall be verifiably validated and it shall be stated in the calibration certificate that this process deviates from the calibration process defined by the manufacturer.

K.4 Measuring receiver specifics

This standard specifies measuring receiver requirements using a "black box" approach. This means that the instrument shall show a specific response when a defined signal is applied to its input. Therefore, the demonstration of compliance of measuring receivers with specifications defined in this standard can be provided through the manufacturer's calibration process or the procedures and measuring equipment defined in this standard.

In case compliance of a measuring receiver is determined with the specifications in this standard, the following minimum set of parameters shown in Table K.1 shall be included in the verification process.

Table K.1 – Verification parameter summary

Parameter	Subclause in CISPR 16-1-1	Suggested Frequencies
VSWR	4.2, 5.2, 6.2, 7.2	VSWR to be determined for 0 dB and ≥ 10 dB input attenuation at the following tuning frequencies: 100 kHz, 15 MHz, 475 MHz and 8,5 GHz
Sine wave voltage accuracy	4.3, 5.4, 6.4, 7.4	Verification at the following tuning frequencies: start frequency, stop frequency and centre frequency of CISPR Bands A/B/C and D/E
Response to pulses	4.4, 5.5, 6.5, 7.5	Verification at the following tuning frequencies: start frequency, stop frequency and centre frequency of CISPR Bands A/B/C and D/E
Selectivity	4.5, 5.6, 6.6, 7.6	Verification at the following tuning frequencies: centre frequency of CISPR Bands A/B/C and D/E

The parameters summarized in Table K.1 are only applicable to the frequency ranges covered by the instrument under verification and its implemented detector functions. Specifics described in the referenced subclauses apply in their entirety as well as the stated tolerances.

It is to be noted that the requirements called out in this standard constitute a subset of all the specifications the receiver manufacturer publishes. In addition, some requirements in this standard may be stated in a way that differs from the manufacturer's specifications (e.g. CW frequency accuracy in this standard versus a combination of absolute amplitude accuracy at a reference frequency and frequency response).

If evidence of compliance with the requirements presented in this standard cannot be directly provided through the manufacturer's calibration process, due to differences in the form of the stated specifications, the verification of these requirements shall be requested by the test laboratory in addition to the actual receiver calibration based on the manufacturer's calibration process.

K.5 Partial calibration of measuring receivers

Offentimes the complete functionality of a measuring receiver is not utilized when performing emission measurements. For economic reasons test laboratories therefore may decide to have encompassed by the purchased calibration service only functions that are actually used to perform measurements. Care shall be taken when specifying such a partial or limited calibration service because the calibration of the identified functions may require calibration of other functions as a prerequisite. Such dependencies shall be determined by the test laboratory or the calibration laboratory through a review of the manufacturer's calibration procedure. If the test laboratory does not have access to the manufacturer's calibration procedure, this review shall be requested from the calibration laboratory as part of the calibration service purchase.

K.6 Determination of compliance of a measuring receiver with applicable specifications

Compliance of a measuring receiver with the specifications of the manufacturer or with the tolerances specified in CISPR standards requires that measurement results reported in calibration certificates are below an upper limit, or above a lower limit, or between an upper and lower limit. The uncertainty of the calibration or verification measurement has a direct impact on the pass/fail determination. Therefore, the measurement uncertainty shall be taken into account when determining compliance of a measuring receiver with its stated

specifications. The application of measurement uncertainty to a measurement result can lead to one of the four cases described as follows and depicted in Figure K.1:

- the measurement result is within the specified limit range by a margin larger than the expanded uncertainty value applicable to the calibration measurement;
- the measurement result is within the specified limit range by a margin less than the expanded uncertainty value applicable to the calibration measurement;
- the measurement result is outside of the specified limit range by a margin less than the expanded uncertainty value applicable to the calibration measurement; or
- the measurement result is outside of the specified limit range by a margin larger than the expanded uncertainty value applicable to the calibration measurement, and the specification is not met.

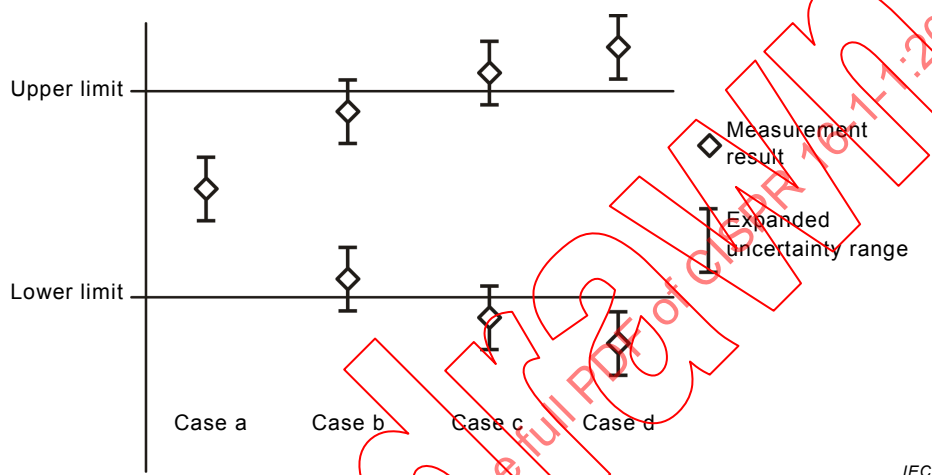


Figure K.1 – Compliance determination process with application of measurement uncertainty

The four cases in Figure K.1 shall be interpreted as follows:

- specification is met;
- and c) the result is inconclusive, a definitive compliance statement is not possible;
- specification is not met.

Bibliography

- [1] CISPR 15, *Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment*
- [2] CISPR 16-1-2:2014, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-2: Radio disturbance and immunity measuring apparatus – ~~Ancillary equipment~~ Coupling devices for conducted disturbances measurements*
- [3] CISPR 16-1-3:2004, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-3: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Disturbance power*
- [4] CISPR 16-1-4:~~2007~~ 2010, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-4: Radio disturbance and immunity measuring apparatus – ~~Ancillary equipment~~ Antennas and test sites for radiated disturbance measurements*
- [5] CISPR 16-1-5:~~2003~~ 2014, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-5: Radio disturbance and immunity measuring apparatus – Antenna calibration sites and reference test sites for ~~30 MHz to 1 000 MHz~~ 5 MHz to 18 GHz*
- [6] CISPR 16-2 (all parts), *Specification for radio disturbance and immunity measuring apparatus and methods*
- [7] CISPR 16-2-4:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-4: Methods of measurement of disturbances and immunity – Immunity measurements*
- [8] CISPR 16-4 (all parts), *Specification for radio disturbance and immunity measuring apparatus and methods*
- [9] CISPR TR 16-4-1:2009, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-1: Uncertainties, statistics and limit modelling – Uncertainties in standardized EMC tests (only available in English)*
- [10] CISPR 16-4-2:~~2003~~ 2011, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-2: Uncertainties, statistics and limit modelling – ~~Uncertainty in EMC measurements~~ Measurement instrumentation uncertainty*
- [11] CISPR TR 16-4-3:2004, *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 (~~only available in English~~)*
- [12] CISPR TR 16-4-4:2007, *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 (~~only available in English~~)*
- [13] CISPR 22, *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement*
- [14] CISPR 25, *Vehicles, boats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of on-board receivers*
- [15] CISPR 32, *Electromagnetic compatibility of multimedia equipment – Emission requirements*

- [16] ISO IEC Guide 98-3:2008, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*
- [17] ISO IEC Guide 99:2007, *International vocabulary of metrology – Basic and general concepts and associated terms (VIM)*
- [18] EN 50065-1, *Signalling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz – Part 1: General requirements, frequency bands and electromagnetic disturbances*
- [19] GESELOWITZ, dB., *Response of ideal radio noise meter to continuous sine-wave, recurrent impulses, and random noise*, IRE Transactions, RFI, May, 1961, vol. RFI-3, no. 1, p. 2-11 (only available in English)
- [20] RAUSCHER, C., *Fundamentals of Spectrum Analysis*, 5th edition, 2011, ISBN 978-3-939837-01-5 (available from Rohde & Schwarz Bookshop, <http://www.books.rohde-schwarz.com/>)
- [21] SABAROFF, S., *Impulse excitation of a cascade of series tuned circuits*, Proceedings of the IRE, December 1944, vol. 32, p. 758-760 (only available in English)

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INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE
COMITÉ INTERNATIONAL SPÉCIAL DES PERTURBATIONS RADIOÉLECTRIQUES

BASIC EMC PUBLICATION
PUBLICATION FONDAMENTALE EN CEM

Specification for radio disturbance and immunity measuring apparatus and methods –

Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus

Spécification des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques –

Partie 1-1: Appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Appareils de mesure

INTERNATIONAL ELECTROTECHNICAL COMMISSION

CISPR 16-1-1
Edition 4.0 2015-09

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

**Part 1-1: Radio disturbance and immunity measuring apparatus –
Measuring apparatus**

INTERPRETATION SHEET 1

This interpretation sheet has been prepared by subcommittee CISPR A: Radio-interference measurements and statistical methods, of IEC technical committee CISPR: International special committee on radio interference.

The text of this interpretation sheet is based on the following documents:

FDIS	Report on voting
CIS/A/1244/FDIS	CIS/A/1255/RVD

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

INTRODUCTION:

CISPR/A/1118/FDIS was approved (see CISPR/A/1135/RVD) and consequently the corresponding international standard, CISPR 16-1-1:2015 (Edition 4.0) was published on 22 September 2015.

However, seven National Committees had submitted a negative vote. Most concerns were related to the measuring receiver specifics covered in K.4. That clause states:

“This standard specifies measuring receiver requirements using a “black box” approach. This means that the instrument shall show a specific response when a defined signal is applied to its input. Therefore, the demonstration of compliance of measuring receivers with specifications defined in this standard can be provided through the manufacturer’s calibration process or the procedures and measuring equipment defined in this standard.

In case compliance of a measuring receiver is determined with the specifications in this standard, the following minimum set of parameters shown in Table K.1 shall be included in the verification process.”

It was argued that the wording in these two cited paragraphs might be misinterpreted in such a way that the specifications in CISPR 16-1-1 are not met when using the manufacturer's calibration process. Furthermore, concerns were raised that the wording may have the effect that only manufacturers' calibration procedures can be used to show compliance with the specifications in CISPR 16-1-1.

Because of these concerns, K.4 could benefit from further clarification. An interpretation sheet would be helpful to users of the standard, with the intent that this clarification would be published in a future amendment to the standard.

This information does not change the standard; it serves only to clarify the points noted.

INTERPRETATION:

Demonstration of compliance with CISPR 16-1-1

For demonstrating compliance with CISPR 16-1-1 using the manufacturer's calibration process, the specifications in CISPR 16-1-1 shall be met, including verification of the minimum set of parameters listed in Table K.1.

It is permissible to use either the manufacturer's calibration process or a calibration laboratory's own process that is applying the procedures and measuring equipment defined in this standard. The user of CISPR 16-1-1 is responsible for deciding which of these two approaches to use, both which are considered equivalent.

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INTERNATIONAL ELECTROTECHNICAL COMMISSION
INTERNATIONAL SPECIAL COMMITTEE ON RADIO INTERFERENCE

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

**Part 1-1: Radio disturbance and immunity measuring apparatus –
Measuring apparatus**

FOREWORD

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- 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.

International Standard CISPR 16-1-1 has been prepared by CISPR subcommittee A: Radio-interference measurements and statistical methods.

This fourth edition cancels and replaces the third edition published in 2010, Amendment 1:2010 and Amendment 2:2014. This edition constitutes a technical revision.

The main technical change with respect to the previous edition consists of the addition of a new normative annex on calibration requirements for measuring receivers.

It has the status of a basic EMC publication in accordance with IEC Guide 107, *Electromagnetic compatibility – Guide to the drafting of electromagnetic compatibility publications*.

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

FDIS	Report on voting
CISPR/A/1118/FDIS	CISPR/A/1135/RVD

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.

A list of all parts of the CISPR 16 series can be found, under the general title *Specification for radio disturbance and immunity measuring apparatus and methods*, 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 website 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.

The contents of the Interpretation sheet of April 2018 have been included in this copy.

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

The CISPR 16 series, published under the general title *Specification for radio disturbance and immunity measuring apparatus and methods*, is comprised of the following sets of standards and reports:

- CISPR 16-1 – six parts covering measurement instrumentation specifications;
- CISPR 16-2 – five parts covering methods of measurement;
- CISPR 16-3 – a single publication containing various technical reports (TRs) with further information and background on CISPR and radio disturbances in general;
- CISPR 16-4 – five parts covering uncertainties, statistics and limit modelling.

CISPR 16-1 consists of the following parts, under the general title *Specification for radio disturbance and immunity measuring apparatus and methods – Radio disturbance and immunity measuring apparatus*:

- Part 1-1: Measuring apparatus
- Part 1-2: Ancillary equipment – Conducted disturbances
- Part 1-3: Ancillary equipment – Disturbance power
- Part 1-4: Ancillary equipment – Radiated disturbances
- Part 1-5: Antenna calibration sites and reference test sites for 5 MHz to 18 GHz
- Part 1-6: EMC-antenna calibration

The International Electrotechnical Commission (IEC) draws attention to the fact that it is claimed that compliance with this document may involve the use of a patent concerning the measuring receiver with rms-average detector (patent no DE 10126830) given in Clause 7.

IEC takes no position concerning the evidence, validity and scope of this patent right.

The holder of this patent right has assured the IEC that he/she is willing to negotiate licences either free of charge or under reasonable and non-discriminatory terms and conditions with applicants throughout the world. In this respect, the statement of the holder of this patent right is registered with IEC. Information may be obtained from:

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ISO (www.iso.org/patents) and IEC (<http://patents.iec.ch>) maintain on-line data bases of patents relevant to their standards. Users are encouraged to consult the data bases for the most up to date information concerning patents.

SPECIFICATION FOR RADIO DISTURBANCE AND IMMUNITY MEASURING APPARATUS AND METHODS –

Part 1-1: Radio disturbance and immunity measuring apparatus – Measuring apparatus

1 Scope

This part of CISPR 16 specifies the characteristics and performance of equipment for the measurement of radio disturbance in the frequency range 9 kHz to 18 GHz. In addition, requirements are provided for specialized equipment for discontinuous disturbance measurements.

NOTE In accordance with IEC Guide 107, CISPR 16-1-1 is a basic EMC standard for use by product committees of the IEC. As stated in Guide 107, product committees are responsible for determining the applicability of the EMC standard. CISPR and its sub-committees are prepared to co-operate with product committees in the evaluation of the value of particular EMC tests for specific products.

The specifications in this standard apply to EMI receivers and spectrum analyzers. The term “measuring receiver” used in this standard refers to both EMI receivers and spectrum analyzers. The calibration requirements for measuring receivers are detailed in Annex J.

Further guidance on the use of use of spectrum analyzers and scanning receivers can be found in Annex B of any one of the following standards: CISPR 16-2-1:2014, CISPR 16-2-2:2010 or CISPR 16-2-3:2010.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

CISPR 11:2015, *Industrial, scientific and medical equipment – Radio-frequency disturbance characteristics – Limits and methods of measurement*

CISPR 14-1:2005, *Electromagnetic compatibility – Requirements for household appliances, electric tools and similar apparatus – Part 1: Emission*

CISPR 14-1:2005/AMD1:2008

CISPR 14-1:2005/AMD2:2011

CISPR 16-2-1:2014, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-1: Methods of measurement of disturbances and immunity – Conducted disturbance measurements*

CISPR 16-2-2:2010, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-2: Methods of measurement of disturbances and immunity – Measurement of disturbance power*

CISPR 16-2-3:2010, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-3: Methods of measurement of disturbances and immunity – Radiated disturbance measurements*

CISPR 16-2-3:2010/AMD1:2010

CISPR 16-2-3:2010/AMD2:2014

CISPR TR 16-3:2010, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 3: CISPR technical reports*
CISPR TR 16-3:2010/AMD1:2012
CISPR TR 16-3:2010/AMD2:2015

IEC 60050-161:1990, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*
IEC 60050-161:1990/AMD1:1997
IEC 60050-161:1990/AMD2:1998
IEC 60050-161:1990/AMD3:2014
IEC 60050-161:1990/AMD4:2014
IEC 60050-161:1990/AMD5:2015

3 Terms and definitions

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

Note 1 to entry: n is the stated attenuation in dB.

3.2 CISPR indication range

range specified by the manufacturer which gives the maximum and the minimum meter indications within which the measuring receiver meets the requirements of this part of CISPR 16

3.3 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 1 to entry: 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 IF amplifier is applied to the input of the stage immediately preceding the detector. The indication, D , of an instrument having no inertia (e.g. an 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 0,63 D . The duration of this signal is equal to the charge time of the detector.

3.4 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 1 to entry: 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 0,37 D is the discharge time constant of the detector.

3.5 impulse area

A_{imp}
voltage-time area of a pulse defined by the integral:

$$A_{\text{imp}} = \int_{-\infty}^{+\infty} V(t) dt \quad (1)$$

Note 1 to entry: Impulse area, sometimes referred to as impulse strength, is typically expressed in μVs or $\text{dB}(\mu\text{Vs})$.

Note 2 to entry: Spectral density (D) is related to impulse area and expressed in $\mu\text{V}/\text{MHz}$ or $\text{dB}(\mu\text{V}/\text{MHz})$. For rectangular impulses of pulse duration T at frequencies $f \ll 1/T$, the relationship $D (\mu\text{V}/\text{MHz}) = \sqrt{2} \times 10^6 A_{\text{imp}} (\mu\text{Vs})$ applies.

3.6 impulse bandwidth

B_{imp}

$$B_{\text{imp}} = \frac{A(t)_{\text{max}}}{2G_0 \times A_{\text{imp}}} \quad (2)$$

where

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

G_0 is the gain of the circuit at the centre frequency.

Specifically for two critically-coupled tuned transformers,

$$B_{\text{imp}} = 1,05 \times B_6 = 1,31 \times B_3 \quad (3)$$

where B_6 and B_3 are respectively the bandwidths at the -6 dB and -3 dB points

Note 1 to entry: See A.2 for further information.

3.7 measuring receiver

instrument such as a tunable voltmeter, an EMI receiver, a spectrum analyzer or a FFT-based measuring instrument, with or without preselection, that meets the relevant parts of this standard

Note 1 to entry: See Annex I for further information.

3.8 mechanical time constant of a critically damped indicating instrument

T_M

$$T_M = \frac{T_L}{2\pi} \quad (4)$$

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

Note 1 to entry: For a critically damped instrument, the equation of motion of the system may be written as:

$$T_M^2 \left(\frac{d^2 \alpha}{dt^2} \right) + 2T_M \frac{d\alpha}{dt} + \alpha = ki \quad (5)$$

where

- α is the deflection;
- i is the current through the instrument; and
- 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 to entry: The methods of measurement and adjustment are deduced from one of the following:

- a) the period of free oscillation having been adjusted to $2\pi T_M$, damping is added so that $\alpha T = 0,35\alpha_{\max}$.
- b) when the period of oscillation cannot be measured, the damping is adjusted to be just below critical such that the overshoot is not greater than 5 % and the moment of inertia of the movement is such that $\alpha T = 0,35\alpha_{\max}$.

3.9

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

Note 1 to entry: 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).

3.10

symmetric voltage

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

3.11

weighting (of e.g. impulsive disturbance)

pulse-repetition-frequency (PRF) dependent conversion (mostly reduction) of a peak-detected impulse voltage level to an indication that corresponds to the interference effect on radio reception

Note 1 to entry: For the analogue receiver, the psychophysical annoyance of the interference is a subjective quantity (audible or visual, usually not a certain number of misunderstandings of a spoken text).

Note 2 to entry: For the digital receiver, the interference effect is an objective quantity that may be defined by the critical bit error ratio (BER) or bit error probability (BEP) for which perfect error correction can still occur or by another, objective and reproducible parameter.

3.11.1

weighted disturbance measurement

measurement of disturbance using a weighting detector

3.11.2

weighting characteristic

peak voltage level as a function of PRF for a constant effect on a specific radiocommunication system, i.e. the disturbance is weighted by the radiocommunication system itself

3.11.3

weighting detector

detector which provides an agreed weighting function

3.11.4**weighting factor**

value of the weighting function relative to a reference PRF or relative to the peak value

Note 1 to entry: Weighting factor is expressed in dB.

3.11.5**weighting function****weighting curve**

relationship between input peak voltage level and PRF for constant level indication of a measuring receiver with a weighting detector, i.e. the curve of response of a measuring receiver to repeated pulses

3.12**measurement time** T_m

effective, coherent time for a measurement result at a single frequency (in some areas also called dwell time)

- for the peak detector, the effective time to detect the maximum of the signal envelope
- for the quasi-peak detector, the effective time to measure the maximum of the weighted envelope
- for the average detector, the effective time to average the signal envelope
- for the rms detector, the effective time to determine the rms of the signal envelope

3.13**calibration**

operation that, under specified conditions, in a first step, establishes a relation between the quantity values with measurement uncertainties provided by measurement standards and corresponding indications with associated measurement uncertainties and, in a second step, uses this information to establish a relation for obtaining a measurement result from an indication

Note 1 to entry: A calibration may be expressed by a statement, calibration function, calibration diagram, calibration curve, or calibration table. In some cases, it may consist of an additive or multiplicative correction of the indication with associated measurement uncertainty.

Note 2 to entry: Calibration should not be confused with adjustment of a measuring system, often mistakenly called “self-calibration”, nor with verification of calibration.

Note 3 to entry: Often, the first step alone in the above definition is perceived as being calibration.

[SOURCE: ISO/IEC Guide 99:2007, 2.39] [17]¹

3.14**verification**

provision of objective evidence that a given item fulfils specified requirements

EXAMPLE Checking whether the functions of a measuring instrument or auxiliary equipment, such as a common mode absorption device (CMAD), meets stated specifications, such as those given in a data sheet.

[SOURCE: ISO/IEC Guide 99:2007, 2.44, modified – addition of an example] [17]

3.15**adjustment (of a measuring system)**

set of operations carried out on a measuring system so that it provides prescribed indications corresponding to given values of a quantity to be measured

¹ Figures in brackets refer to Bibliography.

Note 1 to entry: Types of adjustment of a measuring system include zero adjustment of a measuring system, offset adjustment, and span adjustment (sometimes called gain adjustment).

Note 2 to entry: Adjustment of a measuring system should not be confused with calibration, which is a prerequisite for adjustment.

Note 3 to entry: After an adjustment of a measuring system, the measuring system shall usually be recalibrated.

[SOURCE: ISO/IEC Guide 99:2007, 3.11] [17]

3.16

correction

compensation for an estimated systematic effect

Note 1 to entry: See Guide ISO/CEI 98-3:2008, 3.2.3 [16] for an explanation of 'systematic effect'.

Note 2 to entry: The compensation can take different forms, such as an addend or a factor, or can be deduced from a table.

[SOURCE: ISO/IEC Guide 99:2007, 2.53] [17]

3.17

(metrological) traceability

property of a measurement result whereby the result can be related to a reference through a documented unbroken chain of calibrations, each contributing to the measurement uncertainty

[SOURCE: ISO/IEC Guide 99:2007, 2.41] [17]

4 Quasi-peak measuring receivers for the frequency range 9 kHz to 1 000 MHz

4.1 General

The receiver specification depends on the frequency of operation. There is one receiver specification covering the frequency range 9 kHz to 150 kHz (Band A), one covering 150 kHz to 30 MHz (Band B), one covering 30 MHz to 300 MHz (Band C), and one covering 300 MHz to 1 000 MHz (Band D). Fundamental characteristics of a quasi-peak measuring instrument are provided in Annex H.

Spectrum analyzers and FFT-based measuring instruments that meet the requirements of this clause can be used for compliance measurements. For emission measurements, FFT-based measuring instruments shall sample and evaluate the signal continuously during the measurement time.

4.2 Input impedance

The input circuit of measuring receivers shall be unbalanced. For receiver control settings within the CISPR indication range, the input impedance shall be nominally 50 Ω with a voltage standing wave ratio (VSWR) not to exceed 2,0:1 when the radio frequency (RF) attenuation is 0 dB and 1,2:1 when the RF attenuation is 10 dB or greater.

Symmetric input impedance in the frequency range 9 kHz to 30 MHz: to permit symmetrical measurements a balanced input transformer is used. The preferred input impedance for the frequency range 9 kHz to 150 kHz is 600 Ω . This symmetric input impedance may be incorporated either in the relevant symmetrical artificial network necessary to couple to the receiver or optionally in the measuring receiver.

4.3 Sine-wave voltage accuracy

The accuracy of measurement of sine-wave voltages shall be better than ± 2 dB when the instrument measures a sine-wave signal with 50 Ω resistive source impedance.

4.4 Response to pulses

4.4.1 Amplitude relationship (absolute calibration)

Referring to Table 1, the response of the measuring receiver to pulses of impulse area of a) μVs (microvolt second) e.m.f. at 50 Ω source impedance, having a uniform spectrum up to at least b) MHz, repeated at a frequency of c) Hz shall, for all frequencies of tuning, be equal to the response to an unmodulated sine-wave signal at the tuned frequency having an e.m.f. of rms value 2 mV [66 dB(μV)].

When external preamplifiers are used, refer to Annex J for applicable requirements.

The source impedances of the pulse generator and the signal generator shall both be the same. A tolerance of $\pm 1,5$ dB shall be permitted on the sine-wave voltage level.

Table 1 – Test pulse characteristics for quasi-peak measuring receivers

Frequency range	a) μVs	b) MHz	c) Hz
9 kHz to 150 kHz	13,5	0,15	25
0,15 MHz to 30 MHz	0,316	30	100
30 MHz to 300 MHz	0,044	300	100
300 MHz to 1 000 MHz	0,044	1 000	100

NOTE Annexes B and C describe methods for determining the output characteristics of a pulse generator for use in testing the requirements of this subclause.

4.4.2 Variation with repetition frequency (relative calibration)

The response of the measuring receiver to repeated pulses shall be such that for a constant indication on the measuring receiver of e.g. 20 dB(μV), the relationship between pulse amplitude and repetition frequency is in accordance with Figures 1, 2, 3 and 4.

As an alternative the response of the measuring receiver to repeated pulses shall be such that for a constant voltage setting of the pulse generator of e.g. 50 dB(μV) at repetition frequencies of 25 Hz (Band A) and 100 Hz (Bands B, C and D), the relationship between receiver indication and repetition frequency is in accordance with Figures 1, 2, 3 and 4 under opposite sign conditions.

For all measurements, a sufficient signal-to-noise ratio is required. The use of a 10 dB attenuator at the output of the pulse generator is recommended.

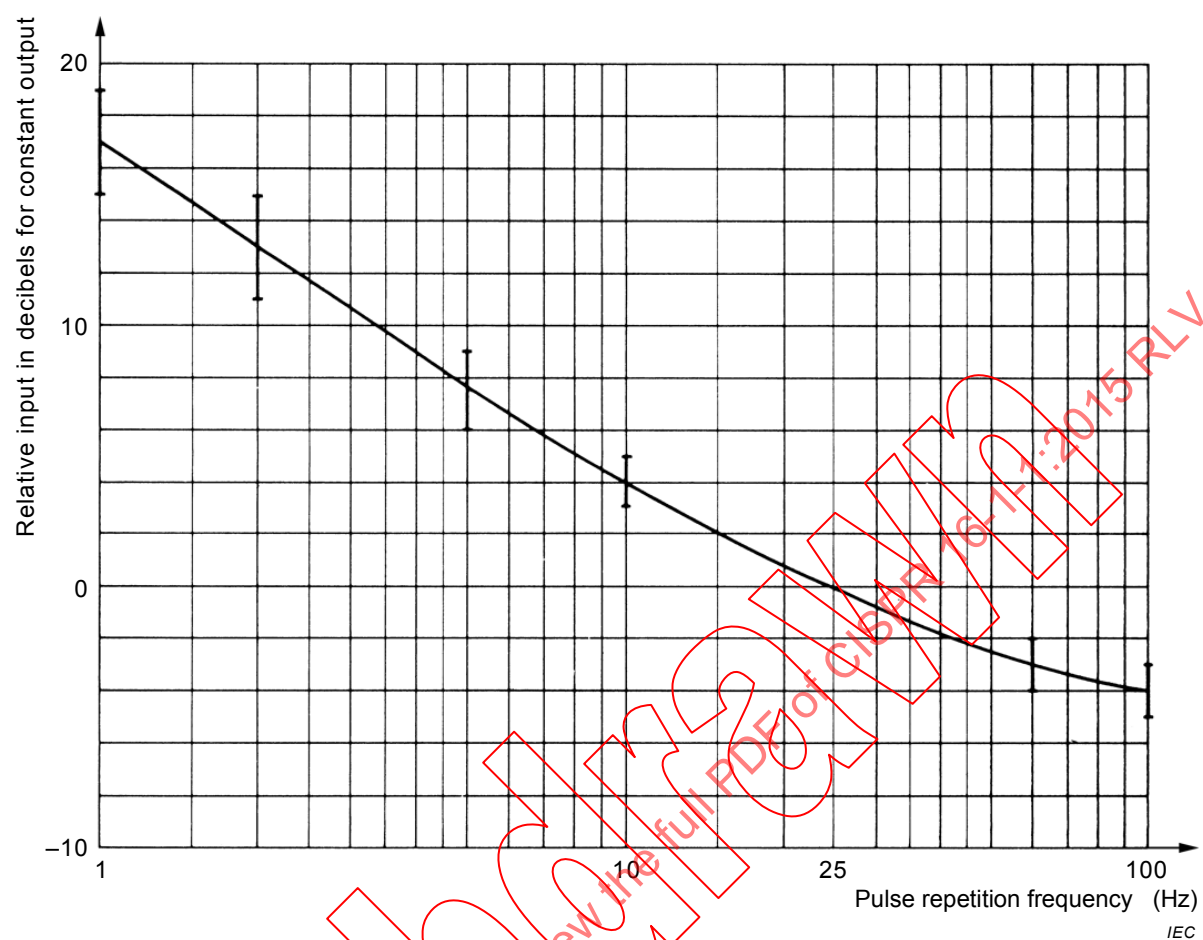


Figure 1 – Pulse response curve (Band A)

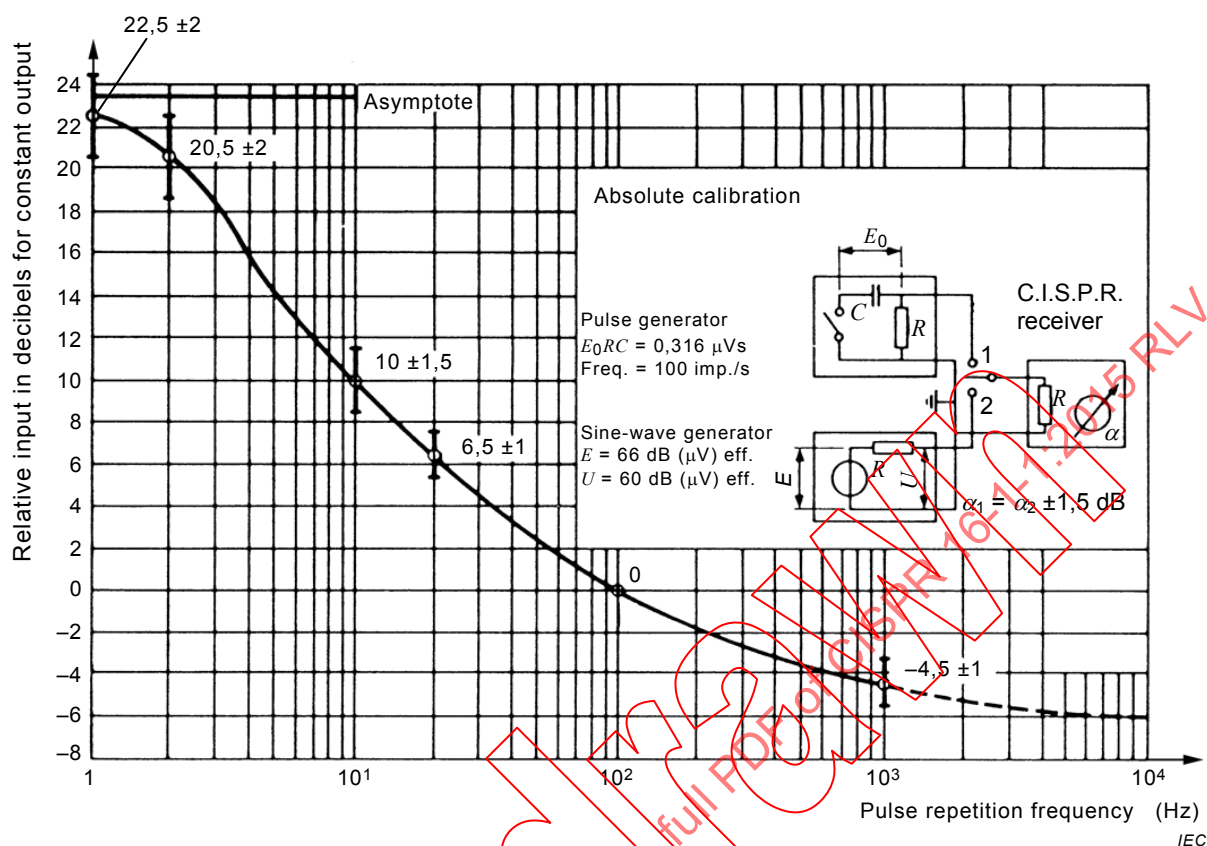


Figure 2 – Pulse response curve (Band B)

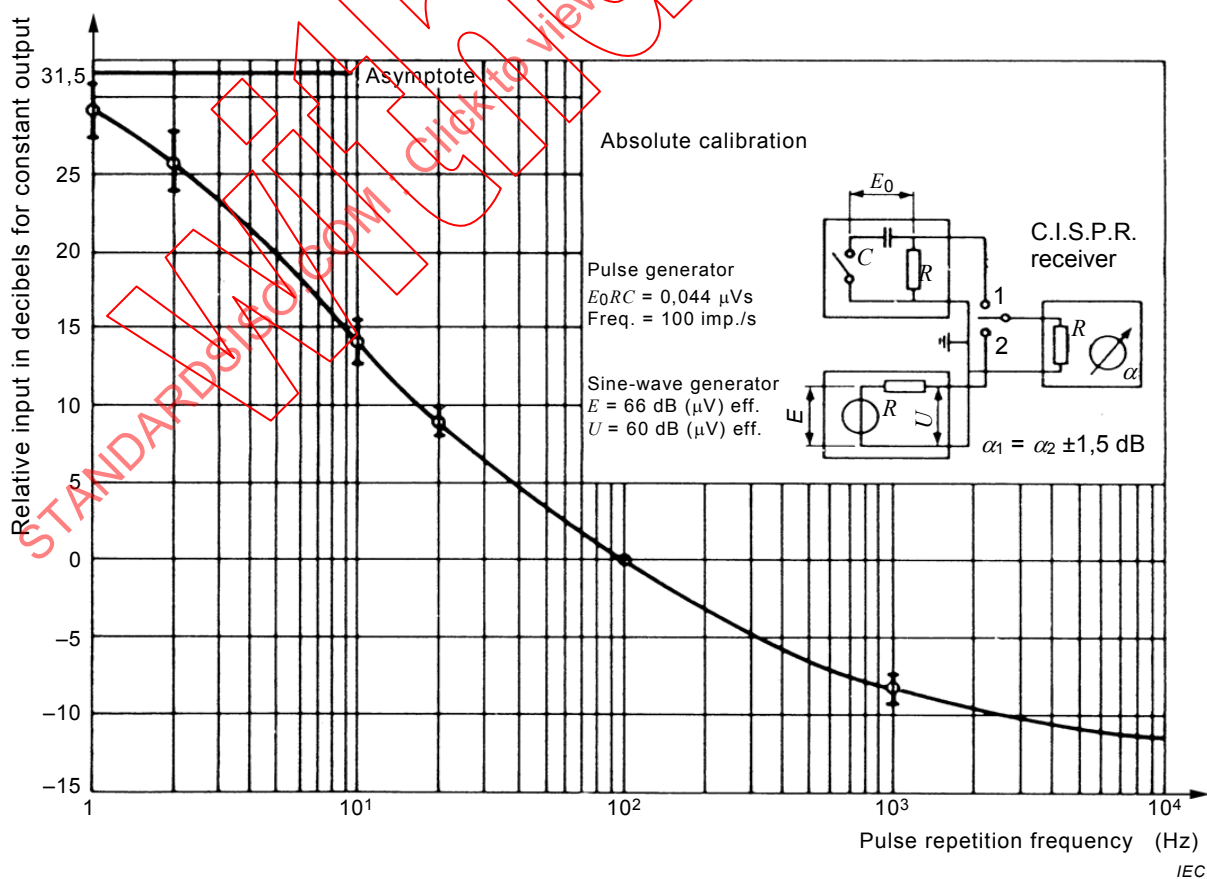


Figure 3 – Pulse response curve (Bands C and D)

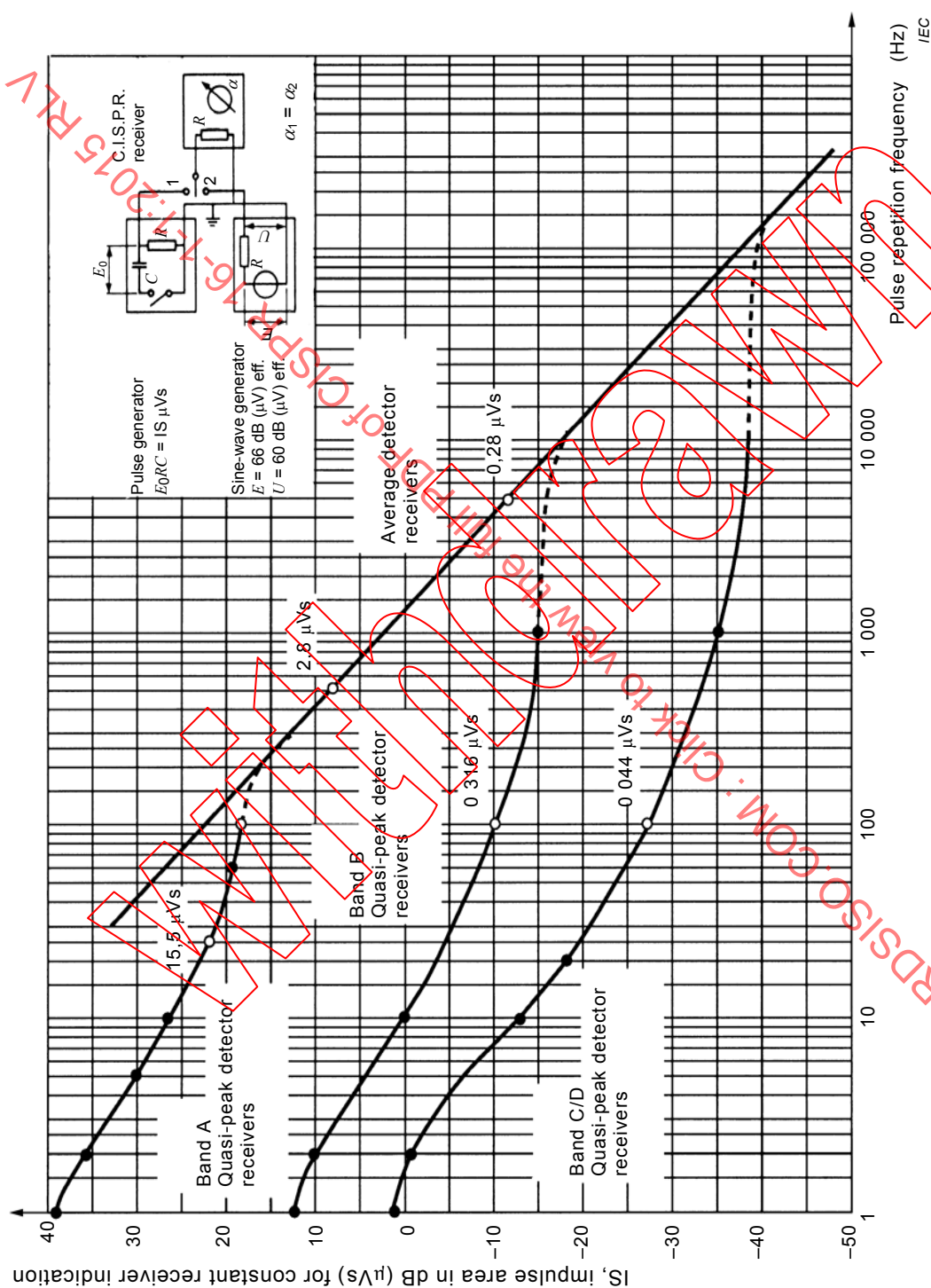


Figure 4 – Theoretical pulse response curve of quasi-peak detector receivers and average detector receiver (see 6.5.4)

The response curve for a particular measuring receiver shall lie between the limits defined in the appropriate figure and quantified in Table 2. For spectrum analyzers without preselection, the requirements in Table 2 for pulse repetition frequencies less than 20 Hz are not applicable. The use of such instruments for compliance testing is conditional. If such spectrum analyzers are used for measurements, the user shall verify and document that the equipment under test does not emit broadband signals of pulse repetition frequencies of 20 Hz or lower. A determination of the suitability of a spectrum analyzer for testing shall be made by performing the procedure documented in Annex B of CISPR 16-2-1:2014, Annex B of CISPR 16-2-2:2010, or Annex B of CISPR 16-2-3:2010.

The pulse response is restricted due to overload at the input to the receiver at frequencies above 300 MHz. The values marked with an asterisk (*) in Table 2 are optional and are not essential.

Table 2 – Pulse response of quasi-peak measuring receivers

Repetition frequency Hz	Relative equivalent level in dB of pulse for stated band			
	Band A 9 kHz to 150 kHz	Band B 0,15 MHz to 30 MHz	Band C 30 MHz to 300 MHz	Band D 300 MHz to 1 000 MHz
1 000	Note 4	$-4,5 \pm 1,0$	$-8,0 \pm 1,0$	$-8,0 \pm 1,0$
100	$-4,0 \pm 1,0$	0 (ref.)	0 (ref.)	0 (ref.)
60	$-3,0 \pm 1,0$	–	–	–
25	0 (ref.)	–	–	–
20	–	$+6,5 \pm 1,0$	$+9,0 \pm 1,0$	$+9,0 \pm 1,0$
10	$+4,0 \pm 1,0$	$+10,0 \pm 1,5$	$+14,0 \pm 1,5$	$+14,0 \pm 1,5$
5	$+7,5 \pm 1,5$	–	–	–
2	$+13,0 \pm 2,0$	$+20,5 \pm 2,0$	$+26,0 \pm 2,0$	$+26,0 \pm 2,0^*$
1	$+17,0 \pm 2,0$	$+22,5 \pm 2,0$	$+28,5 \pm 2,0$	$+28,5 \pm 2,0^*$
Isolated pulse	$+19,0 \pm 2,0$	$+23,5 \pm 2,0$	$+31,5 \pm 2,0$	$+31,5 \pm 2,0^*$

* These values are optional and not essential.

NOTE 1 The influence of the receiver characteristics upon its pulse response is considered in Annex D.

NOTE 2 The relationships between the pulse responses of a quasi-peak receiver and receivers with other detector types are given in 5.5, 6.5 and 7.5.

NOTE 3 The theoretical pulse response curves of quasi-peak and average detector receivers combined on an absolute scale are shown in Figure 4. The ordinate of Figure 4 shows the open-circuit impulse areas in dB(μVs) corresponding to the open-circuit sine-wave voltage of 66 dB(μV) rms. The indication on a measuring receiver with an input matched to the calibrating generators will then be 60 dB(μV). Where the measuring bandwidth is less than the pulse repetition frequency, the curves of Figure 4 are valid when the receiver is tuned to a discrete line of the spectrum.

NOTE 4 It is not possible to specify a response above 100 Hz in the frequency range 9 kHz to 150 kHz because of the overlapping of pulses in the IF amplifier.

NOTE 5 Annex A deals with the determination of the curve of response to repeated pulses.

4.5 Selectivity

4.5.1 Overall selectivity (passband)

The curve representing the overall selectivity of the measuring receiver shall lie within the limits shown in Figure 5, 6 or 7.

Selectivity shall be described by the variation with frequency of the amplitude of the input sine-wave voltage that produces a constant indication on the measuring receiver.

NOTE For the measurement of equipment that requires higher selectivity at the transition between 130 kHz and 150 kHz (e.g. mains signalling equipment as defined in EN 50065-1), a high-pass filter can be added in front of the measuring receiver to achieve the combined selectivity of CISPR measuring receiver and high-pass filter as shown in Table 3.

Table 3 – Combined selectivity of CISPR measuring receiver and high-pass filter

Frequency kHz	Relative attenuation dB
150	≤ 1
146	≤ 6
145	≥ 6
140	≥ 34
130	≥ 81

The measuring receiver in conjunction with the high-pass filter should meet the requirements of this standard.

4.5.2 Intermediate frequency rejection ratio

The ratio of the input sine-wave voltage at the intermediate frequency to that at the tuned frequency that produces the same indication of the measuring receiver shall be not less than 40 dB. Where more than one intermediate frequency is used, this requirement shall be met at each intermediate frequency.

4.5.3 Image frequency rejection ratio

The ratio of the input sine-wave voltage at the image frequency to that at the tuned frequency that produces the same indication on the measuring receiver shall be not less than 40 dB. Where more than one intermediate frequency is used, this requirement shall be met at the image frequencies corresponding to each intermediate frequency.

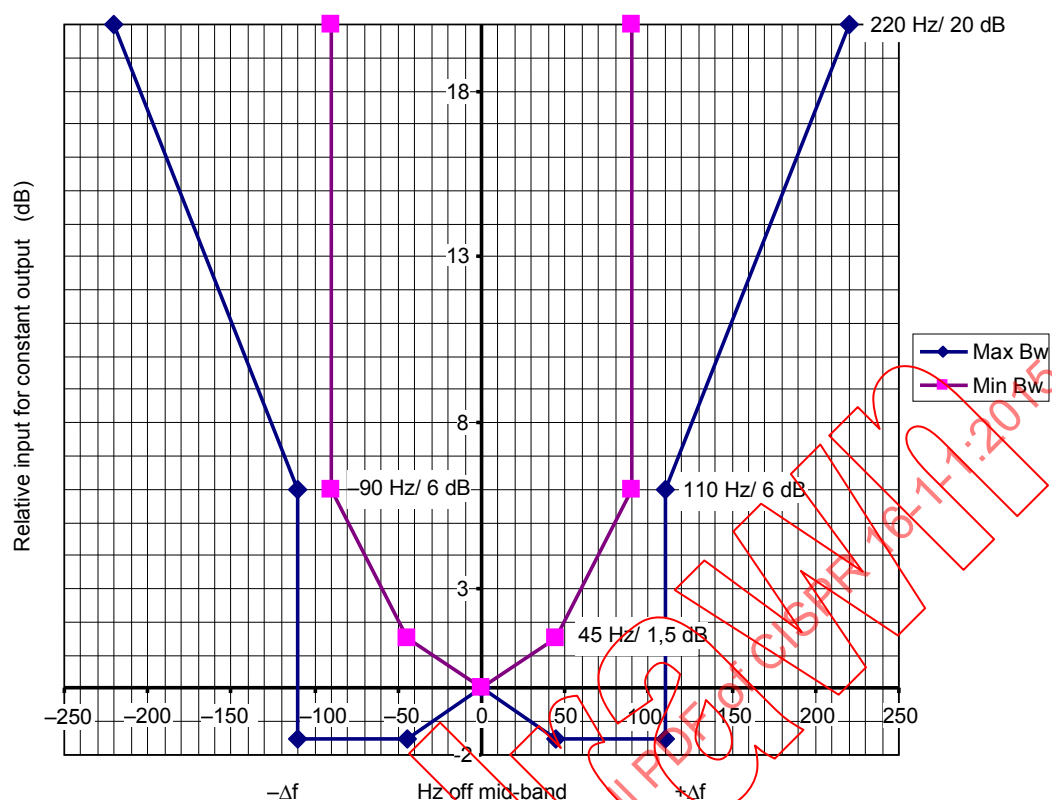


Figure 5 – Limits of overall selectivity – Pass band
(see 4.5.1, 5.6, 6.6, 7.6) (Band A)

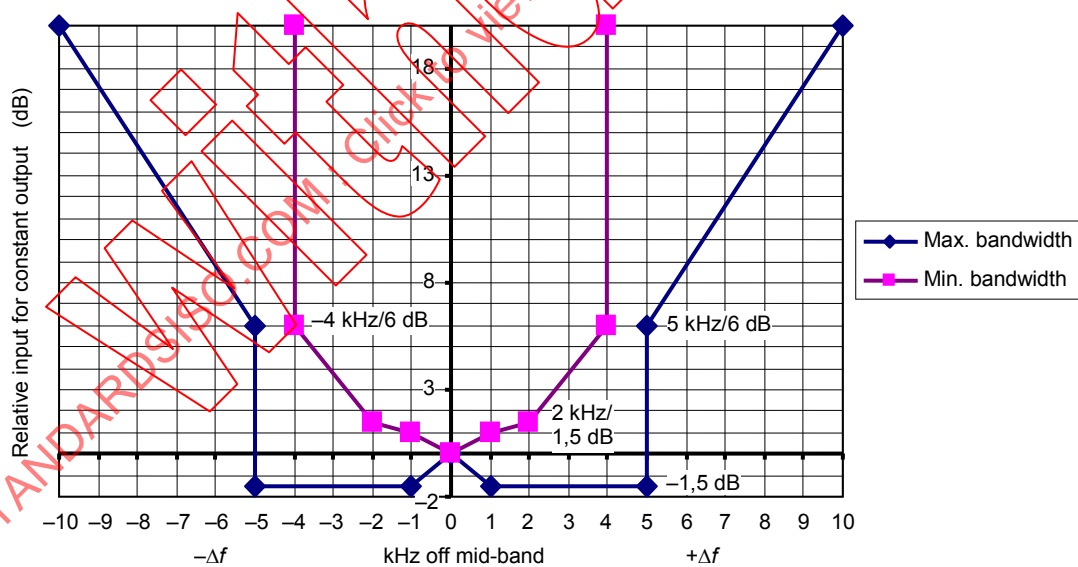


Figure 6 – Limits of overall selectivity –
Pass band (see 4.5.1, 5.6, 6.6, 7.6) (Band B)

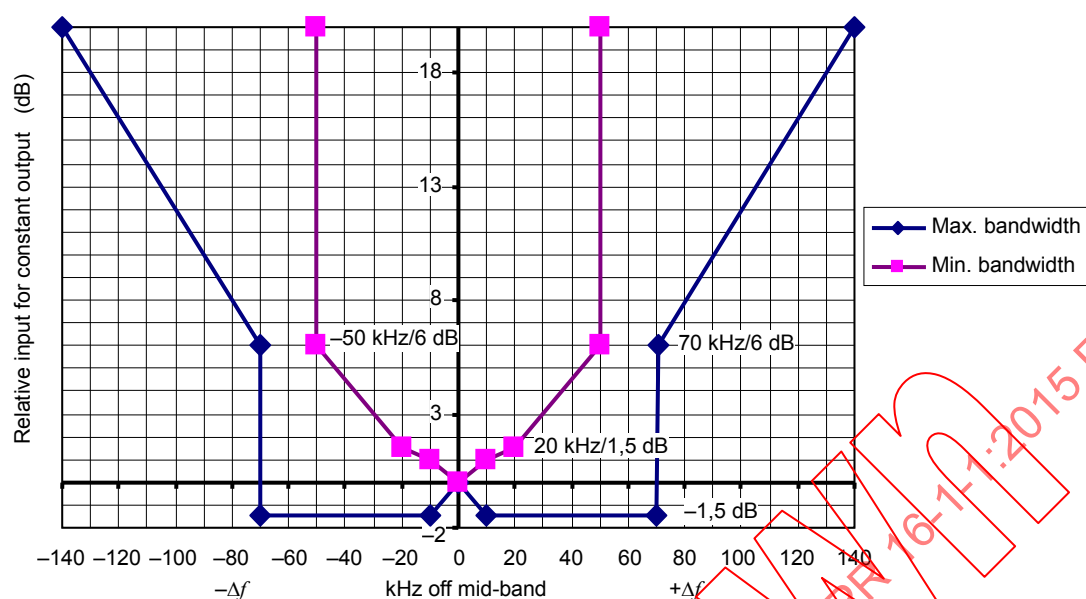


**Figure 7 – Limits of overall selectivity –
Pass band (see 4.5.1, 5.6, 6.6, 7.6) Bands (C and D)**

4.5.4 Other spurious responses

The ratio of the input sine-wave voltage at frequencies other than those specified in 4.5.2 and 4.5.3 to that at the tuned frequency that produces the same indication on the measuring receiver shall be not less than 40 dB. Examples of the frequencies from which such spurious responses may occur are as follows:

$$\left(\frac{1}{m}\right)(nf_L \pm f_i) \text{ and } \left(\frac{1}{k}\right)(f_0) \quad (6)$$

where

m, n, k are integers;

f_L is the local oscillator frequency;

f_i is the intermediate frequency;

f_0 is the tuned frequency.

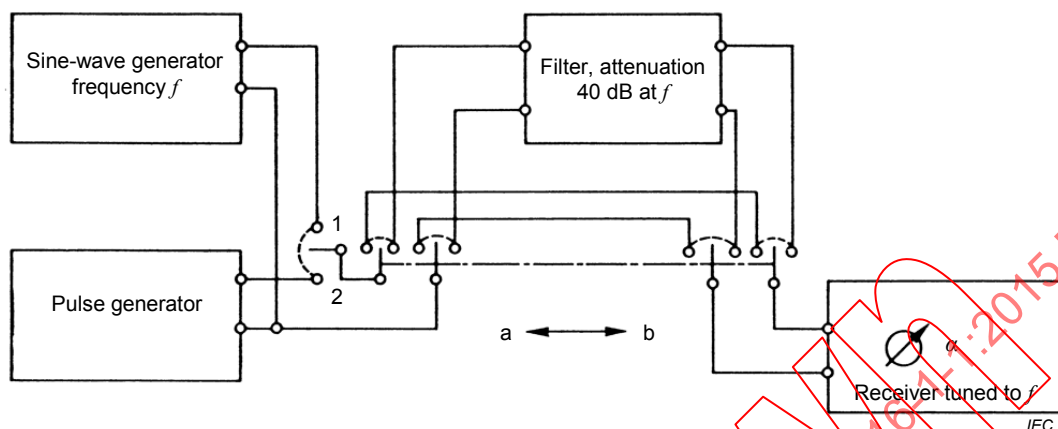
NOTE Where more than one intermediate frequency is used, the frequencies f_L and f_i can refer to each of the local oscillator and intermediate frequencies used. In addition, spurious responses can occur when no input signal is applied to the measuring receiver; for example, when harmonics of the local oscillators differ in frequency by one of the intermediate frequencies. The requirements of this subclause therefore cannot apply in these latter cases. The effect of these spurious responses is dealt with in 4.7. Examples of sources of spurious signals include local oscillators (or their harmonics), internal clocks, computer boards, and their mixing products with the input signal into the receiver.

4.6 Limitation of intermodulation effects

The influence of intermodulation effects on the response of the measuring receiver shall be minimized. The following method shall be applied to determine the suitability of a measuring instrument.

Arrange the apparatus as shown in Figure 8. The pulse generator has a spectrum substantially uniform up to frequency 3) but at least 10 dB down at frequency 4) of the

frequencies given in Table 4. The band-stop filter has an attenuation at the test frequency of at least 40 dB. Its bandwidth, B_6 , relative to the maximum attenuation of the filter shall lie between the frequencies 1) and 2) given in Table 4.



NOTE Following the discussion in 4.6, the measuring receiver responses are:

$$\begin{aligned}\alpha_{1a} &= \alpha_{2a} \\ \alpha_{1b} &= \alpha_{1a} - 40 \text{ dB} \\ \alpha_{2b} &= \alpha_{2a} - 36 \text{ dB}\end{aligned}$$

Figure 8 – Arrangement for testing intermodulation effects

Table 4 – Bandwidth characteristics for intermodulation test of quasi-peak measuring receivers

Frequency range	1) kHz	2) kHz	3) MHz	4) MHz
9 kHz to 150 kHz (Band A)	0,4	4	0,15	0,3
0,15 MHz to 30 MHz (Band B)	20	200	30	60
30 MHz to 300 MHz (Band C)	500	2 000	300	600
300 MHz to 1 000 MHz (Band D)	500	6 000	1 000	2 000

Connect the sine-wave generator output direct to the measuring receiver input and adjust for a convenient reading. Substitute the pulse generator for the sine-wave generator and adjust for the same reading. The pulse repetition frequency shall be 100 Hz for Band A and 1 000 Hz for the other bands.

With the pulse generator connected as described above, switching the filter into circuit shall introduce attenuation of not less than 36 dB for measuring receivers, and of not less than 20 dB for spectrum analyzers without preselection.

4.7 Limitation of receiver noise and internally generated spurious signals

4.7.1 Random noise

Background noise shall not introduce an error in excess of 1 dB.

NOTE The point where the background noise causes an error of 1 dB can be found by applying a signal, S , such that the meter indication is much larger (e.g. 40 dB) than the noise level N . By reducing the signal level S , the meter indication will reach a point, S_1 , where $(S_1 + N)$ deviates by 1 dB from the linear characteristic.

4.7.2 Continuous wave

The existence of spurious responses as described in the note to 4.5.4 shall not introduce a measurement error in excess of 1 dB for any signal input to the measuring receiver. This requirement shall be regarded as satisfied if the receiver complies with 4.7.1 when tested as described in 4.7.1.

4.8 Screening effectiveness

4.8.1 General

Screening effectiveness is a measure of the ability of the measuring receiver to operate in an electromagnetic field without degradation. The requirement applies to receivers operating within the "CISPR indication range" specified by the manufacturer as defined in 3.2.

The screening of the receiver shall be such that when it is immersed in an ambient electromagnetic field of 3 V/m (unmodulated) at any frequency in the range 9 kHz to 1 000 MHz, an error of not greater than 1 dB is produced at the maximum and minimum of the CISPR indication range as specified by the manufacturer of the receiver. In cases where a measuring receiver is not immune to the requirement of 3 V/m, the field strength and frequency at which the error exceeds 1 dB shall be stated by the manufacturer. The test shall be performed as described below.

The receiver is placed inside a screened enclosure. An input signal is applied to the receiver via a 2 m long well-screened cable (e.g. semi-rigid), through a feedthrough in the enclosure wall, to a signal generator placed outside the enclosure. The level of the input signal shall be at the maximum and the minimum of the CISPR indication range as specified by the manufacturer of the receiver. All other coaxial terminals of the receiver shall be terminated in their characteristic impedance.

Only essential leads (e.g. mains and input cables) for the normal use of the measuring receiver in its minimum configuration (excluding options such as headphones) shall be connected during the test. The leads shall have the lengths and be arranged as in typical use.

The strength of the ambient field in the vicinity of the measuring receiver shall be measured by a field strength monitor.

The receiver meter indication in the presence of the ambient electromagnetic field shall differ by not more than 1 dB from the meter indication when the field is absent.

4.8.2 Limitation of radio-frequency emissions from the measuring receiver

4.8.2.1 Conducted emissions

The radio disturbance voltage at any connecting pin of external lines (not only the mains terminals) shall not exceed the limits for class B equipment given in CISPR 11. The measurement of the radio disturbance voltage is however not required on the inner conductors of screened connections to screened equipment. The local oscillator injection power at the measuring receiver input terminated with its characteristic impedance shall not exceed 34 dB(pW) which is equivalent to 51 dB(μ V) across 50 Ω .

4.8.2.2 Radiated emissions

The radio disturbance field strength emitted by the measuring receiver shall not exceed the limits for class B equipment given in CISPR 11, for the frequency range of 9 kHz to 1 000 MHz. The limits shall also apply for frequency bands (ISM frequencies) listed in Table 1 of the same publication. In the frequency range of 1 GHz to 18 GHz, a limit of 45 dB(pW) shall apply, based on an ERP measurement.

Before performing radiated and conducted emission measurements, it is essential that the noise contributions of the test equipment do not affect the measured results (e.g. computer control).

4.9 Facilities for connection to a discontinuous disturbance analyzer

For all bands, the disturbance measuring receiver shall have an intermediate-frequency output if the instrument is to be used for the measurement of discontinuous disturbance. The loading of this output shall have no influence on the indication of the measurement result.

5 Measuring receivers with peak detector for the frequency range 9 kHz to 18 GHz

5.1 General

This clause specifies requirements for measuring receivers employing a peak detector when used for the measurement of impulsive or pulse-modulated disturbance.

Spectrum analyzers and FFT-based measuring instruments that meet the requirements of this clause can be used for compliance measurements. For emission measurements, FFT-based measuring instruments shall sample and evaluate the signal continuously during the measurement time.

5.2 Input impedance

The input port of the measuring receivers shall be unbalanced. For receiver control settings within the CISPR indication range, the nominal input impedance shall be 50 Ω with a VSWR not to exceed the values in Table 5.

Table 5 – VSWR requirements for receiver input impedance

Frequency range	RF attenuation dB	VSWR
9 kHz to 1 GHz	0	2,0 to 1
9 kHz to 1 GHz	≥ 10	1,2 to 1
1 GHz to 18 GHz	0	3,0 to 1
1 GHz to 18 GHz	≥ 10	2,0 to 1

Symmetric input impedance in the frequency range 9 kHz to 30 MHz: a balanced input transformer is to be used for symmetric (that is, ungrounded) measurements. (The preferred input impedance is 600 Ω for the frequency range 9 kHz to 150 kHz.) Symmetric input impedance may be incorporated either in the relevant symmetrical artificial network required to couple to the receiver or, optionally, in the measuring receiver itself.

5.3 Fundamental characteristics

5.3.1 Bandwidth

For all types of broadband disturbance, the actual value of the bandwidth shall be stated when the disturbance level is quoted and the bandwidth is within the values in Table 6.

Table 6 – Bandwidth requirements for measuring receivers with peak detector

Frequency range	Bandwidth B_6	Reference BW
9 kHz to 150 kHz (Band A)	100 Hz to 300 Hz ^a	200 Hz (B_6)
0,15 MHz to 30 MHz (Band B)	8 kHz to 10 kHz ^a	9 kHz (B_6)
30 MHz to 1 000 MHz (Bands C and D)	100 kHz to 500 kHz ^a	120 kHz (B_6)
1 GHz to 18 GHz (Band E)	300 kHz to 2 MHz ^a	1 MHz ^b (B_{imp})
^a Since the response of a peak measuring receiver to non-overlapping pulses is proportional to its impulse bandwidth, either the actual bandwidth is quoted in the result or the level may be quoted as "in a 1 MHz bandwidth", calculated by dividing the measured value by the impulse bandwidth in MHz (see 3.6). For other types of broadband disturbance, this procedure may introduce an error. Therefore, data measured with the reference bandwidth shall take precedence.		
^b The bandwidth selected shall be defined as the impulse bandwidth of the measuring receiver with a tolerance of ± 10 %.		

5.3.2 Charge and discharge time constants ratio

In order to achieve a meter reading within 10 % of the true value of the peak at a repetition rate of 1 Hz, the ratio of discharge time constant to charge time constant shall be equal to or greater than the following values:

- a) $1,89 \times 10^4$ in the frequency range 9 kHz to 150 kHz,
- b) $1,25 \times 10^6$ in the frequency range 150 kHz to 30 MHz,
- c) $1,67 \times 10^7$ in the frequency range 30 MHz to 1 000 MHz,
- d) $1,34 \times 10^8$ in the frequency range 1 GHz to 18 GHz.

If the test receiver has a peak-hold capability, the hold time shall be adjustable to values between 30 ms and 3 s.

NOTE For receivers that use peak hold (and forced discharge after the hold time) or digital peak detection techniques, the requirement on the charge/discharge time constants ratio is not relevant. A maximum-hold function of the display can be used for signals with time-varying amplitudes.

If a spectrum analyzer is used for peak measurements, the video bandwidth (B_{video}) shall be set to a value greater than or equal to the resolution bandwidth (B_{resol}). For peak measurements, the result can be read from the spectrum analyzer display with the detector operating either in the linear or logarithmic mode.

5.3.3 Overload factor

For peak measuring receivers, the overload factor does not need to be as high as it is for other types of measuring receivers. For most direct-reading detectors, the overload factor shall be slightly larger than unity. The overload factor shall be adequate for the time-constants used (see 5.3.2).

5.4 Sine-wave voltage accuracy

The accuracy of sine-wave voltage measurement shall be better than ± 2 dB ($\pm 2,5$ dB above 1 GHz) when the instrument measures a sine-wave signal using a 50 Ω resistive source impedance.

5.5 Response to pulses

Up to 1 000 MHz, the response of the measuring receiver to pulses with impulse area $1,4/B_{imp}$ mVs (where B_{imp} is in Hz) e.m.f. at 50 Ω source impedance shall be equal to the response to an unmodulated sine-wave signal at the tuned frequency having an e.m.f. with rms value of 2 mV [66 dB(μ V)]. The source impedances of both the pulse generator and the

signal generator shall be the same. The pulses shall have a uniform spectrum according to Table 2. A tolerance of $\pm 1,5$ dB is permitted in the sine-wave voltage level, and this is a requirement for all pulse repetition frequencies for which no overlapping pulses occur at the output of the IF amplifier.

NOTE 1 Annexes B and C describe methods for determining the output characteristics of pulse generators for use in testing for the requirements of this subclause.

NOTE 2 At a repetition rate of 25 Hz for Band A and 100 Hz for the other bands, the relationship between the indications of a peak measuring receiver and a quasi-peak measuring receiver with the preferred bandwidth are given in Table 7.

Table 7 – Relative pulse response of peak and quasi-peak measuring receivers for the same bandwidth (frequency range 9 kHz to 1 000 MHz)

Frequency	A_{imp} mVs	B_{imp} Hz	Ratio peak/quasi-peak (dB) for pulse repetition rate	
			25 Hz	100 Hz
Band A	$6,67 \times 10^{-3}$	$0,21 \times 10^3$	6,1	–
Band B	$0,148 \times 10^{-3}$	$9,45 \times 10^3$	–	6,6
Bands C and D	$0,011 \times 10^{-3}$	$126,0 \times 10^3$	–	12,0

NOTE 1 The pulse response is based on the use of the reference bandwidth only (see Table 6).

NOTE 2 The values in this table result from the nominal specification of the detector weighting functions. Therefore, verification by a calibration laboratory is not required.

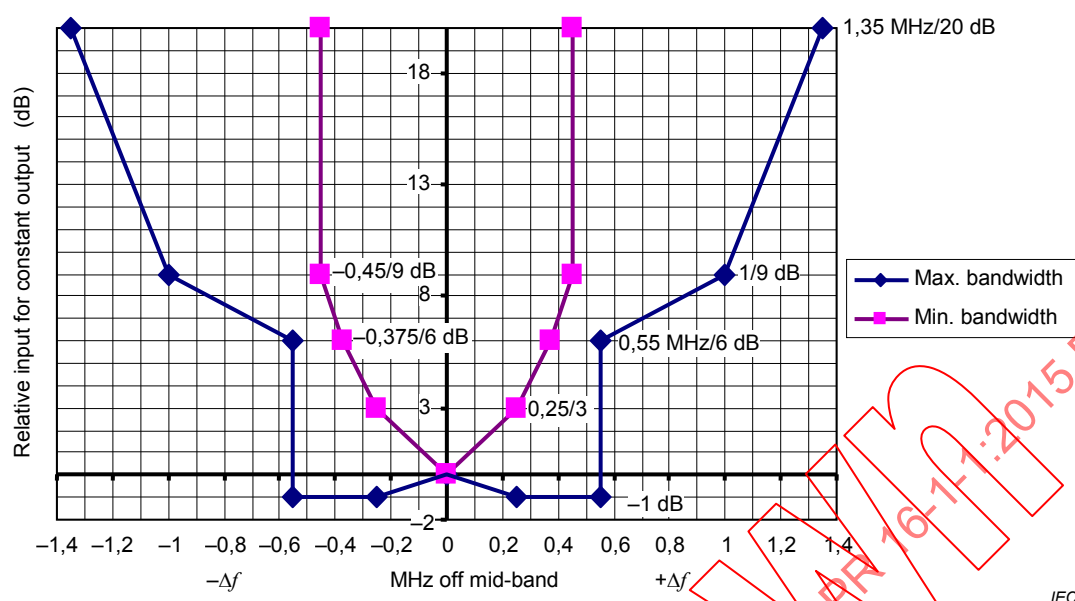
Above 1 GHz, the required impulse area is defined using a pulse-modulated carrier at the frequency of test, since pulse generators with a uniform spectrum up to 18 GHz are not feasible. See E.6.

5.6 Selectivity

Since the bandwidth requirements stated in 5.3.1 allow variations from the bandwidths shown in Figures 5, 6 and 7, these selectivity curves apply to peak measuring receivers in regard to shape only, and the frequency axis shall be scaled accordingly. For example, $B_6/2$ corresponds to 100 Hz in Figure 5.

The requirements in 4.5.2, 4.5.3 and 4.5.4 apply.

The curve representing the overall selectivity of the measuring receiver reference bandwidth for Band E shall lie within the limits of Figure 9.



NOTE 1 The limits for the impulse bandwidth cannot be shown in the diagram, as the related filter attenuation depends on the type of the filter. Therefore bounds for the 6-dB and the 9-dB bandwidths have been given for orientation.

NOTE 2 The limits for the overall selectivity have been derived from equipment being in use at the time of introduction of the selectivity requirement.

Figure 9 – Limits for the overall selectivity – Pass band (Band E)

5.7 Intermodulation effects, receiver noise, and screening

For the frequency range below 1 GHz, the requirements stated in 4.6, 4.7 and 4.8 apply. Subclauses 4.7 and 4.8.2 apply also for Band E.

In addition, the following applies for Band E.

- Requirements for intermodulation effects are under consideration.
- Preselection filter for Band E: when measuring low level spurious signals in the presence of a strong fundamental signal for certain equipment-under-test, insert a filter at the measuring receiver's input (internally or externally) which provides adequate attenuation at the fundamental frequency to protect the input circuits of the receiver from overload and damage and to prevent the generation of harmonic and intermodulation signals.
- Several filters may be required to deal with more than one fundamental frequency.

NOTE 30 dB filter attenuation at the fundamental frequency of the equipment-under-test is normally adequate.

Requirements for screening effectiveness, that is, the immunity to high ambient radiated disturbances, are under consideration.

6 Measuring receivers with average detector for the frequency range 9 kHz to 18 GHz

6.1 General

Average measuring receivers are generally not used for the measurement of impulsive disturbance. This type of receiver has a detector designed to indicate the average value of the envelope of the signal passed through the pre-detector stages. The average detector is used to measure narrowband signals to overcome problems associated with either modulation content or the presence of broadband noise.

Spectrum analyzers and FFT-based measuring instruments that meet the requirements of this clause can be used for compliance measurements. For emission measurements, FFT-based measuring instruments shall sample and evaluate the signal continuously during the measurement time.

6.2 Input impedance

The input port of the measuring receiver shall be unbalanced. For receiver control settings within the CISPR indication range, the input impedance shall be nominally 50 Ω with a VSWR not to exceed the values stated in Table 5.

Symmetric (balanced) input impedance in the frequency range of 9 kHz to 150 kHz: use a balanced input transformer for symmetrical (that is, ungrounded) measurements. (The preferred input impedance for the frequency range of 9 kHz to 150 kHz is 600 Ω). Symmetric input impedance may be incorporated either in the relevant symmetrical artificial network required to couple to the receiver or, optionally, in the measuring receiver itself.

6.3 Fundamental characteristics

6.3.1 Bandwidth

The bandwidths shall lie within the values shown in Table 8.

Table 8 – Bandwidth requirements for measuring receivers with average detector

Frequency range	Bandwidth B_6	Reference BW
9 kHz to 150 kHz (Band A)	100 Hz to 300 Hz ^a	200 Hz (B_6)
150 kHz to 30 MHz (Band B)	8 kHz to 10 kHz ^a	9 kHz (B_6)
30 MHz to 1 000 MHz (Bands C and D)	100 kHz to 500 kHz ^a	120 kHz (B_6)
1 GHz to 18 GHz (Band E)	300 kHz to 2 MHz ^a	1 MHz ^b (B_{imp})
^a The subject of bandwidth is discussed in E.1. If a bandwidth other than the reference BW is used, this bandwidth shall be stated when the disturbance level is reported.		
^b The bandwidth selected shall be defined as in Table 6.		

6.3.2 Overload factor

For receivers with average detectors, the overload factor for circuits preceding the detector at a pulse repetition rate of n Hz shall be B_{imp}/n , with B_{imp} in Hz.

The receiver shall not overload for pulse rates equal to or greater than 25 Hz for Band A, 500 Hz for Band B, and 5 000 Hz for Bands C and D.

NOTE With this type of receiver, in general, it is not possible to provide a sufficient overload factor to prevent non-linear operation of the receiver at very low pulse rates (the response to a single pulse is not defined).

6.4 Sine-wave voltage accuracy

The accuracy of sine-wave voltage measurement shall be better than ± 2 dB ($\pm 2,5$ dB above 1 GHz) when the receiver measures a sine-wave signal with 50 Ω resistive source impedance.

6.5 Response to pulses

6.5.1 General

NOTE Annexes B and C describe methods for determining the output characteristics of pulse generators for use in testing the requirements of this clause in the frequency range below 1 GHz.

6.5.2 Amplitude relationship

Up to 1 000 MHz, the average detector is defined as follows (linear average): the response of the measuring receiver to pulses of repetition rate n Hz and impulse area of $1,4/n$ mVs e.m.f. at 50 Ω source impedance, shall be equal to the response to an unmodulated sine-wave signal at the tuned frequency having an e.m.f. with rms value of 2 mV [66 dB(μ V)]. The source impedances of both the pulse generator and the signal generator shall be the same. The pulses shall have a uniform spectrum according to data shown in Table 2. A tolerance of 1,5 dB/–1,5 dB is permitted on the sine-wave voltage level.

NOTE 1 At repetition frequencies of 25 Hz, 100 Hz, 500 Hz, 1 000 Hz and 5 000 Hz, the relationship between the indications of an average and a quasi-peak measuring receiver of the same bandwidth, assuming adequate overload factors and a constant output level, is given in Table 9.

Table 9 – Relative pulse response of average and quasi peak measuring receivers for the same bandwidth

Frequency range of measuring receiver	Ratio quasi-peak/average indications (dB) for pulse repetition rate				
	25 Hz	100 Hz	500 Hz	1 000 Hz	5 000 Hz
9 kHz to 150 kHz (Band A)	12,4				
0,15 MHz to 30 MHz (Band B)		(32,9)	22,9	(17,4)	
30 MHz to 1 000 MHz (Bands C and D)				(38,1)	26,3
NOTE 1 The pulse response is based on the use of the reference bandwidth only (see Table 8).					
NOTE 2 Values in parentheses are for information only.					
NOTE 3 The values in this table result from the nominal specification of the detector weighting functions. Therefore, verification by a calibration laboratory is not required.					

Above 1 GHz (Band E), two modes of the average (weighting) detector are defined – linear and logarithmic:

For the linear average detector, the response of the measuring receiver to pulses of repetition rate n Hz and impulse area of $1,4/n$ mVs e.m.f. at 50 Ω source impedance shall be equal to the response of an unmodulated sine-wave signal at the tuned frequency having an e.m.f. of rms value of 2 mV [66 dB(μ V)]. The pulse shall be defined as a pulse-modulated carrier. The value of n shall be 50 000 Hz. A tolerance of $\pm 1,5$ dB is permitted on the sine-wave voltage level.

For the logarithmic average detector, the response of the measuring receiver to pulses of repetition rate 333 kHz (inverse of period 3 μ s) and impulse area of 6,7 nVs e.m.f. at 50 Ω source impedance shall be equal to the response of an unmodulated sine-wave signal at the tuned frequency having an e.m.f. with rms value of 2 mV [66 dB(μ V)]. A tolerance of ± 4 dB is allowed on the sine-wave voltage level (the 10 % tolerance of the bandwidth causes a possible variation of approximately $\pm 2,5$ dB).

For further details, see E.6.

Average detection can be achieved with spectrum analyzers operated with a video bandwidth $B_{\text{video}} \ll B_{\text{resol}}$ in order to achieve proper averaging based on the repetition frequency of the measured signal. For measurements based on a reduction of the video bandwidth, ensure the scanning time is sufficiently long to allow the video filter to respond correctly.

NOTE 2 For average (weighted) measurements in the linear mode, the result will correspond to the average level of the measured signal. If the logarithmic mode is used, the result will correspond to the average of the logarithmic values of the measured signal. Thus, for a square-wave signal taking alternatively the values 20 dB(μ V) and 60 dB(μ V), the level obtained in the logarithmic mode is 40 dB(μ V), whereas in the linear mode, the level of 54,1 dB(μ V) represents the true average value of the signal.

6.5.3 Variation with repetition frequency

The response to repetitive pulses of a measuring receiver equipped with a linear average detector shall be such that, for a constant indication on the measuring receiver, the relationship between amplitude and repetition frequency is in accordance with the following rule:

Amplitude proportional to (repetition frequency)⁻¹

A tolerance of +3 dB to –1 dB is allowed in the frequency range from the lowest useable repetition frequency to a frequency equal to $B_3/2$, as determined from overload considerations.

NOTE 1 The theoretical pulse response curves of quasi-peak and average detector receivers, combined on an absolute scale, are shown in Figure 4. The response to repeated pulses of the measuring receiver equipped with a logarithmic average detector (above 1 GHz) is influenced by the noise level between the pulses. Using the following values:

- $L_{\log Av}$ is the level indicated by the logarithmic average detector;
- T_P is the pulse duration;
- L_P is the pulse level in dB(μV);
- T_N is the duration of the noise level;
- L_N is noise level in dB(μV);

then the following approximate relationship applies.

$$L_{\log Av} = \frac{T_P L_P + T_N L_N}{T_P + T_N} \quad (7)$$

EXAMPLE If the pulse level L_P is 85 dB(μV) and the noise level L_N is 8 dB(μV), $T_P = 1/B_{imp} = 1 \mu s$, the pulse rate n is 100 000 Hz, then $T_N \approx 9 \mu s$. From this equation, $L_{\log Av} = 15,7$ dB(μV). In reality, $L_{\log Av}$ is higher because T_P is higher, because the pulse signal at the IF output does not drop to noise level immediately after 1 μs.

NOTE 2 A tolerance is under consideration.

6.5.4 Response to intermittent, unsteady and drifting narrowband disturbances

The response to intermittent, unsteady and drifting narrowband disturbances shall be such that the measurement result is equivalent to the peak reading of a meter with a time constant of 160 ms for Bands A and B and of 100 ms for Bands C and D, as depicted in Figure 11. The time constant is as defined in A.3.2. This can be accomplished by a meter-simulating network following the envelope detector of the receiver. The peak reading may be taken, for example, by continuous monitoring of the meter output using an A/D converter and a microprocessor, as shown in Figure 10.

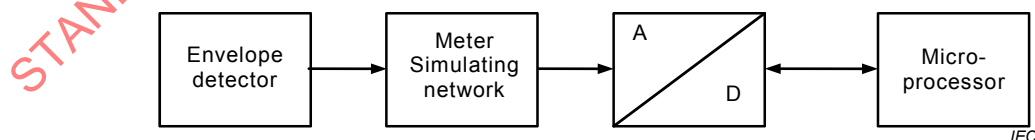


Figure 10 – Block diagram of an average detector

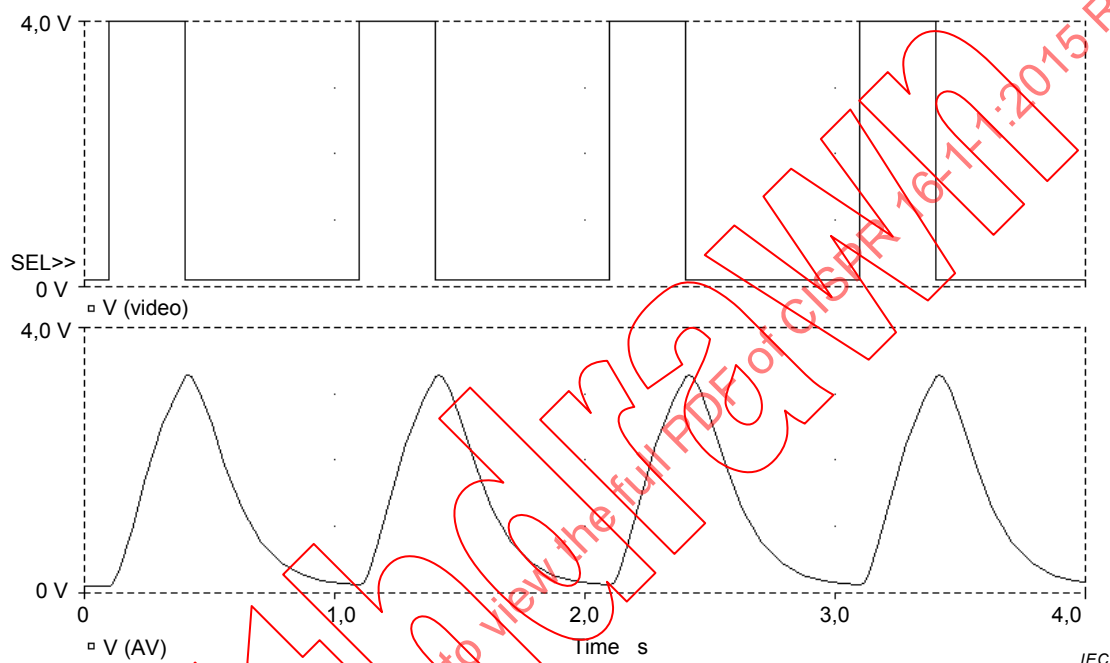
For Band E, the meter time constant for the linear average detector is 100 ms. For the logarithmic average detector, the requirement is under consideration.

It is deduced from the above requirement that an average measuring receiver shall yield the maximum reading listed in Table 10 for a radio frequency sine-wave input signal modulated with repeated rectangular pulses having the duration and period indicated in the table. A tolerance of ±1,0 dB is allowed for this requirement.

Table 10 – Maximum reading of average measuring receivers for a pulse-modulated sine-wave input in comparison with the response to a continuous sine wave having the same amplitude

Repeated rectangular pulses for modulation	Band A/B receiver $T_M = 0,16 \text{ s}$	Band C/D receiver $T_M = 0,1 \text{ s}$
Duration = T_M Period = 1,6 s	0,353 (= -9,0 dB)	0,353 (= -9,0 dB)

NOTE In Band E, this applies for the linear average detector only.



NOTE 1 The response shown is caused by an intermittent narrowband signal with a duration of 0,3 s and a repetition frequency of 1 Hz, when a time constant of 100 ms is used. If the time constant is 160 ms, the peaks at the output of the meter-simulating network will be lower.

NOTE 2 The response to intermittent narrowband disturbances can also be defined for the logarithmic average detector operating with a certain video bandwidth, for example, 10 Hz, and the maximum hold function of the spectrum display.

Figure 11 – Screenshot showing response of the meter-simulating network to an intermittent narrowband signal

6.6 Selectivity

For receivers with a bandwidth of 200 Hz (for the frequency range 9 kHz to 150 kHz) or a bandwidth of 9 kHz (for frequency range 0,15 MHz to 30 MHz) the overall selectivity shall be within the limits shown in Figure 5 and 6, respectively. For receivers with a bandwidth of 120 kHz (for the frequency range 30 MHz to 1 000 MHz), the overall selectivity shall be within the limits shown in Figure 7. For receivers having other bandwidths, Figures 5, 6 and 7 describe the shape only and the frequency axis shall be scaled accordingly. The curve representing the overall selectivity of the measuring receiver reference bandwidth for Band E shall lie within the limits of Figure 9.

The requirements of 4.5.2, 4.5.3 and 4.5.4 apply.

NOTE For the measurement of equipment that requires higher selectivity at the transition between 130 kHz and 150 kHz (for example, mains signaling equipment as defined in EN 50065-1 [18]²), a high-pass filter may be added in front of the measuring receiver to achieve the following combined selectivity of CISPR measuring receiver and high-pass filter:

Frequency kHz	Relative attenuation dB
150	≤ 1
146	≤ 6
145	≥ 6
140	≥ 34
130	≥ 81

The measuring receiver in conjunction with the high-pass filter should meet the requirements of this standard.

6.7 Intermodulation effects, receiver noise, and screening

The requirements in 5.7 shall apply.

7 Measuring receivers with rms-average detector for the frequency range 9 kHz to 18 GHz

7.1 General

RMS-average weighting receivers employ a weighting detector that is a combination of the rms detector (for pulse repetition frequencies above a corner frequency f_c) and the average detector (for pulse repetition frequencies below the corner frequency f_c), thus achieving a pulse response curve with the following characteristics: 10 dB/decade above the corner frequency and 20 dB/decade below the corner frequency.

Spectrum analyzers and FFT-based measuring instruments that meet the requirements of this clause can be used for compliance measurements. For emission measurements, FFT-based measuring instruments shall sample and evaluate the signal continuously during the measurement time.

7.2 Input impedance

The input circuit of measuring receivers shall be unbalanced. For receiver control settings within the CISPR indication range, the input impedance shall be nominally 50 Ω with a VSWR not to exceed the values in Table 11.

Table 11 – VSWR requirements of input impedance

Frequency range	RF Attenuation dB	VSWR
9 kHz to 1 GHz	0	2,0 to 1
9 kHz to 1 GHz	10	1,2 to 1
1 GHz to 18 GHz	0	3,0 to 1
1 GHz to 18 GHz	10	2,0 to 1

Symmetric input impedance in the frequency range 9 kHz to 30 MHz: to permit symmetrical measurements, a balanced input transformer is used. The preferred input impedance for the

² Figures in square brackets refer to the Bibliography.

frequency range 9 kHz to 150 kHz is 600 Ω . This symmetric input impedance may be incorporated either in the relevant symmetrical artificial network necessary to couple to the receiver or optionally in the measuring receiver.

7.3 Fundamental characteristics

7.3.1 Bandwidth

The bandwidths shall lie within the values of Table 12.

Table 12 – Bandwidth requirements for measuring receivers with rms-average detector

Frequency range	Bandwidth
9 kHz to 150 kHz (Band A)	200 Hz (B_6)
150 kHz to 30 MHz (Band B)	9 kHz (B_6)
30 MHz to 1 000 MHz (Bands C and D)	120 kHz (B_6)
1 GHz to 18 GHz (Band E)	1 MHz (B_{imp})
NOTE The chosen value in band E is defined as the impulse bandwidth of the measuring receiver with a tolerance of ± 10 %.	

7.3.2 Overload factor

Above the corner frequency f_c , specified below, the overload factor for circuits preceding the detector at a pulse repetition rate of n Hz shall be $1,27(B_3 n)^{1/2}$, with B_3 in Hz. Below the corner frequency the overload factor at a pulse repetition rate of n Hz shall be above the value $1,27(B_3 / f_c)^{1/2} \times (f_c / n)$.

NOTE 1 “Corner frequency” is the pulse repetition frequency above which the rms-average detector behaves like an rms detector and below which the rms-average detector has the slope of a linear average detector.

The minimum pulse repetition rate without overload shall conform to the values given in Table 13.

Table 13 – Minimum pulse repetition rate without overload

Frequency range of measuring receiver	Corner frequency f_c kHz	Minimum pulse repetition rate Hz	Ratio peak/rms -average indications dB
9 kHz to 150 kHz (Band A)	0,01	5	19
0,15 MHz to 30 MHz (Band B)	0,01	5	35,5
30 MHz to 1 000 MHz (Bands C and D)	0,1	31,6	40,6
1 GHz to 18 GHz (Band E)	1	316	40

NOTE 2 With this type of detector it will not, in general, be possible to provide sufficient overload factor to prevent non-linear operation of the instrument at very low pulse repetition rates for short pulses in Bands C/D and E (the response to a short pulse is only theoretically defined in these bands).

NOTE 3 Annex A describes the calculation for the overload factor for the rms detector. Annex B describes the determination of the pulse generator spectrum. Annex C describes the accurate measurement of the output levels of nanosecond pulse generators.

NOTE 4 For Band E, the test can be made with a pulse-modulated sine-wave signal, with an occupied bandwidth of e.g. 2 MHz. E.6 gives the specification of an applicable test signal.

7.4 Sine-wave voltage accuracy

The accuracy of sine-wave voltage measurement shall be better than ± 2 dB ($\pm 2,5$ dB above 1 GHz) when the receiver measures a sine-wave signal with a 50 Ω resistive source impedance.

7.5 Response to pulses

7.5.1 Construction details

The detector function can be represented by an rms detector that continuously determines rms values during periods of time equal to the reciprocal of the corner frequency f_c . These rms values are then passed through a second order low-pass filter that corresponds to the critically damped indication that is specified for the quasi-peak detector, the time constant of which is defined up to 1 GHz. For Band E, the time constant is 100 ms. In case of variation with time, the maximum output of the low-pass filter is the measurement result.

NOTE Annexes B, C and E describe methods for determining the output characteristics of pulse generators for use in testing the requirements of this clause.

7.5.2 Amplitude relationship

The response of the measuring receiver for Band A to pulses of impulse area $278 \times (B_3)^{-1/2}$ μ Vs e.m.f. at a 50 Ω source impedance which have a uniform spectrum up to at least the highest tuneable frequency of Band A, and repeated at a frequency of 25 Hz, shall for all frequencies of tuning, be equal to the response to an unmodulated sine-wave signal at the tuned frequency having an e.m.f. of 2 mV [66 dB(μ V)] rms. For the measuring receivers for Bands B, C, D and E, the corresponding values are $44 \times (B_3)^{-1/2}$ μ Vs and 1 000 Hz. The source impedances of the pulse generator and the signal generator shall both be the same. A tolerance of $\pm 1,5$ dB is permitted in the sine-wave voltage levels prescribed above.

NOTE Annex A describes the calculation for the pulse response of the rms detector. At a repetition frequency of 25 Hz and 100 Hz (i.e. the quasi-peak detector reference pulse repetition frequency), respectively, the relationship between the indications of an rms-average and a quasi-peak measuring receiver of the same bandwidth is given in Table 14.

When external preamplifiers are used, refer to Annex J for applicable requirements.

Table 14 – Relative pulse response of rms-average and quasi-peak measuring receivers

Frequency range of measuring receiver	Pulse repetition rate	Ratio quasi-peak/rms-average indications
	Hz	dB
9 kHz to 150 kHz (Band A)	25	4,2
0,15 MHz to 30 MHz (Band B)	100	14,3
30 MHz to 1 000 MHz (Bands C and D)	100	20,1
NOTE The values in this table result from the nominal specification of the detector weighting functions. Therefore, verification by a calibration laboratory is not required.		

7.5.3 Variation with repetition frequency

The response of the measuring receiver to repeated pulses shall be such that, for a constant indication on the measuring receiver, the relationship between amplitude and repetition frequency above the corner frequency f_c shall be in accordance with the following rule:

amplitude proportional to (repetition frequency) $^{-1/2}$.

Below the corner frequency f_c the relationship shall be in accordance with the following rule:

amplitude proportional to (repetition frequency) $^{-1}$.

The response curve for a particular receiver shall lie between the limits in Table 15.

Table 15 – Pulse response of rms-average measuring receiver

Repetition frequency Hz	Relative equivalent level of pulse in dB			
	Band A	Band B	Bands C and D	Band E
100 k	-	-	$(-20 \pm 2,0)$	$-20 \pm 2,0$
10 k	-	-	$-10 \pm 1,0$	$-10 \pm 1,0$
1 000	-	0 (ref.)	0 (ref.)	0 (ref.)
316	-	$+5 \pm 0,5$	$+5 \pm 0,5$	$+10 \pm 1,0$
100	$-6 \pm 0,6$	$+10 \pm 1,0$	$+10 \pm 1,0$	$(+20 \pm 2,0)$
31,6	-	$+15 \pm 1,5$	$+20 \pm 2,0$	
25	0 (ref.)	$+16 \pm 1,6$		
10	$+4 \pm 0,4$	$+20 \pm 2,0$		
5	$+9 \pm 0,7$	$+25 \pm 2,3$		
1	-	-		
NOTE 1 Values in brackets are for information only.				
NOTE 2 The values at 5 Hz for Bands A and B take into account the effect of the meter time constant.				

7.5.4 Response to intermittent, unsteady and drifting narrowband disturbances

The response to intermittent, unsteady and drifting narrowband disturbances shall be such that the measurement result is equivalent to the peak reading of a meter with a time constant of 160 ms for Bands A and B and of 100 ms for Bands C, D and E. This can be accomplished by the meter-simulating network (analog or digital) to which the rms values described in 7.5.1 are used as input.

It is deduced from the above requirement that an rms-average measuring receiver shall yield the maximum reading listed in Table 9 for a radio frequency sine-wave input signal modulated with repeated rectangular pulses having the duration and period indicated in Table 16. A tolerance of $\pm 1,0$ dB is allowed for this requirement.

Table 16 – Maximum reading of rms-average measuring receivers for a pulse-modulated sine-wave input in comparison with the response to a continuous sine wave having the same amplitude

Repeated rectangular pulses for modulation	Band A/B receiver $T_M = 0,16$ s	Band C/D/E receiver $T_M = 0,1$ s
Duration = T_M Period = 1,6 s	0,398 (= -7,9 dB)	0,353 (= -9,0 dB)
NOTE The value for the Band A/B receiver can vary by about $\pm 0,5$ dB due to varying overlapping of the 160 ms pulse duration with the 100 ms rms integration time duration.		

7.6 Selectivity

The selectivity curves for the rms-average weighting receiver shall be equal to those of Figures 5, 6 and 7, for Bands A, B, C and D. For the Band E receiver, the selectivity curve is given in Figure 9.

The requirements of 4.5.2, 4.5.3 and 4.5.4 apply. For Band E receivers, requirements are under consideration.

7.7 Intermodulation effects, receiver noise, and screening

For the frequency range below 1 GHz, the requirements of 4.6, 4.7 and 4.8 apply. Subclauses 4.7 and 4.8.2 also apply for Band E.

For Band E, the following applies:

- requirements for intermodulation effects are under consideration.
- preselection filter: when measuring weak spurious signals in the presence of a strong fundamental signal from certain equipment under test, a filter shall be provided at the input of the measuring receiver to ensure adequate attenuation at the fundamental frequency to protect the input circuits of the receiver from overload and damage, and to prevent the generation of harmonic and intermodulation signals.

NOTE 1 30 dB filter attenuation at the fundamental frequency of the equipment under test is normally adequate.

NOTE 2 A number of such filters may be required to deal with more than one fundamental frequency.

Requirements for screening effectiveness, i.e. the immunity to high ambient radiated disturbances, are under consideration.

8 Measuring receivers for the frequency range 1 GHz to 18 GHz with amplitude probability distribution (APD) measuring function

APD of disturbance is defined as the cumulative distribution of the “probability of time that the amplitude of disturbance exceeds a specified level”.

APD can be measured at the output of the envelope detector or the succeeding circuits of an RF measuring receiver or a spectrum analyzer. The amplitude of disturbance should be expressed in terms of the corresponding field strength or voltage at the receiver input. Usually, an APD measurement is carried out at a fixed frequency.

The APD measuring function will be an additional function of the measuring apparatus and may be attached to, or incorporated in the measuring instrument.

The APD measuring function can be implemented using the following methods. One approach uses comparators and counters (Figure G.1). The equipment determines the probabilities of exceeding a set of pre-assigned amplitude (i.e. voltage) levels. The number of levels equals the number of comparators. Another possible method involves the use of an analog-to-digital converter, a logic circuit, and memory (Figure G.2). The equipment can also provide the APD figure for a set of pre-assigned amplitude levels. The number of levels depends on the resolution of the analog-to-digital converter (e.g. 256 levels for an 8-bit converter).

APD measurements using the aforementioned function are applicable to products or product families if their potential to cause interference to digital communication systems is to be determined (see 4.7 of CISPR 16-3:2010/CISPR 16-3:2010/AMD1:2012, for background material on amplitude probability distribution, APD, specifications).

The following specifications apply to the APD measuring function. A rationale for these specifications is provided in Annex G.

• Specifications

- a) The dynamic range of the amplitude shall be greater than 60 dB.
- b) The amplitude accuracy, including threshold level setting error, shall be better than $\pm 2,7$ dB.
- c) The maximum measurable time of a disturbance shall be longer than or equal to 2 min. The intermittent measurement can be used if the dead time is less than 1 % of the total measurement time.

- d) The minimum measurable probability shall be 10^{-7} .
- e) The APD measuring function shall be capable of assigning at least two amplitude levels. The probabilities corresponding to all pre-assigned levels shall be measured simultaneously. The resolution of the pre-assigned amplitude levels shall be 0,25 dB at a minimum or better.
- f) The sampling rate shall be greater than or equal to 10 million samples per second when using a resolution bandwidth of 1 MHz.

- **Recommended specification**

- g) Amplitude resolution of the APD display should be less than 0,25 dB for APD measuring equipment with an A/D converter.

NOTE APD measurements can also be applicable in the frequency range below 1 GHz.

9 Disturbance analyzers

9.1 General

Disturbance analyzers are used for the automatic assessment of amplitude, rate and duration of discontinuous disturbances (clicks).

A 'click' has the following characteristics:

- a) the QP amplitude exceeds the quasi-peak limit of continuous disturbance,
- b) the duration is not longer than 200 ms, and
- c) the spacing from a preceding or subsequent disturbance is equal to or more than 200 ms.

A series of short pulses shall be treated as a click when its duration, measured from the start of the first to the end of the last pulse, is not longer than 200 ms and conditions a) and c) are fulfilled.

The time parameters are determined from the signal that exceeds the IF reference level of the measuring receiver.

NOTE 1 Definition and assessment of clicks are in compliance with CISPR 14-1.

NOTE 2 Current analyzers are designed for use with a quasi-peak measuring receiver of the type that works with a limited internal signal level. As a result, such analyzers may not interface correctly with all receivers.

9.2 Fundamental characteristics

- a) The analyzer shall be equipped with a channel to measure the duration and spacing of discontinuous disturbances; the input of this channel shall be connected to the IF output of the measuring receiver. For these measurements, only the part of the disturbance has to be considered which exceeds the IF reference level of the receiver. The accuracy of duration measurements shall be not worse than $\pm 5\%$.

NOTE 1 The IF reference level is the corresponding value in the IF output of the measuring receiver to an unmodulated sinusoidal signal, which produces a quasi-peak indication equal to the limit for continuous disturbances.

- b) The analyzer shall be equipped with a channel to assess the quasi-peak amplitude of a disturbance.
 - c) The amplitude in the quasi-peak channel shall be measured 250 ms after the last falling edge in the IF channel.
 - d) The combination of both channels shall comply in all respects with the requirements of 4.2.
 - e) The analyzer shall be capable of indicating the following information:
 - the number of clicks of duration equal to or less than 200 ms;
 - the duration of the test in minutes;

- the click rate;
- the incidence of disturbances other than clicks which exceed the QP limit of continuous disturbance.

NOTE 2 An example of a disturbance analyzer is shown in the form of a block diagram in Figure 12.

- f) For validation of the fundamental characteristics the analyzer has to pass the performance check with all the waveforms (test pulses) in Table 14.

Figure 13 presents in a graphical form the waveforms listed in Table 17.

Figure F.1 presents in a graphical form all the waveforms listed in Table F.1 for the performance check of the exceptions from the definitions of a click according to 4.2.3 of CISPR 14-1:2005.

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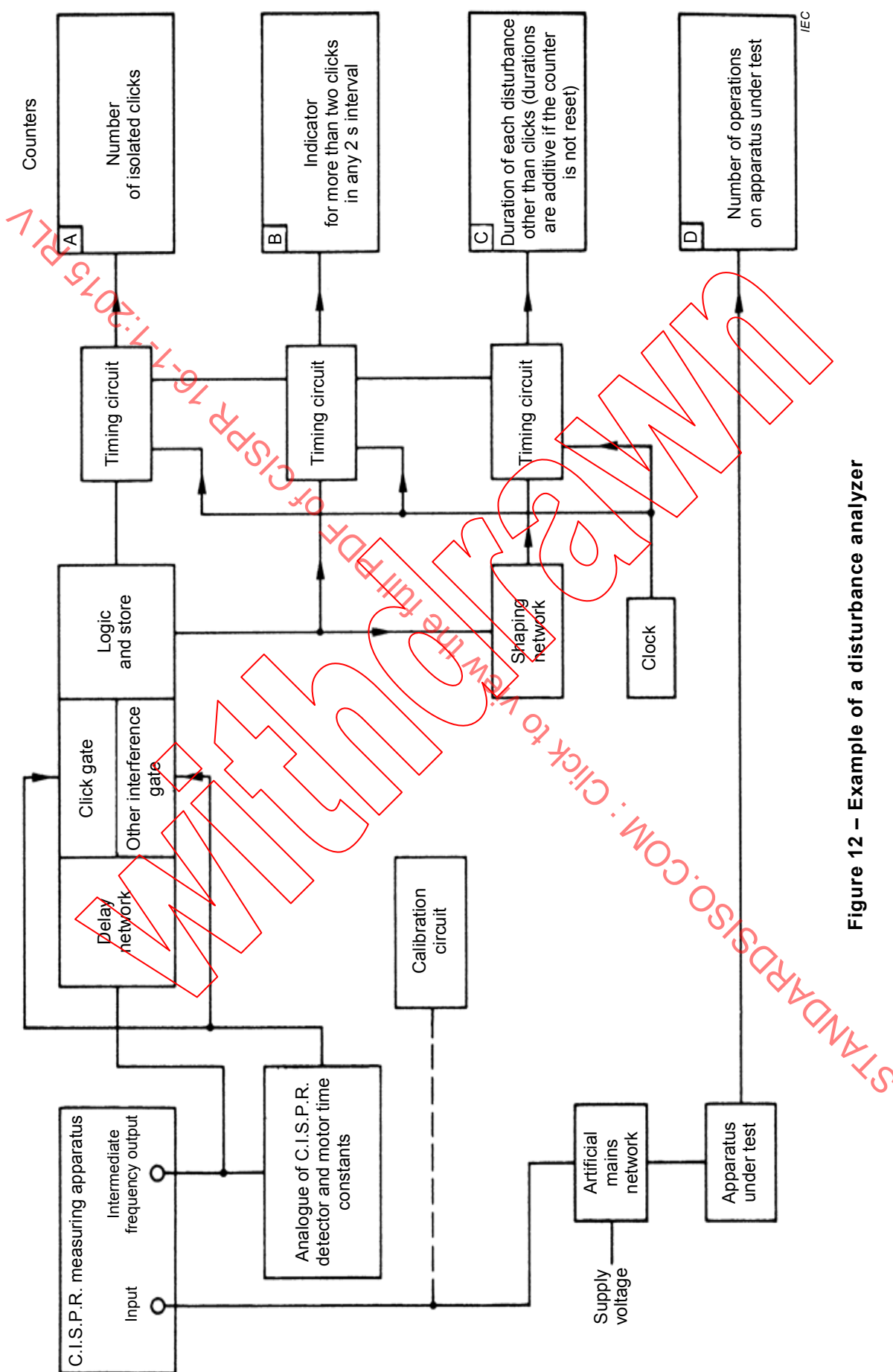


Figure 12 – Example of a disturbance analyzer

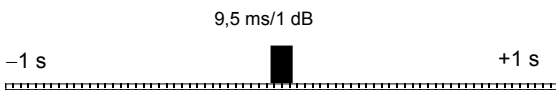
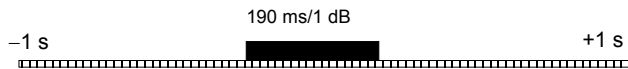
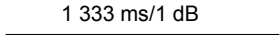
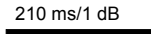
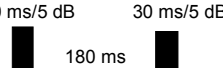
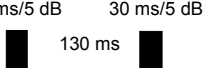
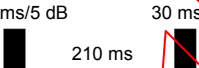
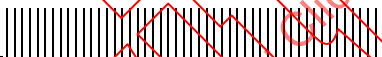
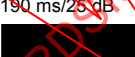
Test No.	Test signal	Evaluation by the analyzer
1	 0,11ms/1 dB	1 click
2	 9,5 ms/1 dB -1 s +1 s	1 click
3	Background: noise or CISPR pulses, 200 Hz: -2,5 dB (QP)  190 ms/1 dB -1 s +1 s	1 click
4	Background: noise or CISPR pulses, 200 Hz: -2,5 dB (QP)  1 333 ms/1 dB	Other than click
5	 210 ms/1 dB	Other than click
6	 30 ms/5 dB 180 ms 30 ms/5 dB	Other than click
7	 30 ms/5 dB 130 ms 30 ms/5 dB	1 click
8	 30 ms/5 dB 210 ms 30 ms/5 dB	2 clicks
9	 Min. 21 pulses/0,11 ms/periodicity 10 ms/1 dB	Other than click
10	 265 ms 30 ms/25 dB 30 ms/-2,5 dB	1 click
11	 190 ms/25 dB Band B: 1 034 ms/Band C: under consideration  30 ms/-2,5 dB/2 dB IF	2 clicks
12	 190 ms/25 dB Band B: 1 166 ms/Band C: under consideration  30 ms/-2,5 dB/2 dB IF	1 click

Figure 13 – A graphical presentation of test signals used in the test of the analyzer for the performance check against the definition of a click according to Table 14

**Table 17 – Disturbance analyzer performance test –
Test signals used for the check against the definition of a click (1 of 4)**

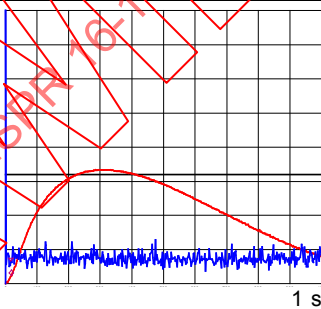
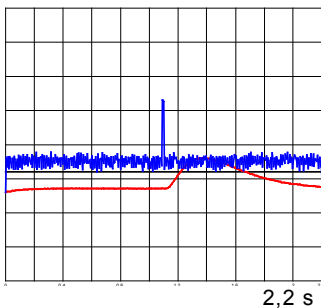
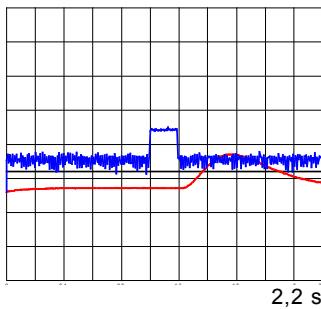
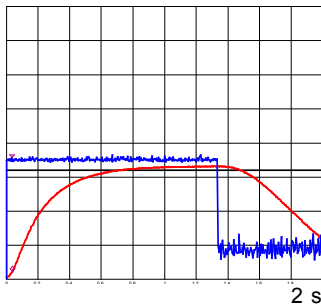
Test No.	Test signal parameters							
	1		2		3	4	5	
	QP amplitude of impulses adjusted individually relative to QP reference indication of the measurement receiver dB		Duration of impulses ^f adjusted in the intermediate frequency output of the measurement receiver ms		Separation of impulses or periodicity (IF-output) ms	Evaluation by the analyzer	Graphical presentation of the test signal measured in the IF-output and the associated QP signal relative to the reference indication of the measurement receiver	
	Pulse 1	Pulse 2	Pulse 1	Pulse 2				
1	1		0,11			1 click		
2 ^a	1		9,5			1 click		
3 ^a	1		190			1 click		
4	1		1 333 ^b			Other than click		

Table 17 (2 of 4)

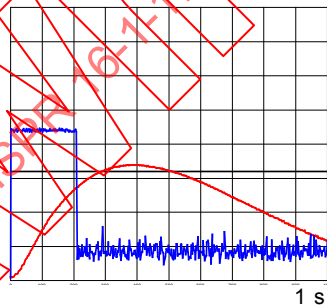
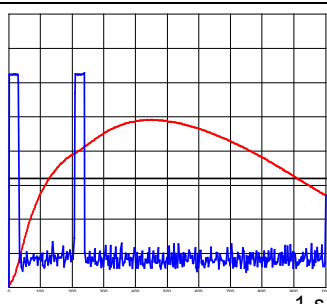
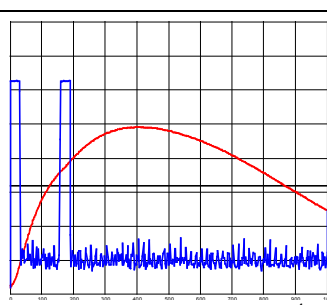
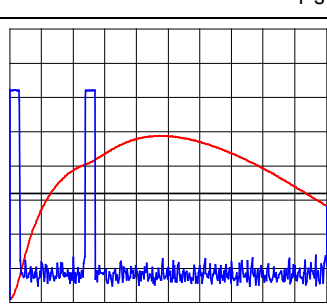
Test No.	Test signal parameters					Evaluation by the analyzer	Graphical presentation of the test signal measured in the IF-output and the associated QP signal relative to the reference indication of the measurement receiver
	1		2		3		
	QP amplitude of impulses adjusted individually relative to QP reference indication of the measurement receiver dB		Duration of impulses t adjusted in the intermediate frequency output of the measurement receiver ms		Separation of impulses or periodicity (IF-output) ms		
	Pulse 1	Pulse 2	Pulse 1	Pulse 2			
5	1		210			Other than click (210 ms)	
6	5	5	30	30	180	Other than click (240 ms)	
7	5	5	30	30	130	1 click	
8	5	5	30	30	210	2 clicks	

Table 17 (3 of 4)

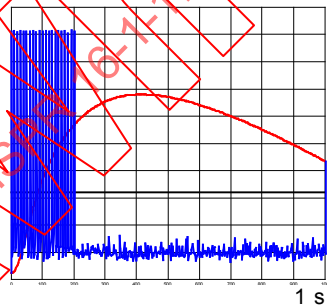
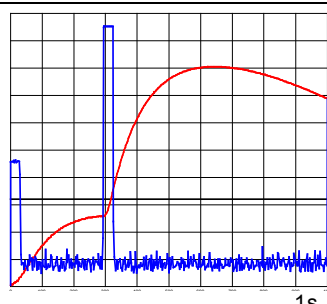
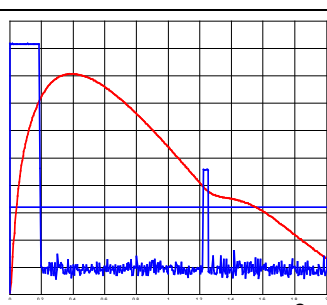
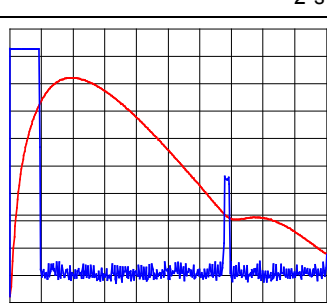
Test No.	Test signal parameters					Evaluation by the analyzer	Graphical presentation of the test signal measured in the IF-output and the associated QP signal relative to the reference indication of the measurement receiver
	1		2		3		
	QP amplitude of impulses adjusted individually relative to QP reference indication of the measurement receiver dB		Duration of impulses ^f adjusted in the intermediate frequency output of the measurement receiver ms		Separation of impulses or periodicity (IF-output) ms		
	Pulse 1	Pulse 2	Pulse 1	Pulse 2			
9	1		0,11		Periodicity 10, minimum 21 pulses	Other than click	
10	-2,5	25	30	30	265	1 click	
11	25	-2,5 ^c	190	30	1 034 ^e	2 clicks ^d	
12	25	-2,5 ^c	190	30	1 166 ^e	1 click	

Table 17 (4 of 4)

a	To be performed with background noise consisting of 200 Hz CISPR pulses at a level 2,5 dB below the quasi-peak threshold level. These pulses should be present commencing at least 1 s before the test pulse and lasting until at least 1 s after the test pulse.
Observations:	
1)	The graphical representation is done with peak measurements of a very short hold time (<1 ms) of the test receiver which show the 200-Hz pulse. When the pulse-modulated sine wave arrives, the 200-Hz-pulse is no longer visible (as seen in the graph for test no. 3) but still present during the event of the click disturbance
2)	The very narrow responses at the origin in the graphs are due to a firmware imperfection.
b	The 1,333 s impulse checks the threshold of the analyzer for impulses, which are only 1 dB above the quasi-peak threshold level.
c	These lower levels shall be set such that the intermediate frequency threshold is exceeded but the quasi-peak threshold is not exceeded
d	If these two pulses are measured as separate disturbances, only one click will be registered.
e	The correspondent values for the frequency range above 30 MHz are under consideration and will be revised after further investigations.
f	The rise times of the pulses shall not be longer than 40 µs.

9.3 Test method for the validation of the performance check for the click analyzer

9.3.1 Basic requirements

The disturbance analyzer is connected to the quasi-peak measuring receiver and tuned to a convenient frequency.

A CW signal and a pulsed CW signal both at the tuned frequency of the receiver are required. A signal generated by CISPR pulse generator, as defined in Annex B, with a 200 Hz PRF covering the receiver bandwidth at the tuned frequency is also required for test numbers 2 and 3.

The pulsed CW signal source shall provide two independently variable pulses. The rise time of the pulses shall not be longer than 40 µs. The pulse duration shall be variable between 110 µs and 1,3 s and the amplitudes variable over a 44 dB range. Any background noise of the pulsed CW signal source shall be at least 20 dB below the reference level used in step a) in the test measured on the receiver's quasi-peak meter.

The test procedure is as follows:

- a) The CW signal is connected to the input of the measuring receiver used in conjunction with the disturbance analyzer. The amplitude of the CW signal is adjusted to bring the meter indication to the reference (zero) point on the meter scale of the measuring receiver equal to a value identical to the QP-limit for continuous disturbance. The receiver RF sensitivity (attenuator) control is adjusted to a level above the receiver noise but below the limit for continuous disturbance used as threshold in the IF channel. The corresponding level of the CW signal at the IF output of the receiver constitutes the IF reference level.
- b) The pulsed CW signal is connected to the input of the measuring receiver. For test numbers 2 and 3, the signal from the CISPR pulse generator is added to the pulsed CW signal. The parameters of the signal are given in Table 14. The amplitudes of the pulses shown in column 1 of Table 14 are adjusted individually relative to the indication of the limit (QP) for continuous disturbance used as threshold in the IF channel. The levels shall be relative to the respective RF and IF reference levels established in the previous paragraph.

9.3.2 Additional requirements

The test method is identical to the one described in 9.3.1a). The parameters of the signal are given in Table F.1.

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Withdrawn

Annex A (normative)

Determination of response to repeated pulses of quasi-peak and rms-average measuring receivers (See 3.6, 4.4.2, 7.3.2 and 7.5.1)

A.1 General

This annex sets out the data for the numerical calculation, and the procedure for establishing the curve of response to repeated pulses. The assumptions inherent in the method are also stated. The calculation is divided into three successive stages.

NOTE The text on the rms detector in this annex deals with the rms measuring receiver in theory and applies to the rms-average measuring receiver above the corner frequency f_c as defined in Clause 7.

A.2 Response of the pre-detector stages

The pulse response of these stages is, in general, determined solely by the IF stages that define the overall selectivity of the receiver.

It is common practice to consider that this selectivity can be obtained by an assembly of two critically-coupled tuned transformers arranged in cascade so as to produce the desired passband at the –6 dB points. Any other equivalent arrangement can be reduced to the above for purposes of calculation. The practical symmetry of this passband permits the use of the equivalent low-pass filter for calculating the envelope of the pulse response. The error resulting from this approximation is negligible.

The envelope of the pulse response is written:

$$A(t) = 4\omega_0 G e^{-\omega_0 t} (\sin \omega_0 t - \omega_0 t \cos \omega_0 t) \quad (\text{A.1})$$

where

G is the overall gain at tuned frequency;

ω_0 is the angular frequency of value $(\pi/\sqrt{2}) B_6$.

The envelope of the response of two critically-coupled tuned transformers to an impulse area $\nu\tau$ is, from the previous equation:

$$A(t) = (\nu\tau) 4\omega_0 G e^{-\omega_0 t} (\sin \omega_0 t - \omega_0 t \cos \omega_0 t) \quad (\text{A.2})$$

The corresponding selectivity curve of the equivalent low-pass filter may be written, for $\tau \ll 1/\omega_0$:

$$F(f) = G \times \frac{2\omega_0^2}{[(\omega_0 + j\omega)^2 + \omega_0^2]^2} \quad (\text{A.3})$$

where $\omega = 2\pi f$.

The bandwidths B_3 and B_6 will be:

$$B_3 = \frac{\left[\sqrt{2} \times \sqrt[4]{(\sqrt{2}-1)} \right] \omega_0}{\pi} = 0,361 \omega_0 \quad (\text{A.4})$$

$$B_6 = \frac{\sqrt{2} \times \omega_0}{\pi} = 0,450 \omega_0 \quad (\text{A.5})$$

The effective bandwidth of a receiver, comprising an idealized rectangular filter giving the same rms value of response as an actual receiver, is equal to the power bandwidth Δf defined as:

$$\Delta f = \left(\frac{1}{F_0^2} \right) \int_{-\infty}^{+\infty} F^2(f) df \quad (\text{A.6})$$

where

$F(f)$ is the selectivity curve;

F_0 is the maximum value of $F(f)$ (assuming a single peak selectivity curve).

The power bandwidth is then, for $F_0 = 1$

$$\Delta f = \int_{-\infty}^{+\infty} F^2(f) df \quad (\text{A.7})$$

Taking $F(f)$ from Equation (A.3) and putting $G = 1$, we have:

$$\Delta f = \int_0^{\infty} 2 \left\{ \frac{2\omega_0^2}{[(\omega_0 + j\omega)^2 + \omega_0^2]^4} \right\} d\omega \quad (\text{A.8})$$

this leads to:

$$\Delta f = 0,265 \sqrt{2} \times \omega_0 = 0,375 \omega_0 \quad (\text{A.9})$$

thus:

$$B_3 = 0,963 \Delta f \quad (\text{A.10})$$

A.3 Response of the quasi-peak voltmeter detector to output of preceding stages

A.3.1 General

The calculation is made on the assumption that the connection of the detector circuits to the output of the last IF stages does not affect either the amplitude or the shape of the signal therefrom. In other words, the output impedance of this stage is regarded as negligible compared with the input impedance of the detector.

Any detector may be reduced to the form (actual or equivalent) of a non-linear element (for example a diode) in association with a resistance (total forward resistance S) and followed by a circuit consisting of a capacitance C in shunt with a discharge resistance R .

The electrical charge time constant T_C is related to the product $S \times C$, while the electrical discharge time constant T_D is given by the product $R \times C$.

The relationship between T_C and the product $S \times C$ will be established by obtaining, in a time $t = T_C$, an indicated voltage of 0,63 times the final steady value when a constant amplitude RF signal is suddenly applied.

The voltage U across the capacitor is related to the amplitude A of the RF signal applied to the detector by the equation:

$$\frac{dU}{dt} + UI(RC) = \frac{A(\sin \theta - \theta \cos \theta)}{\pi \times S \times C} \quad (\text{A.11})$$

where θ is the conduction angle ($U = A \cos \theta$).

This equation cannot be directly integrated. A value for the product $S \times C$, which, for the time constants chosen satisfies the above conditions, is found by methods of approximation, for example:

in Band A:	T_C	=	45 ms
	T_D	=	500 ms
	$2,81 S \times C$	=	1 ms
in Band B:	T_C	=	1 ms
	T_D	=	160 ms
	$3,95 S \times C$	=	1 ms
in Bands C and D:	T_C	=	1 ms
	T_D	=	550 ms
	$4,07 S \times C$	=	1 ms

By inserting the value thus obtained in Equation (A.11), this may be solved for either an isolated pulse or repeated pulses (again by methods of approximation) by introducing, in place of the constant amplitude A , the function $A(t)$ given by Equations (A.1) and (A.2).

This case of repeated pulses can be solved practically only by arbitrarily assuming a level for the output voltage of the detector at the start of each pulse, by determining the increment ΔU of this voltage caused by the pulse, and then finding the spacing which shall exist between two successive pulses in order to repeat the assumed initial conditions.

A.3.2 Response of the indicating instrument to the signal from the detector

The only simplifying, but perfectly legitimate, assumption is that the rising portion of the output voltage of the detector is instantaneous.

The following characteristic equation then has to be solved:

$$\frac{d^2 \alpha}{dt^2} + \left(\frac{2}{T_M} \frac{d\alpha}{dt} \right) + \frac{1}{T_M^2} \alpha = \left(\frac{1}{T_M^2} \right) e^{-t/T_D} \quad (\text{A.12})$$

where

$\alpha(t)$ is the instrument deflection;

T_D is the electrical discharge time constant of the quasi-peak voltmeter;

T_M is the mechanical time constant of the critically damped indicating instrument.

The solution of the problem is relatively simple for the two extremes of the response curve; on the one hand, for pulses sufficiently separated for the starting point to be zero and thus known, and on the other, for pulses having a sufficiently high repetition rate for the inertia of the instrument to prevent it following the fluctuations faithfully. For the intermediate cases, the calculation becomes more complicated. At the start of each pulse, the instrument deflection is varying and it is necessary to find a solution that takes account of the initial position and velocity.

A.4 Response of rms detector to output voltage of preceding stages

A.4.1 Output voltage and amplitude relationship

By definition, the output voltage of the rms detector is given by:

$$U_{\text{rms}} = \left[n \int_0^{+\infty} \frac{A^2(t)}{2} dt \right]^{1/2} \quad (\text{A.13})$$

where n is the pulse repetition frequency in Hz.

The output may also be deduced from the frequency response curve as:

$$U_{\text{rms}} = \left[n \int_{-\infty}^{+\infty} \frac{2v\tau \times F^2(f)}{2} df \right]^{1/2} \quad (\text{A.14})$$

where $v\tau$ is the area of pulse having a uniform frequency spectrum.

This gives:

$$U_{\text{rms}} = \left[\sqrt{2} \times v\tau \times \sqrt{n} \left[\int_{-\infty}^{+\infty} F^2(f) df \right] \right]^{1/2} \quad (\text{A.15})$$

Which, from Equation (A.7), gives:

$$U_{\text{rms}} = \sqrt{2} \times v\tau \times \sqrt{n} \times \sqrt{\Delta f} \quad (\text{A.16})$$

From Equation (A.16), the amplitude relationship may be deduced by taking:

$$U_{\text{rms}} = 2 \text{ mV, when } n = 100 \text{ Hz}$$

thus:

$$\nu\tau = \frac{100\sqrt{2}}{\sqrt{\Delta f}} \mu Vs \quad (A.17)$$

or from Equation (A.10):

$$\nu\tau = \frac{139}{\sqrt{B_3}} \mu Vs \quad (A.18)$$

A.4.2 Calculation of overload factor

The overload factor corresponding to a pulse repetition frequency of n Hz is calculated as follows.

From Equation (A.16):

$$U_{rms} = (\nu\tau) \times (2n\Delta f)^{1/2}$$

From Equations (A.1) and (A.2), and for $G = 1$:

$$A(t)_{peak} = 0,944 \times \nu\tau \times \omega_0$$

Thus the overload factor:

$$\frac{A(t)_{peak}}{\sqrt{2} \times U_{rms}} = 1,28 \left(\frac{B_3}{n} \right)^{1/2} \quad (A.19)$$

A.5 Relationship between indication of rms meter and quasi-peak meter

The amplitude relationship for the rms meter that states the value of pulse $(\nu\tau)_{rms}$ for the case of 100 Hz, which is equivalent to a sine-wave signal of 2 mV, is from Equation (A.18):

$$(\nu\tau)_{rms} = \frac{139}{\sqrt{B_3}} \mu Vs$$

For the selectivity characteristic quoted in Equation (A.3), this corresponds to:

$$(\nu\tau)_{rms} = \frac{155}{\sqrt{B_6}} \mu Vs$$

when reference is made to the bandwidth at 6 dB.

For the quasi-peak receiver, the value of pulse $(\nu\tau)_{qp}$, which is equivalent to a sine-wave signal of 2 mV, is as follows:

for the frequency range 0,15 MHz to 30 MHz:

$$(\nu\tau)_{qp} = 0,316 \mu\text{Vs}$$

for the frequency range 30 MHz to 1 000 MHz:

$$(\nu\tau)_{qp} = 0,044 \mu\text{Vs}$$

Thus for measuring receivers having band-pass characteristics according to Equation (A.3) and a bandwidth at 6 dB equal to the nominal bandwidths prescribed in Clauses 4, 5, 6 and 7 the following relationships for $(\nu\tau)_{rms}/(\nu\tau)_{qp}$ exist:

for the frequency range 0,15 MHz to 30 MHz:

$$\frac{(\nu\tau)_{rms}}{(\nu\tau)_{qp}} = 14,3 \text{ dB}$$

for the frequency range 30 MHz to 1 000 MHz:

$$\frac{(\nu\tau)_{rms}}{(\nu\tau)_{qp}} = 20,1 \text{ dB}$$

These relationships are valid for a pulse repetition frequency of 100 Hz. At other repetition frequencies, it is necessary to use the corresponding pulse response curves.

Annex B (normative)

Determination of pulse generator spectrum (See 4.4, 5.5, 6.5, 7.5)

B.1 Pulse generator

B.1.1 General

For checking compliance with the requirements of this standard, a pulse generator is needed. Compliance with the requirements of 4.4, 4.6, 5.5, 6.5 and 7.5 may be tested using the pulse generator technique.

For each frequency band of the measuring receiver under test, the generator used shall be capable of producing pulses with the impulse area specified and over the range of repetition frequencies given in Table B.1. The impulse area should be known within $\pm 0,5$ dB and the repetition frequency to within about 1 %.

Table B.1 – Pulse generator characteristics

Frequency band of receiver under test MHz	Impulse area μVs	Repetition frequency Hz
0,09 to 0,15	13,5	1, 2, 5, 10, 25, 60, 100
0,15 to 30	0,316	1, 2, 10, 20, 100, 1 000
30 to 300	0,044	1, 2, 10, 20, 100, 1 000
300 to 1 000	(see Note)	1, 2, 10, 20, 100, 1 000
The generator should be capable of producing pulses of adequate impulse area with a spectrum up to 1 000 MHz as uniform as possible.		

B.1.2 The spectrum of the generated pulses

The spectrum is defined by a curve that represents as a function of the tuned frequency of the receiver under test, the law of variation of the equivalent voltage at the input of a measuring apparatus having a constant bandwidth.

The spectrum should be substantially constant up to the upper limit of the frequency band of the receiver under test. The spectrum may be regarded as satisfactorily uniform if, within this band, the variation of the spectrum amplitude is not greater than 2 dB relative to its value for the lower frequencies within the band. The impulse area at the measurement frequency shall be known to within $\pm 0,5$ dB.

For checking compliance with the requirements of 4.6, the spectrum above the upper limit of the frequency band shall be limited (10 dB down at twice the upper frequency). This is necessary to standardize the severity of the test since the inter-modulation products of all components of the spectrum will contribute to the response.

B.2 General method of measurement

Methods for the accurate determination of the absolute value of the spectrum amplitude of pulses are given in Annex C.

For measurement of the variation of the spectrum amplitude with frequency, the following method may be used.

The pulse generator is connected to the input of an RF receiver followed by an oscilloscope connected so as to indicate the RF pulse at the output of the receiver.

At each frequency of tuning of the receiver, the following are measured:

- a) the bandwidth, B_6 Hz, of the receiver at the –6 dB points,
- b) the rms value, E_0 , of the output from a standard signal generator having the same impedance as the pulse generator and tuned to the mid-band of the receiver and producing on the oscilloscope a deflection equal in amplitude to the peak of the RF pulses.

The relative spectrum amplitude at each frequency is taken to be:

$$S_r(f) = \frac{E_0}{B_6}$$

The measurement is repeated for various test frequencies in the band under consideration.

The spectrum of the pulse generator is given by the curve relating $S_r(f)$ to the measurement frequency.

The receiver used should be linear for the peak levels of the signals used.

The suppression of parasitic responses, in particular the image frequency and IF responses, should be at least 40 dB.

The measurements may be made with a receiver conforming to the present specification, using the quasi-peak indicator in place of the oscilloscope, provided that the repetition frequency of the pulses is kept constant throughout the series of measurements.

Annex C (normative)

Accurate measurements of the output of nanosecond pulse generators (See 4.4, 5.5, 6.5, 7.5)

C.1 Measurement of impulse area (A_{imp})

C.1.1 General

Theoretical and practical investigations have shown that, when applied with reasonable care, accurate methods of measurement include those given in C.1.2 to C.1.5.

C.1.2 Area method

The pulses to be measured are fed through a narrow band filter whose passband is centred at frequency f having a symmetrical amplitude characteristic, and an asymmetrical phase characteristic (in conjunction with a filter, an amplifier may be used provided it is operated in its linear range).

The total area under the envelope $A(t, f)$ of the output from the band-pass filter (taking into account the sign of different parts of it) is measured, so as to evaluate the integral in the equation:

$$2(A_{\text{imp}}) = S(f) = \int_{-\infty}^{+\infty} A(t, f) dt \quad (\text{C.1})$$

where

$S(f)$ is the spectral intensity; and

$A(t, f)$ is the magnitude of the envelope due to a single isolated pulse (expressed in terms of equivalent input sine-wave voltage).

In applying this equation, the intermediate-frequency amplifier of a low-frequency receiver or a disturbance-measuring receiver is used together with a series of frequency converters to tune across the spectrum of the pulse. The output of the final intermediate-frequency amplifier is taken directly to an oscilloscope for the area measurement.

In a variation of this method for pulses of duration much shorter than the period of the frequency (f), the impulse area can be measured directly as an integrated area by means of a suitable oscilloscope (for example, for nanosecond pulses, a sampling oscilloscope is required), the integration taking into account the sign of different parts of the area.

C.1.3 Standard transmission line method

A transmission line of length corresponding to propagation time τ and charged to a voltage V_0 is discharged into a load resistance equal to the characteristic impedance of the line. The transmission line is considered to consist of the actual line as well as the charged section of the line contained in the switch housing. It has been found that spectral intensity, $S(f)$, has the value $2V_0\tau$ in the low-frequency portion of the spectrum of the resulting pulse in which the amplitude is constant with frequency, this amplitude being independent of the existence of certain stray impedances between the line and the load resistor (e.g. inductance or resistance) or of finite switching time.

C.1.4 Harmonic measurement

This method may be used for pulse generators producing a sequence of pulses with sufficiently high and stable repetition frequency.

When the pulse repetition frequency F exceeds the values of the bandwidth of the measuring receiver, the latter may select one line from the pulse spectrum. In this case, the impulse area may be determined as follows:

$$A_{\text{imp}} = \frac{V_K}{2F} = \frac{V\sqrt{2}}{2F} \quad (\text{C.2})$$

where $V_K = V\sqrt{2}$ is the peak value of the k -th harmonic.

The pulse generator may then be used to calibrate the pulse response characteristics of a measuring receiver in which the bandwidth is sufficiently wide to accept many harmonic components (approximately 10 or more within the 6 dB bandwidth).

C.1.5 Energy method

Another method compares the power produced by a thermal source (resistor) with that produced by the pulse generator. However, the accuracy obtained with this method is somewhat less than with the three methods mentioned above. This method may be useful at frequencies of the order of 1 000 MHz.

C.2 Pulse generator spectrum

C.2.1 To determine compliance with 4.4.1, 5.5, 6.5.2 and 7.5.2, the impulse area shall be known with an error not greater than $\pm 0,5$ dB.

C.2.2 The pulse repetition frequency shall be known with an error not greater than 1 %.

C.2.3 For determining compliance with 4.4.2, 5.5, 6.5.4 and 7.5.3, the impulse area shall not depend on their repetition frequency.

C.2.4 For determining compliance with 4.4, 5.5, 6.5 and 7.5, the generator frequency spectrum should be uniform over the passband of the measuring receiver. This requirement is considered fulfilled in the following cases:

- a) if variation of the frequency spectrum is substantially linear with respect to frequency within the frequency passband of the receiver, and the spectrum irregularity does not exceed 0,5 dB within the receiver passband measured at the -6 dB points;
- b) if the frequency spectrum is smoothly tapered on both sides from the tuning frequency of the receiver, and if the spectrum width at the -6 dB points is at least five times greater than the receiver passband at that level.

In both cases, the impulse area is assumed to be equal to its value at the tuning frequency.

Annex D (normative)

Influence of the quasi-peak measuring receiver characteristics on its pulse response (See 4.4.2)

The level of the pulse response curve for high repetition frequencies depends essentially on the magnitude of the bandwidth. On the other hand, for low repetition frequencies, the time constants play the more important role. No tolerance has been stated for these time constants, but it is suggested for guidance that a value of 20 % is considered reasonable.

It is also at very low repetition frequencies that the effect of lack of overload factors will be most noticeable. The values required for the overload factors are those necessary for the accurate measurement of an isolated pulse using the bandwidth and the time constants prescribed.

Examination of the pulse response-curve at the two ends of the range of the indicating instrument provides a check on possible non-linear behaviour of the detector. The most critical repetition frequencies in this respect are most probably in the neighbourhood of 20 Hz to 100 Hz.

Annex E (normative)

Response of average and peak measuring receivers (See 6.3.1)

E.1 Response of pre-detector stages

It is shown in [19] and [20] that the area under the envelope of the impulse response curve of a narrowband circuit having a symmetrical frequency characteristic is independent of the bandwidth, and is given by:

$$\int_{-\infty}^{+\infty} A(t) dt = 2\nu\tau G_0 \quad (\text{E.1})$$

where ν and τ are the amplitude and duration of a rectangular pulse for which $B_{\text{imp}} \tau \ll 1$ and G_0 is the gain of the circuit at the centre frequency.

This theorem is valid only in the case of a non-oscillating envelope. The oscillatory envelope is characteristic of double-tuned circuits, and unless a phase sensitive detector is used, it may be necessary to compensate by calibration the error introduced by the oscillatory response. In the case of critical coupling, the second peak of the envelope is about 8,3 % of the first one.

NOTE The response of the pre-detector stages as defined in A.2 is oscillatory. Therefore, the calibration error introduced by the oscillatory response is compensated with a biased tolerance of +2,5 dB/–0,5 dB in 6.5.2.

As long as pulses do not overlap in the output of the IF amplifier, the average value is proportional to the pulse repetition rate, n .

Therefore, the average voltage is equal to $2\nu\tau G_0 n$.

In view of Equation (E.1), it is not considered meaningful to define an effective bandwidth for an average measuring receiver.

E.2 Overload factor

For calculation of overload factor and for use in connection with peak measuring receivers, it is useful to define a quantity known as the effective impulse bandwidth of the pre-detector circuit as follows:

$$B_{\text{imp}} = \frac{A(t)_{\text{max}}}{2G_0} \quad (\text{E.2})$$

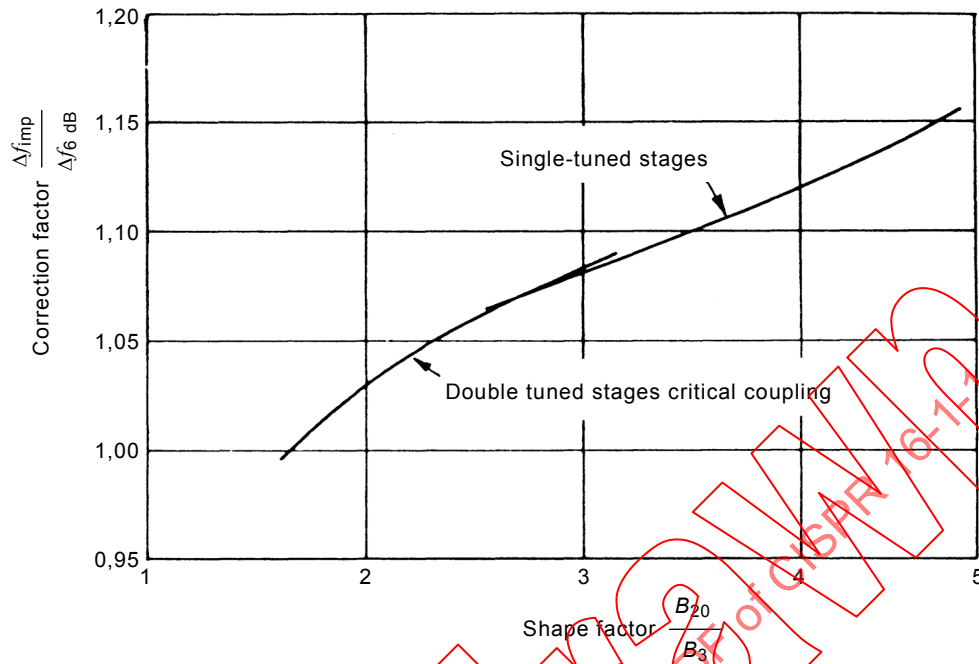
where $A(t)_{\text{max}}$ is the peak envelope output of the intermediate-frequency stages with a unit impulse applied.

From the work leading to Equation (A.19), we have:

$$B_{\text{imp}} = \left(\frac{0,944}{2} \right) \omega_0 = 1,05B_6 \text{ or } 1,31B_3 \quad (\text{E.3})$$

where B_6 and B_3 are defined in 3.6.

For other types of tuned circuits, the ratio of B_{imp} to B_6 may be estimated from Figure E.1 if the ratio of B_{20} to B_3 is known, where B_{20} is the bandwidth at 20 dB.



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Figure E.1 – Correction factor for estimating the ratio B_{imp}/B_6 for other tuned circuits

E.3 Relationship between indication of an average and a quasi-peak measuring receiver

At a repetition rate of n Hz, the value of impulse area required to produce a response on an average measuring receiver equivalent to the response to an unmodulated sine-wave signal at the tuned frequency of rms value 2 mV from a signal generator having the same output impedance as the pulse generator is:

$$\nu\tau = \frac{1,4}{n} \text{ mVs} \quad (\text{E.4})$$

At a repetition rate of 100 Hz, $\nu\tau$ is 14 μVs .

Therefore, from A.5 the ratio of $(\nu\tau)_{\text{ave}}$ to $(\nu\tau)_{\text{qp}}$ to produce the same indication will be:

for the frequency range 0,15 MHz to 30 MHz:

$$\frac{(\nu\tau)_{\text{ave}}}{(\nu\tau)_{\text{qp}}} = 32,9 \text{ dB}$$

for the frequency range 30 MHz to 1 000 MHz:

$$\frac{(\nu\tau)_{\text{ave}}}{(\nu\tau)_{\text{qp}}} = 50,1 \text{ dB}$$

The above assumes adequate overload factor at the repetition rate in question, and that the bandwidths in use correspond respectively to those in Clause 4. At a repetition rate of 1 000 Hz, the corresponding ratios will be 17,4 dB and 38,1 dB.

E.4 Peak measuring receivers

Where a direct-reading meter is used in the receiver, the requirement for time constants can be determined from the curve in Figure E.2, which shows the percentage of the reading referred to the true peak in function of a parameter and which includes the time constants ratio, the bandwidth B_6 and the pulse repetition rate. In using this curve, it should be noted that:

$$\frac{R_C}{R_D} = \frac{1}{4} \left(\frac{T_C}{T_D} \right) \quad (\text{E.5})$$

where T_C and T_D are respectively the charge and discharge time constants.

For example, if it is desired to have the receiver read at least 90 % of true peak at a repetition rate of 1 Hz, it would be necessary to have a discharge-time constant to charge time constant ratio of:

$1,25 \times 10^6$ in the frequency range 0,15 MHz to 30 MHz;

$1,67 \times 10^7$ in the frequency range 30 MHz to 1 000 MHz.

E.5 Relationship between indication of a peak and a quasi-peak measuring receiver

The value of impulse area, A_{imp} , required to produce a response on a peak measuring receiver equivalent to the response to an unmodulated sine-wave signal at the tuned frequency of rms value 2 mV is:

$$\frac{1,4}{B_{\text{imp}}} \text{ mVs (with } B_{\text{imp}} \text{ in Hz)} \quad (\text{E.6})$$

From the 6 dB bandwidths specified in Table H.1, the B_{imp} values are obtained as $1,05B_6$ (see E.2). These values and the corresponding A_{imp} values required for a peak meter are shown in Table E.1.

Table E.1 – B_{imp} and A_{imp} values for a peak measuring receiver

Frequency	$A_{\text{imp,peak}}$ mVs	B_{imp} Hz
Band A	$6,67 \times 10^{-3}$	$0,21 \times 10^3$
Band B	$0,148 \times 10^{-3}$	$9,45 \times 10^3$
Bands C and D	$0,011 \times 10^{-3}$	126×10^3

Therefore, using the values given as a) in Table 1 for $A_{\text{imp, qp}}$, the ratio of $A_{\text{imp, qp}}$ to $A_{\text{imp, peak}}$ to produce the same indication is:

For Band A 6,1 at 25 Hz pulse repetition frequency;
 For Band B 6,6 at 100 Hz pulse repetition frequency;
 For Bands C and D 12,0 at 100 Hz pulse repetition frequency.

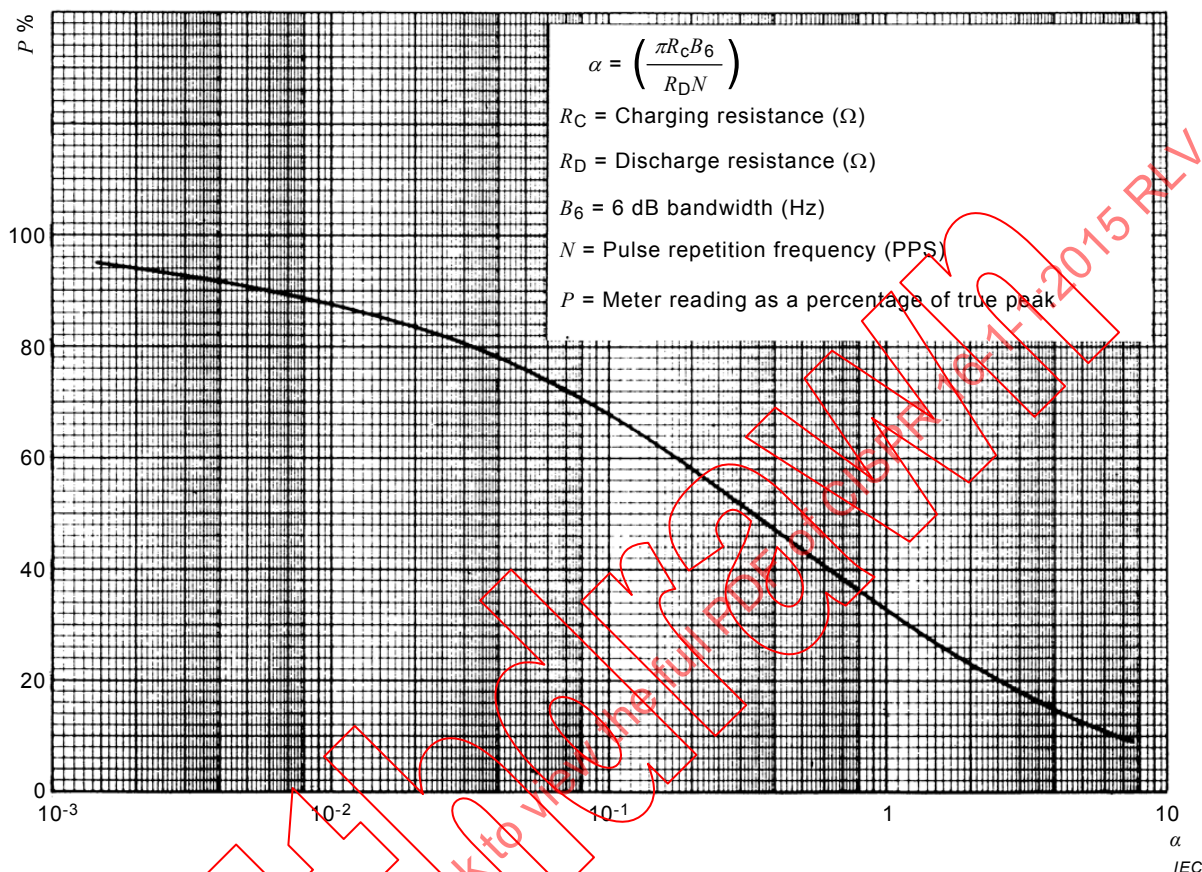


Figure E.2 – Pulse rectification coefficient P

E.6 Test of measuring receiver response above 1 GHz to pulses

Pulse generators with a uniform spectrum up to 18 GHz are not feasible. To test the response of measuring receivers above 1 GHz to pulses and to verify the amplitude relationship of various types of measuring receivers, it is practical to use a pulse-modulated carrier tuned to the receive frequency. The pulse width shall be less than or equal to $(1/3 B_{\text{imp}})$. The accuracy of the impulse width is important for the precise generation of a certain impulse area as required in the relevant subclause. In addition to a measurement of the pulse duration using an oscilloscope, the pulse duration of a rectangular pulse can be verified by the distance between the minima on the spectrum display (see Figure E.3 for a sample waveform).

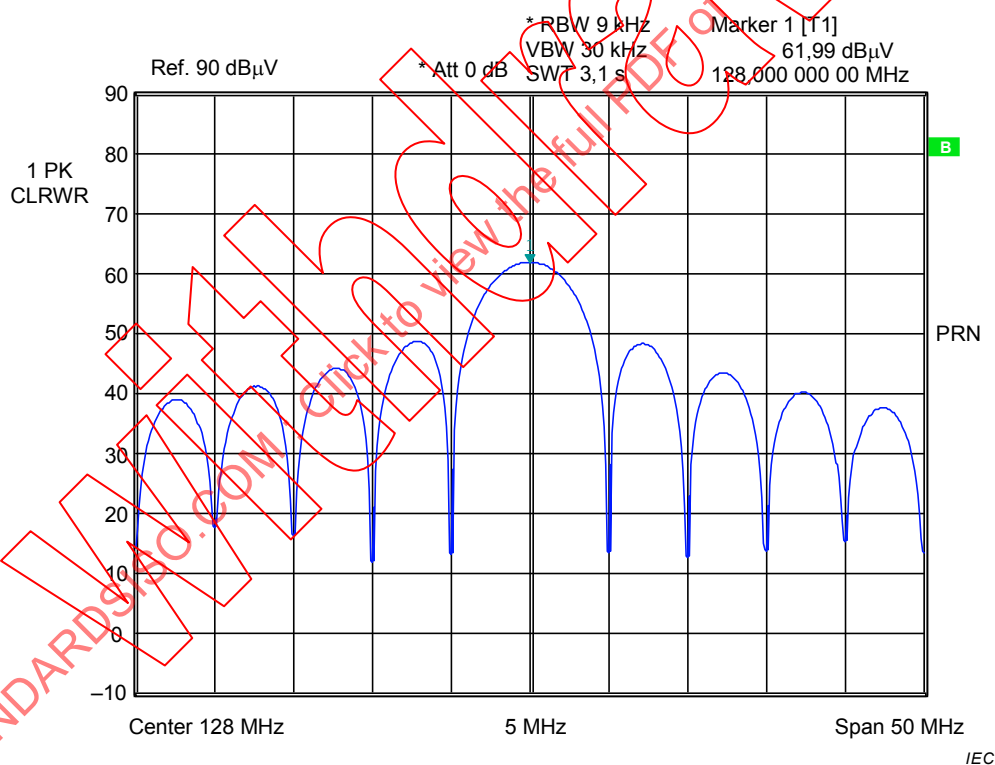
For the measuring receiver with a peak detector with a bandwidth B_{imp} of 1 MHz, an impulse area (e.m.f.) of $1,4/ B_{\text{imp}}$ mVs is required, that is, 1,4 nVs for a response equal to that of an unmodulated sine-wave signal tuned to the receive frequency having an e.m.f. with rms value of 2 mV [66 dB(μ V)]. A pulse-modulated carrier having the required impulse area can be generated with the various pulse widths as shown in Table E.2.

Table E.2 – Carrier level for pulse-modulated signal of 1,4 nVs

Pulse width w_p/ns	Carrier level (e.m.f.) $L_{\text{carrier}}/\text{dB}(\mu\text{V})$
100	86
200	80

For a measuring receiver with a linear average detector, the impulse area (e.m.f.) equal to an unmodulated sine-wave signal at the receive frequency having an e.m.f. with rms value of 2 mV [66 dB(μV)] shall be $1,4/n$ mVs (n being the pulse repetition rate). For $n = 50\,000$, the impulse area is 28 nVs, that is, 26 dB higher than for the peak measuring receiver with a B_{imp} of 1 MHz.

For a measuring receiver with an rms detector, the impulse area (e.m.f.) equal to an unmodulated sine-wave signal at the receive frequency having an e.m.f. with rms value of 2 mV [66 dB(μV)] shall be $44(B_3^{-1/2})$ μVs for pulse repetition rate of 1 kHz. For an impulse bandwidth B_{imp} of 1 MHz, the corresponding B_3 is 700 kHz. Therefore, the required impulse area is 52,6 nVs, that is, 31,5 dB higher than for the peak measuring receiver with a B_{imp} of 1 MHz.

**Figure E.3 – Example (spectrum screenshot) of a pulse-modulated signal with a pulse width of 200 ns**

E.7 Measurement of the impulse bandwidth of a measuring receiver

E.7.1 General

The impulse bandwidth B_{imp} of a measuring receiver is defined as the peak value U_p (measured by the receiver) divided by the pulse spectral density D of the test pulse:

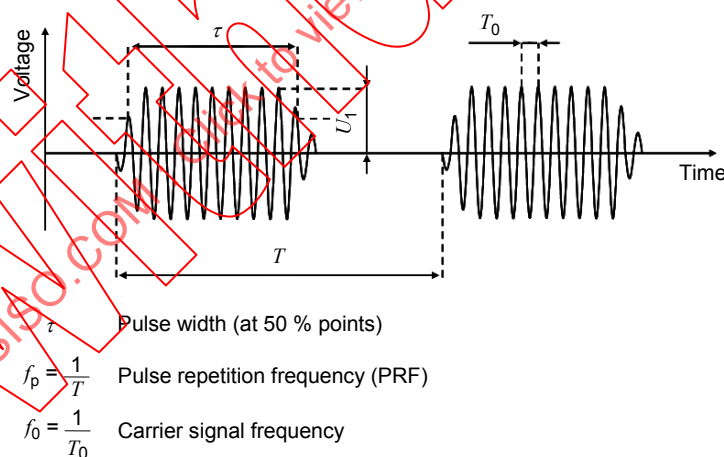
$$B_{\text{imp}} = \frac{U_p}{D} \quad (\text{E.7})$$

If U_p is measured in μV and D is given in $\mu\text{V}/\text{MHz}$, then B_{imp} will result in units of MHz. Both quantities, U_p and D , are assumed to be calibrated in rms values of an unmodulated sine wave signal, which is the case for CISPR measuring receivers.

The pulse spectral density D will frequently not be available as a precise reference quantity. In order to reduce the uncertainty of the impulse bandwidth measurement, Methods 1 and 2 are using two measurements. Under certain circumstances, the selectivity curve of a measuring receiver can also be used to calculate B_{imp} (as described in method 3), since B_{imp} is the “voltage bandwidth” of the measuring receiver (not to be confused with the power bandwidth or equivalent noise bandwidth, which determines the rms value of Gaussian noise when using the rms detector of the measuring receiver). B_{imp} is determined by the selectivity curve of the IF filter, the (possibly non-linear) phase response of the filter and the video bandwidth of the receiver. It is wider than B_6 , but there is no general factor for the relationship between B_{imp} and B_6 or B_3 of the receiver.

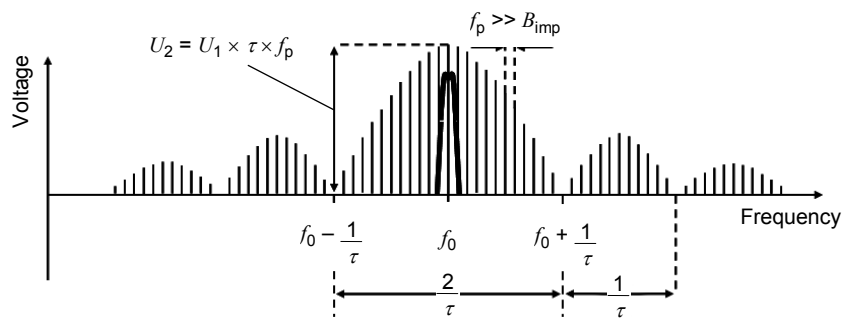
E.7.2 Method 1: Measurement by comparison of the responses of B_{imp} to two pulses with identical amplitude and width but with low and high pulse repetition frequencies (prf)

This method applies a pulse-modulated RF signal, with short pulse duration as shown in Figure E.4 and two different prfs. With the high prf ($f_p \gg B_{\text{imp}}$), the receiver can be tuned to the carrier frequency as shown in Figure E.5 and with the low prf f_p ($f_p \ll B_{\text{imp}}$), the spectrum will appear as a broadband signal as in Figure E.6. with a pulse spectral density of $D = U_1 \times \tau$. The pulse shape (amplitude U_1 and duration τ) has to be independent of the prf. For $B_{\text{imp}} = 1 \text{ MHz}$, f_{p1} could be selected to be 30 MHz and f_{p2} could be 30 kHz.



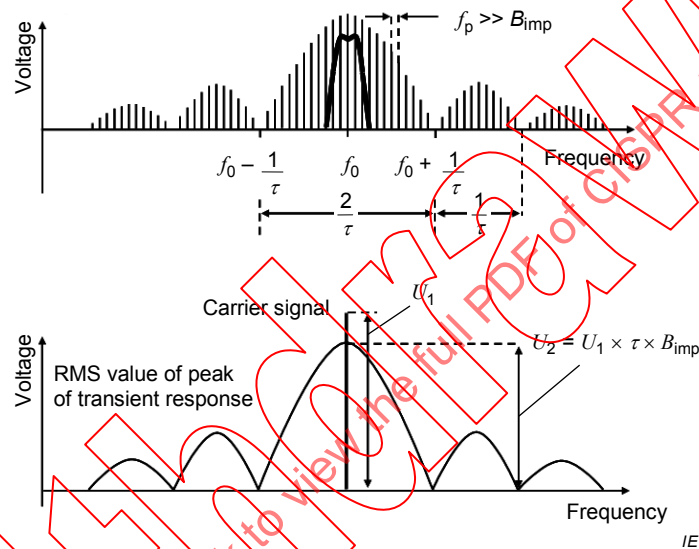
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Figure E.4 – Pulse-modulated RF signal applied to a measuring receiver



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Figure E.5 – Filtering with a B_{imp} much smaller than the prf



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Figure E.6 – Filtering with a B_{imp} much wider than the prf

With the first measurement, the rms amplitude U_2 can be expected as $U_2 = U_1 \times \tau \times f_{p1}$. Low measurement uncertainty can be achieved by a high signal-to-noise ratio. But care shall be taken to avoid overload. With the second measurement, the maximum response of the rms value of the peak to the transient can be expected as $U_p = U_1 \times \tau \times B_{\text{imp}}$. If the product $U_1 \times \tau$ is perfectly equal in both measurements, then B_{imp} can be calculated from the two measurement results as shown in Figure E.7 using Equation (E.2):

$$B_{\text{imp}} = f_{p1} \times \frac{U_p}{U_2} \quad (\text{E.8})$$

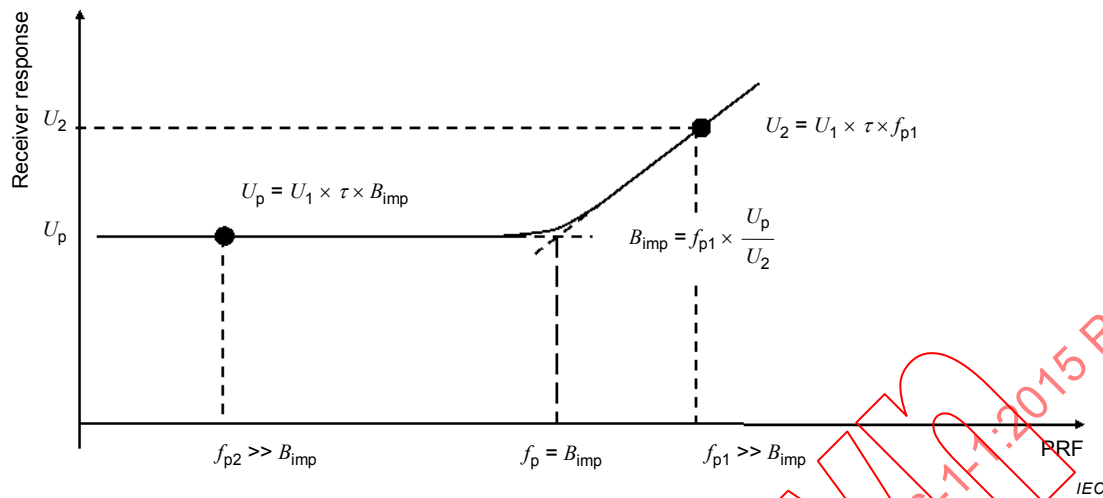


Figure E.7 – Calculation of the impulse bandwidth

E.7.3 Method 2: Measurement by comparison of the response of B_{imp} to an impulsive signal with the response of a narrow bandwidth to the same signal

If a pulse generator that retains a constant amplitude, independent of the selected prf, is not available, method 2 can be applied with a relatively low prf. It is based on the same principle as method 1, measurement. However, instead of using a high prf signal, the second measurement is made with a filter much narrower than the prf. The method is also described in C.1.5.

This method determines the pulse spectral density D using the equation $D = U_k / f_p$, where U_k is the measured voltage of one spectral line (i.e. the carrier frequency, if the signal is a pulse-modulated carrier, or the center line at the receive frequency, at which B_{imp} is to be measured) and f_p is the prf. Again, f_p shall be much higher than the narrow bandwidth and much lower than the B_{imp} to be measured, i.e. $B_{\text{narrow}} \ll f_p \ll B_{\text{imp}}$. Example settings could be $B_{\text{narrow}} = 9 \text{ kHz}$, $f_p = 100 \text{ kHz}$ for $B_{\text{imp}} = 1 \text{ MHz}$. The method requires a comparison of the responses of the narrowband filter and of the filter to be measured by applying an unmodulated sinewave signal to both filters and deriving a correction factor c for the calculation of D ($c = U_2 / U_1$, with U_2 being the value for the wide filter and U_1 being the value for the narrow filter). Therefore $D = c \times U_k / f_p$. When D is determined, U_p is measured with the peak detector and B_{imp} can be calculated using Equation (E.2).

E.7.4 Method 3: Integration of the normalized linear selectivity function

This method has the advantage of high precision and is applicable for filters with a perfectly linear selectivity function (e.g. digital filters, or per specification by the manufacturer) and where the video bandwidth is much wider (e.g. 10 times) than the impulse bandwidth ($B_{\text{video}} \gg B_{\text{imp}}$).

In this case, the impulse bandwidth of a measuring receiver is defined as the area of the normalized linear selectivity function $U(f)$, with $1/U_{\text{max}}$ as the normalization factor:

$$B_{\text{imp}} = \frac{1}{U_{\text{max}}} \int_{-\infty}^{+\infty} U(f) df \quad (\text{E.9})$$

Measuring receivers with high-resolution digital frequency displays can be tuned in N steps of Δf to measure the selectivity function $U(f_n)$. Measurements between the 60 dB points with 100 steps ($N = 101$) are usually sufficient for a correct bandwidth measurement. Analogous, a swept receiver can be set up such that its start and stop frequencies coincide with the 60 dB points of the filter curve and a sweep is taken to obtain the amplitude values. The test signal

will be a CW signal to trace out the filter shape of the filter under investigation. In this case, the impulse bandwidth can be measured and calculated using

$$B_{\text{imp}} = \frac{1}{U_{\text{max}}} \sum_{n=1}^N [U(f_n) + U(f_{n+1})] \times \frac{\Delta f}{2} \quad (\text{E.10})$$

Figure E.8 depicts an example of a normalized linear 1 MHz selectivity function.

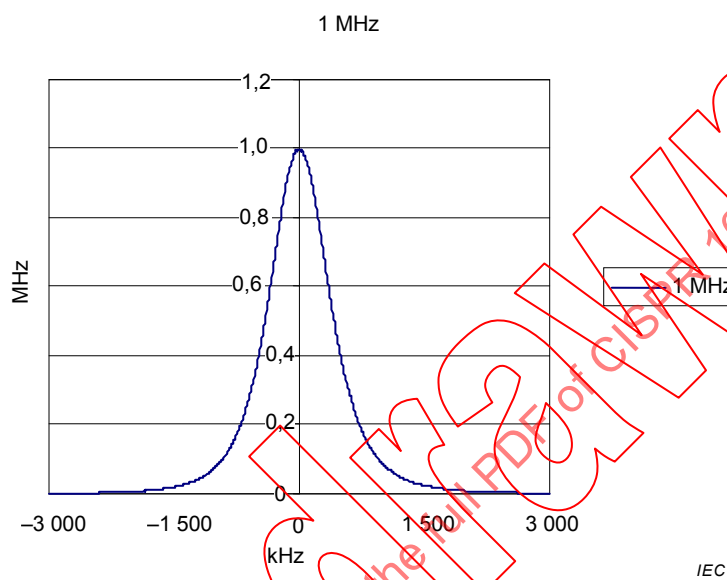


Figure E.8 – Example of a normalized linear selectivity function

Annex F (normative)

Performance check of the exceptions from the definitions of a click according to 4.2.3 of CISPR 14-1:2005

For the application of the exceptions given in CISPR 14-1, the disturbance analyzer shall provide the following additional information (refer to Table F.1 for test details):

- a) the number of clicks of duration equal to or less than 10 ms;
- b) the number of clicks of duration greater than 10 ms but equal to or less than 20 ms;
- c) the number of clicks of duration greater than 20 ms but equal to or less than 200 ms;
- d) the duration of each registered disturbance the amplitude of which exceeds the QP level limit for continuous disturbance;
- e) an indication that the appliance failed the test, if it is clear that it produces disturbances other than clicks not corresponding to the definition of a click and to which none of the exceptions can be applied;
- f) the time interval from the start of the test to the occurrence of disturbances; mentioned under e);
- g) the total duration of disturbances other than clicks the QP level limit of which exceeds the limit for continuous disturbance;
- h) the click rate.

Table F.1 – Disturbance analyzer test signals ^a (1 of 5)

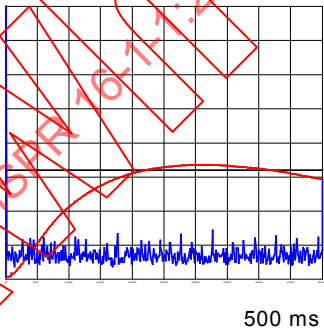
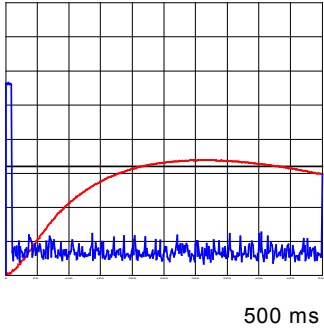
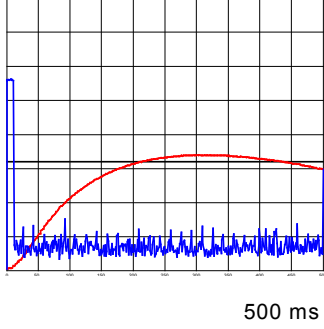
Test No.	Test signal parameters					Graphical presentation of the test signal measured in the IF output and the associated QP signal relative to the reference indication of the measurement receiver
	1		2		3	
	QP Amplitude of impulses adjusted individually relative to QP reference indication of the measurement receiver dB		Duration of impulses ^b adjusted in the intermediate frequency output of the measurement receiver ms		Separation of impulses or periodicity (IF-output) ms	
	Pulse 1	Pulse 2	Pulse 1	Pulse 2		
1	1		0,11			1 click ≤10 ms 
2	1		9,5			1 click ≤10 ms 
3	1		10,5			1 click >10 ms, ≤20 ms 

Table F.1 (2 of 5)

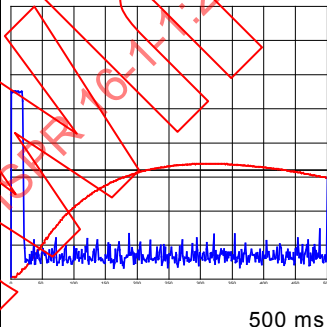
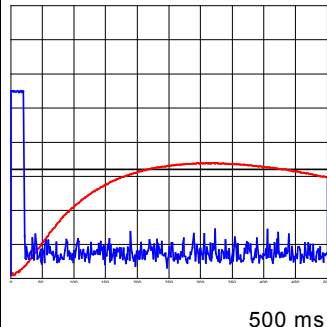
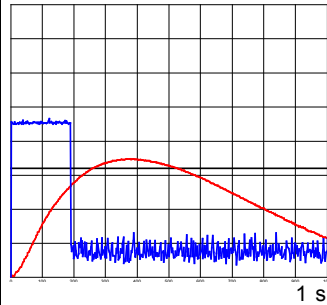
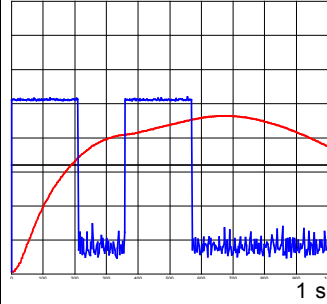
Test No.	Test signal parameters					Graphical presentation of the test signal measured in the IF output and the associated QP signal relative to the reference indication of the measurement receiver
	1		2		3	
	QP Amplitude of impulses adjusted individually relative to QP reference indication of the measurement receiver dB		Duration of impulses ^b adjusted in the intermediate frequency output of the measurement receiver ms		Separation of impulses or periodicity (IF-output) ms	
	Pulse 1	Pulse 2	Pulse 1	Pulse 2		
4	1		19			1 click >10 ms, ≤20 ms 
5	1		21			1 click >20 ms 
6	1		190			1 click >20 ms 
7	5	5	210	210	150	IF only once per program cycle or per minimum observation time: counted as 1 click >20 ms (See E2 and Note 1 of this table, 600 ms rule) 
						OTHERWISE Continuous disturbance (570 ms)

Table F.1 (3 of 5)

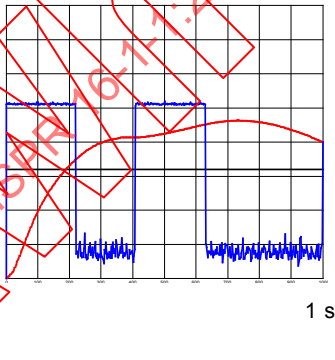
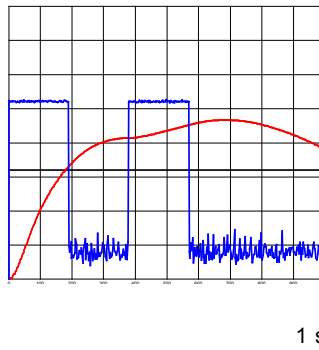
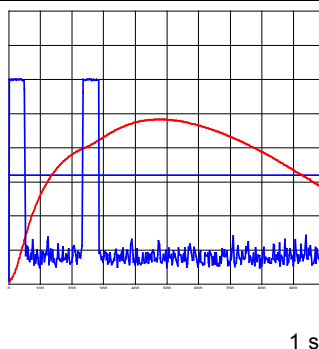
Test No.	Test signal parameters					Graphical presentation of the test signal measured in the IF output and the associated QP signal relative to the reference indication of the measurement receiver
	1		2		3	
	QP Amplitude of impulses adjusted individually relative to QP reference indication of the measurement receiver dB		Duration of impulses ^b adjusted in the intermediate frequency output of the measurement receiver ms		Separation of impulses or periodicity (IF-output) ms	
	Pulse 1	Pulse 2	Pulse 1	Pulse 2		
8	5	5	220	220	190	FAIL Continuous disturbance (See E2 and Note 1 of this table: no exception is applicable because the total duration is 630 ms > 600 ms) 
9	5	5	190	190	190	IF the final click rate is less than 5: 2 clicks >20 ms (See E4 and Note 1 of this table; refrigerator rule; also see Note 2 of this table) 
						OTHERWISE IF only once per program cycle or once during the minimum observation time: counted as 1 click >20 ms (see E2 and Note 1 of this table) OTHERWISE Fail: continuous disturbance (570 ms)
10	5	5	50	50	185	IF the final click rate is less than 5: 2 clicks >20 ms (See E4 and Note 1 of this table; also see Note 2 of this table) 

Table F.1 (4 of 5)

Test No.	Test signal parameters						
	1		2		3	4	5
	QP Amplitude of impulses adjusted individually relative to QP reference indication of the measurement receiver dB		Duration of impulses ^b adjusted in the intermediate frequency output of the measurement receiver ms		Separation of impulses or periodicity (IF-output) ms	Evaluation by the analyzer	Graphical presentation of the test signal measured in the IF output and the associated QP signal relative to the reference indication of the measurement receiver
	Pulse 1	Pulse 2	Pulse 1	Pulse 2			
						OTHERWISE IF not more than once per program cycle or during the minimum observation time: counted as 1 click < 600 ms (See E2 and Note 1 of this table, 2 × 285 ms > 20 ms) OTHERWISE fail: continuous disturbance (285 ms)	
11	20	20	15	5	1 × Pulse 1 + 9 × Pulse 2, repeated until 40 clicks are registered, where the separation between each impulse is 13 s	36 clicks < 10 ms 4 clicks > 10 ms, ≤ 20 ms ≥ 90 % of the clicks < 10 ms PASS (see E3, Note 1 and Note 3 of this table; a measurement of the click amplitudes is <u>not</u> required.)	
12	20	20	15	5	1 × Pulse 1 + 8 × Pulse 2, repeated until 40 clicks are registered, where the separation between each impulse is 13 s	35 clicks ≤ 10 ms 5 clicks > 10 ms, ≤ 20 ms < 90 % of the clicks ≤ 10 ms (see E3, Note 1 and Note 3 of this table. No exception is applicable. After application of upper quartile method the final result will be “FAIL” because the click amplitudes are too high.)	

Table F.1 (5 of 5)

CISPR 14-1:2005, 4.2.3, contains the following exceptions:

- E1 – “Individual switching operations”
This exception can be evaluated only by the operator, not automatically by the disturbance analyzer. It is mentioned here to avoid confusion with the numbering of the exceptions for users of both this standard and CISPR 14-1.
- E2 – “Combination of clicks in a time frame less than 600 ms” (“600 ms rule”)
In program-controlled appliances, a combination of clicks in a time frame less than 600 ms is allowed once per selected program cycle. For other appliances such a combination of clicks is allowed once during the minimum observation time. This is also valid for thermostatically controlled three-phase switches, causing three disturbances sequentially in each of the three phases and the neutral. The combination of clicks is considered as one click.
- E3 – “Instantaneous switching”
Appliances which fulfil the following conditions:
 - the click rate is not more than 5,
 - none of the caused clicks has a duration longer than 20 ms, and
 - 90 % of the caused clicks have a duration less than 10 ms,
 shall be deemed to comply with the limits, independent of the amplitude of the clicks. If one of these conditions is not satisfied then the limits for discontinuous disturbance apply.
- E4 – “Separation of clicks less than 200 ms” (refrigerator rule)
For appliances which have a click rate less than 5, any two disturbances each having a maximum duration of 200 ms, shall be evaluated as two clicks even when the separation between the disturbances is less than 200 ms. In this case, for instance observed with refrigerators, such a configuration has to be evaluated as two clicks and not as a continuous disturbance.

NOTE 1 The analyzer has to apply exception E2 only if E4 is not applicable.

NOTE 2 The check wave forms 11 and 12 can pass the test only in case exception E3 can be applied, as the following calculation shows:

- Including the click at “0” seconds for the check waveforms 11 and 12, the required 40 clicks are counted after $13 \text{ s} \times 39 = 507 \text{ s}$, i.e. 8,45 min. The click rate is $40 / 8,45 = 4,734$ (less than 5 as required – here all depends on whether 90 % are $\leq 10 \text{ ms}$ or not).

NOTE 3 The relaxation of the limit for the clicks according to CISPR 14-1 is: $20 \times \log(30 / 4,734) = 16,04 \text{ [dB]}$. Therefore the check waveforms 11 and 12 (amplitude 20 dB over the limit) never can pass the upper quartile check according to CISPR 14-1:2005, which means that no more than 25 % of the clicks are allowed to exceed the click limit.

^a Test signals used for the performance check with the evaluation of the exceptions from the definition of a click according to CISPR 14-1:2005, 4.2.3.

^b The rise times of the pulses shall not be longer than 40 μs .

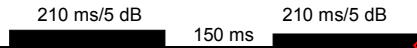
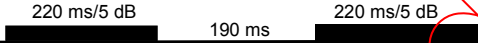
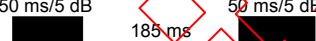
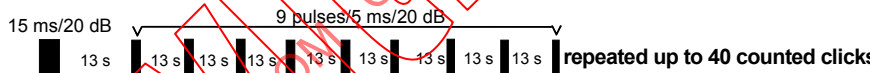
	9,5 ms/1 dB	1 click ≤10 ms
	10,5 ms/1 dB	1 click >10 ms, ≤20 ms
	19 ms/1 dB	1 click >10 ms, ≤20 ms
	21 ms/1 dB	1 click >20 ms
	190 ms/1 dB	1 click >20 ms
		1 click ≤600 ms (DUT programme-controlled)
		Continuous ≥600 ms
		1 click ≤600 ms (counted as 2 clicks refrigerator rule)
		for N <5 - 2 clicks for N ≥5 - continuous, or 1 click ≤600 ms for programme controlled DU
		36 clicks ≤10 ms 4 clicks >10 ms, ≤20 ms
		35 clicks <10 ms 5 clicks >10 ms, ≤20 ms

Figure F.1 – A graphical presentation of the test signals used for the performance check of the analyzer with the additional requirements according to Table F.1

Figure F.1 – A graphical presentation of the test signals used for the performance check of the analyzer with the additional requirements according to Table F.1

Annex G (informative)

Rationale for the specifications of the APD measuring function

The specifications are based on the following definitions and considerations:

a) Dynamic range of the amplitude

The dynamic range of the amplitude is defined as the range necessary to obtain the APD. The upper limit of the dynamic range shall be greater than the peak level of disturbance to be measured and the lower limit shall be lower than the level of disturbance limit specified by the product committees.

According to CISPR 11, the peak limit for group 2, class B, for ISM equipment is set at 110 dB(μV/m), and the weighted limit is specified as 60 dB(μV/m). Therefore, a dynamic range of greater than 60 dB is proposed, with a 10 dB margin.

b) Sampling rate

Ideally, the APD of disturbances is measured using the equivalent bandwidth of the radio service to be protected. However, the spectrum analyzer's resolution bandwidth is specified as 1 MHz for the frequency range above 1 GHz. The sampling rate shall therefore be greater than 10 million samples per second.

c) Maximum measurable time

CISPR 11 specifies the maximum hold time as a 2 min period for peak measurements of microwave cooking appliances above 1 GHz. Therefore, the measurable time for an APD measurement shall be 2 min minimum. Because the size of the counter or memory is limited, continuous measurements may be difficult for long measurement periods. Therefore, intermittent measurements are allowed under the condition that the dead time is less than 1 % of the total measurement time.

d) Minimum measurable probability

About 100 occurrences may be necessary to obtain a meaningful result. Therefore, the minimum measurable probability is calculated as follows:

assuming 2 min for the measuring time and a 10-million-samples-per-second sampling rate, the probability is determined as:

$$100/(120 \times 10 \times 10^6) \pm 10^{-7}$$

e) Display of APD measurement data

The amplitude resolution for the display of APD results depends on the dynamic range and the resolution of the A/D converter. For example, the resolution of the display comes to less than 0,25 dB (± 60 dB/256) when an 8-bit A/D converter is applied to a dynamic range of 60 dB.

Figures G.1 and G.2 show block diagrams of implementations of the APD measurement function.

An example of an APD measurement result is depicted in Figure G.3.

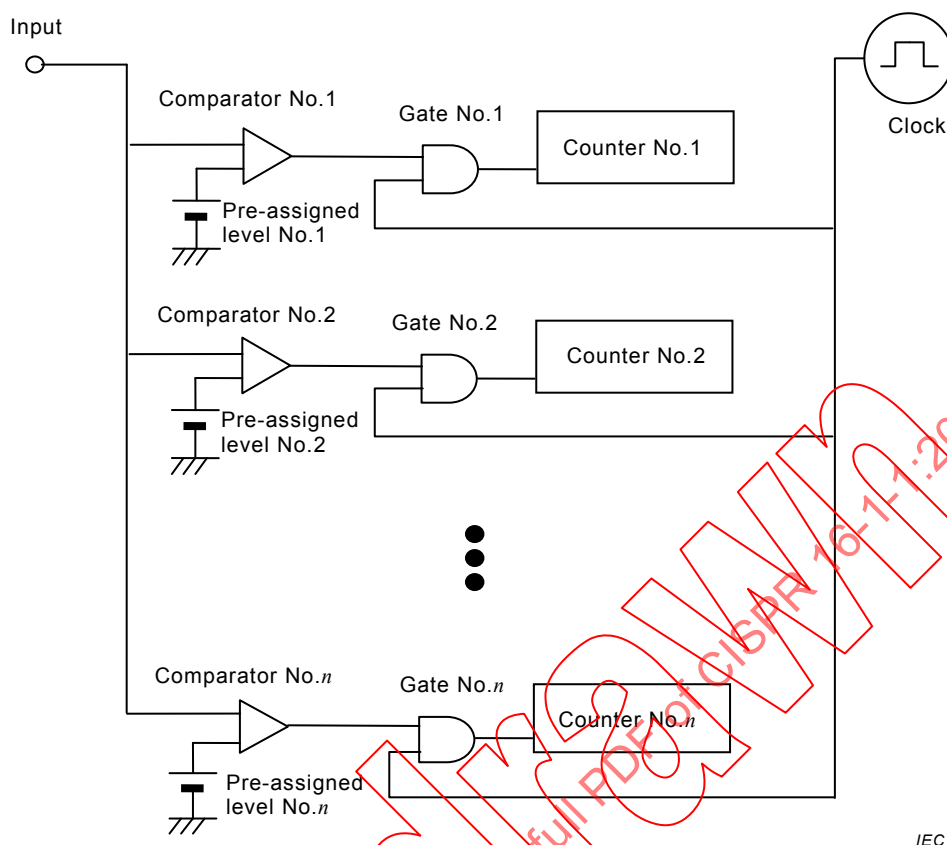


Figure G.1 – Block diagram of APD measurement circuit without A/D converter

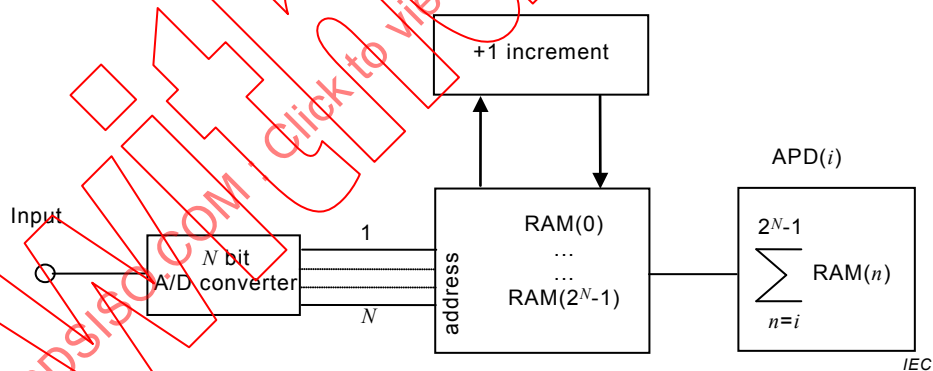


Figure G.2 – Block diagram of APD measurement circuit with A/D converter

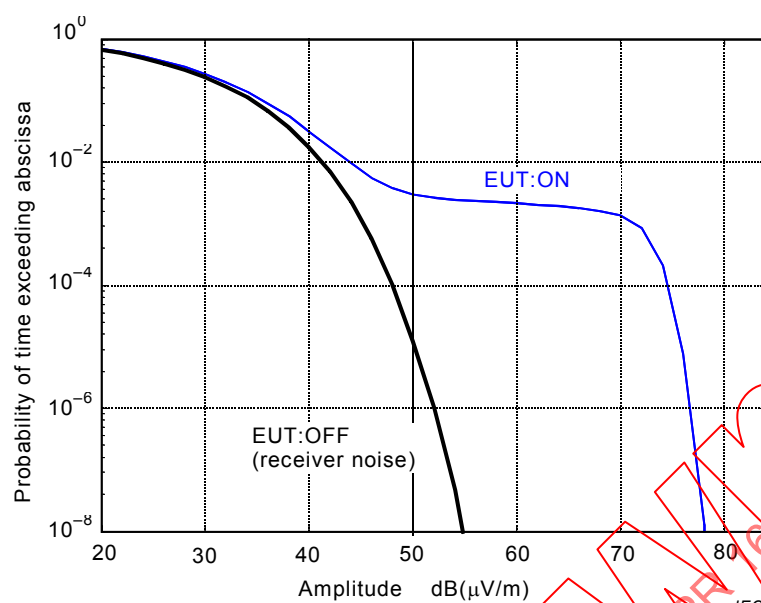


Figure G.3 – Example of display of APD measurement

Annex H (informative)

Characteristics of a quasi-peak measuring receiver

Table H.1 provides specifications of a quasi-peak measuring receiver. These specifications describe the overall characteristics of such an instrument and do not describe the specification of individual components and subassemblies of the instrument. The responses to pulses as specified in 4.4 are calculated on the basis of the measuring receivers having the following fundamental characteristics.

Table H.1 – Characteristics of quasi-peak measuring receivers

Characteristics	Frequency band		
	Band A 9 kHz to 150 kHz	Band B 0,15 MHz to 30 MHz	Bands C and D 30 MHz to 1 000 MHz
Bandwidth at the –6 dB points, B_6 in kHz	0,20	9	120
Detector electrical charge time constant, in ms	45	1	1
Detector electrical discharge time constant, in ms	500	160	550
Mechanical time constant of critically damped indicating instrument, in ms	160	160	100
Overload factor of circuits preceding the detector, in dB	24	30	43,5
Overload factor of the d.c. amplifier between detector and indicating instrument, in dB	6	12	6
NOTE 1 The definition of mechanical time constant (see 3.8) assumes that the indicating instrument is linear, i.e. equal increments of current produce equal increments of deflection. An indicating instrument having a different relation between current and deflection can be used provided that the instrument satisfies the requirements of this subclause. In an electronic instrument, the mechanical time-constant can be simulated by a circuit. NOTE 2 No tolerance is given for the electrical and mechanical time constants. The actual values used in a specific receiver are determined by the design to meet the requirements in 4.4.			

Annex I (informative)

Example of EMI receiver and swept spectrum analyzer architecture

This annex provides a brief description of the main differences between “EMI receivers” and “swept spectrum analyzers”, as far as this standard is concerned. Figure I.1 illustrates an example of the architecture of both types of instruments. The parts shaded in grey are typically implemented in test instrumentation to achieve compliance with specifications called out in this standard.

NOTE Additional background information is currently in preparation for CISPR 16-3.

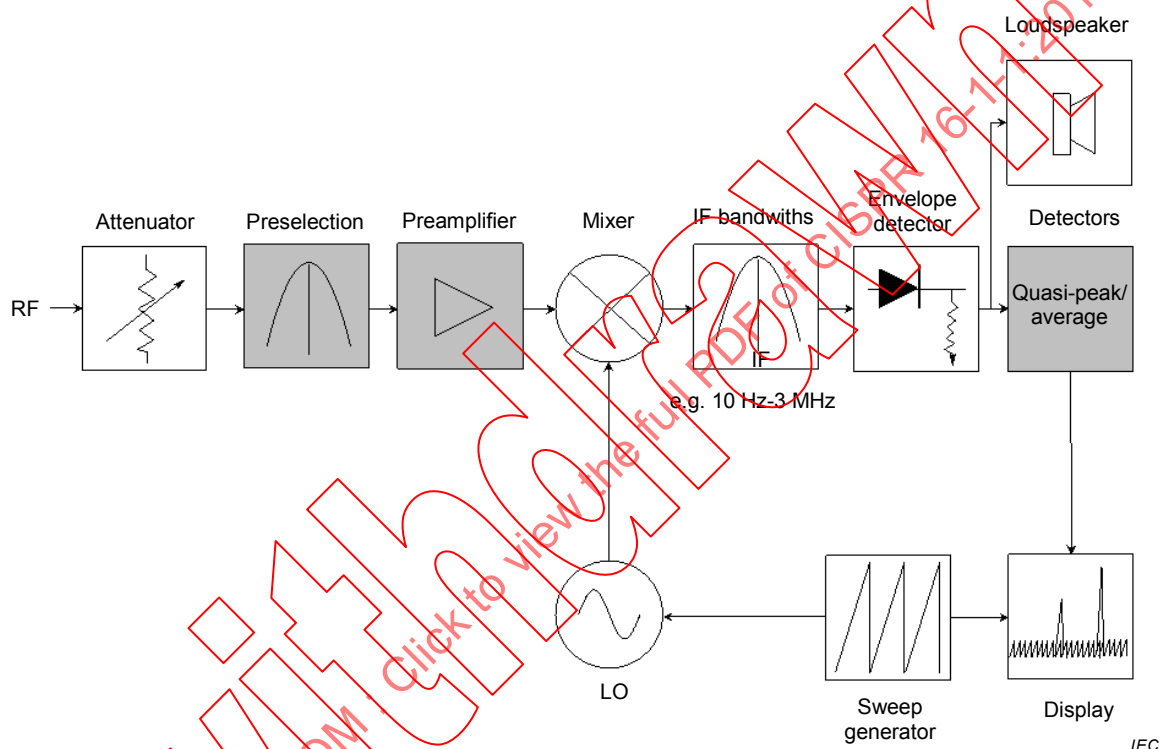


Figure I.1 – Example block diagram of EMI receiver consisting of swept spectrum analyzer with added preselector, preamplifier and quasi-peak/average detector

The main differences between the two instrument types are described below.

- Swept spectrum analyzers are scanning instruments, which tune their local oscillator (LO) frequency continuously to cover the selected frequency range of interest. Some EMI receivers perform a stepped sweep, i.e. the instrument is tuned to fixed frequencies, in defined frequency step sizes, to cover the frequency range of interest. The amplitude at each tuning frequency is measured and retained for further processing or display.
- Most swept spectrum analyzers do not have preselection (i.e. filtering at the input) built into the instrument before the first frequency conversion stage. This usually results in an inadequate dynamic range for measurements of low repetition frequency pulses with quasi-peak detection and thus may lead to erroneous measurement results under these circumstances.
- Swept spectrum analyzers with preselection are commercially available. This type of instruments may meet all requirements called out in this standard and, in case of full compliance with this standard, can be used without any restrictions to perform emission measurements in accordance with CISPR 16-2 series.

- d) The specifications applicable to spectrum analyzers without preselection in regard to quasi-peak detection are less stringent and their use is conditional on the signals to be measured.
- e) Spectrum analyzers may not have a built-in preamplifier. EMI receivers tend to have a preamplifier built in after the preselection stage.
- f) The frequency selectivity criteria, defined in 4.5, may not be met by swept spectrum analyzers. Typically swept spectrum analyzers use Gaussian shaped filters that may not meet these requirements. This standard requires swept spectrum analyzers to meet the stated specifications in 4.5.
- g) Swept spectrum analyzers may not have a quasi-peak detector built in. This standard requires spectrum analyzers to meet the stated specifications in 4.4 for quasi-peak detection. However, the documented requirements for pulse repetition frequencies are not applicable to swept spectrum analyzers without preselection.
- h) Swept spectrum analyzers may not have the proper response to intermittent, unsteady and drifting narrowband disturbances as described in 6.5.4. This standard requires spectrum analyzers to meet the stated specifications in 6.5.4.

Annex J (normative)

Requirements when using an external preamplifier with a measuring receiver

J.1 General

Using an external preamplifier at the input of a measuring receiver shall be considered carefully as, while it improves system sensitivity, it may invalidate the system's compliance with the overload requirements of this standard. Further, an external preamplifier may invalidate the usability of a spectrum analyzer without preselection for the measurement of impulsive signals with pulse repetition frequencies down to 20 Hz using the quasi-peak detector as specified in 4.4.2.

Therefore the operator of a measuring system that includes an external preamplifier shall determine the limitations of the system and shall apply linearity checks for the test system. Automated measurement results with external preamplifiers need to be verified using a final manual linearity check. The information given in this annex provides guidance for the user of emission measurement systems.

J.2 Considerations for optimum emission measurement system design

Internally, measuring receivers are designed to achieve optimum sensitivity while avoiding overload. Built-in preselection in the measuring receiver avoids overload by impulsive signals. In spite of preselection, measuring receivers usually have no linearity reserve for quasi-peak measurements of a single pulse above the specified indication range. Missing preselection in measuring receivers causes problems with quasi-peak detection of impulsive signals with low PRF.

The use of an external broadband preamplifier shall be considered only after all other possible measures for improving the system sensitivity have been exhausted, e.g. using measuring receivers with built-in preamplifiers, using antennas of sufficient gain, or using low loss connecting cables. An external preamplifier need only be added when the disturbance limit and all of the emissions expected and emissions to be measured are very close to the system noise level, e.g. for compliance with Class 5 radiated disturbance limits of CISPR 25 [14]. If high emission signals or high ambients are expected, external preamplifiers are not recommended.

From experience, external preamplifiers are not needed for radiated disturbance measurements to Class B limits of CISPR 11, CISPR 22 [13] and CISPR 32 [15], either at 3 m or at 10 m measurement distance, when measuring receivers with built-in preamplifiers including preselection and low-loss antenna cables are used. The same situation applies for radiated disturbance measurements to CISPR 14-1, CISPR 15 [1], and the generic emission standards, as well as for disturbance power measurements.

External preamplifiers are not recommended for conducted disturbance measurements below 30 MHz; their use may cause harmonics in the presence of high-level disturbance at frequencies below 150 kHz, where many emission standards do not specify disturbance limits.

If an external preamplifier is added for improved sensitivity, the following needs to be considered:

- a) preamplifiers have a wide bandwidth, i.e. they are susceptible to overload by impulsive signals and high level narrowband signals;

- b) preamplifiers may produce intermodulation products and harmonics; this is especially important when measurements are made on an OATS and/or in the presence of radio transmission equipment;
- c) preamplifiers increase the signal level at the receiver input and thus may overload the receiver input stages, a condition which cannot be avoided entirely by the receiver's built-in preselection;
- d) the gain in sensitivity will be less than the gain in signal level, thus limiting the dynamic range of the preamplifier/receiver combination;

NOTE 1 The gain in sensitivity is understood as the difference between the noise figure without preamplifier and the system noise figure with preamplifier.

- e) for maximum sensitivity in the frequency range above 1 GHz, the preamplifier is mounted/connected directly to the measurement antenna;
- f) use of an external preamplifier requires that an accurate gain versus frequency characterization be accounted for in the measurement result;
- g) the uncertainty of the gain as a function of temperature and aging, as well as the additional mismatch uncertainty between the preamplifier output port and the receiver input port, shall be included in the uncertainty budget for the measurement; the input impedance shall, as far as possible, comply with the requirements for the measuring receiver and shall be included in the uncertainty budget;
- h) for CISPR Band E, a system consisting of an external preamplifier and a measuring receiver shall be designed such that it cannot be overloaded by signals of lower frequency bands, and/or by any signal whose out-of-band or spurious signals are to be measured; e.g. the ISM signal of a microwave oven shall not drive the system into overload.

The gain in sensitivity is determined using the following quantities and equations:

$$F = \frac{P_{ie}}{kT_0B} \text{ and,} \quad (J.1)$$

$$\text{for an amplifier, } F = \frac{P_o}{gkT_0B} \quad (J.2)$$

where

- F is the noise factor, with $10 \lg F$ = noise figure (often denoted by the symbol NF);
- P_{ie} is the equivalent noise input power;
- P_o is the noise output power;
- g is calculated from the gain, $G = 10 \lg g$, respectively $g = 10^{G/10}$;
- k is Boltzmann's constant = $1,38 \times 10^{-23}$ Ws/K and $kT_0 = 4 \times 10^{-21}$ W/Hz;
- T_0 is the absolute reference room temperature (293 K);
- B is the noise bandwidth (e.g. of the measuring receiver).

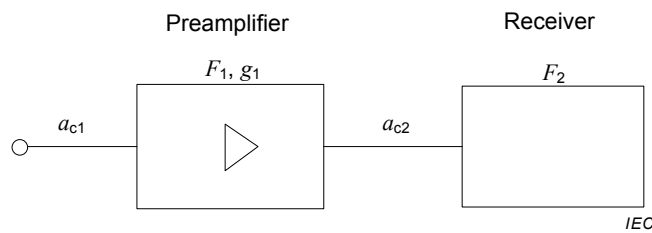


Figure J.1 – Receiver with preamplifier

In Figure J.1, assuming that the cable attenuation $a_{c2} = 0$ dB, then

$$10 \lg F_{\text{tot}} = a_{c1} + 10 \lg \left(F_1 + \frac{F_2 - 1}{g_1} \right) \quad (\text{J.3})$$

where F_{tot} is the noise factor of the system at the input cable with a_{c1} .

If $a_{c2} \neq 0$ dB, then the preamplifier gain factor g_1 in Equation (J.3) has to be replaced by $10(G_1 - a_{c2})/10$. Cable attenuation $a_{c1} = 0$ dB is achieved by mounting and/or connecting the preamplifier directly to the antenna. If $a_{c1} \neq 0$ dB, then the cable attenuation a_{c1} adds to the system noise figure as shown by Equation (J.3).

State-of-the-art preamplifiers typically have noise figures of 3 dB or less, corresponding to a noise factor of $F_1 = 2$. Receivers with built-in preamplifiers typically have noise figures around 8 dB, corresponding to a noise factor $F_2 = 6,3$. This high noise factor is due to attenuation caused by preselection and other internal insertion losses of the receiver. Receivers without built-in preamplifiers typically have noise figures around 15 dB, corresponding to a noise factor $F_2 = 31,6$.

NOTE 2 The noise figure $10 \lg F_2$ of a measuring receiver can be determined from the indicated noise level using

$$10 \lg F_2 = V_{\text{Nav}} + 67 - 10 \lg B_N - w_{\text{Nav}}$$

where

V_{Nav} is the receiver noise floor with linear average detection, in dB(μV);

B_N is the noise bandwidth of the measuring receiver, in Hz;

w_{Nav} is the noise weighting factor for linear average detection, in dB.

EXAMPLE If $V_{\text{Nav}} = -10,7$ dB(μV), $B_N = 85$ kHz (for $B_6 = 120$ kHz), and $w_{\text{Nav}} = -1$ dB, then the noise figure $10 \lg F_2 = 8$ dB.

The quantity w_{Nav} is the difference between the indications of the linear average detector and the r.m.s. detector for Gaussian noise [21]; values for quasi-peak detection w_{Nqp} are approximately 4 dB for Band B, and 6 dB for Bands C/D; for peak detection w_{Npk} is up to 12 dB, depending on measurement time.

The noise bandwidth B_N is close to the 3 dB bandwidth B_3 of the measuring receiver. A rough approximation is given by $B_N = 1,1 B_3$. See [21] for details about specific filter implementations.

Considering a given preamplifier noise figure of 3 dB, it will be acceptable to achieve a system noise figure $10 \lg F_{\text{tot}} = 4$ dB, corresponding to a noise factor of 2,51. This requires that $(F_2 - 1)/g_1 = 0,51$, or $g_1 = (F_2 - 1)/0,51$.

- For receivers with a built-in preamplifier, the resulting gain is $g_1 = 10,39$, or $G_1 = 10,2$ dB.

- For receivers without a built-in preamplifier, the resulting gain is $g_1 = 60$, or $G_1 = 17,8$ dB.

For a receiver without a built-in preamplifier, as described above, an external preamplifier with a noise figure of 3 dB and a gain of 10 dB will give a system noise figure of 7 dB.

From the preceding examples, it can be seen that an improvement in sensitivity of 4 dB requires a signal gain of around 10 dB for a receiver with a built-in preamplifier. For a receiver without a built-in preamplifier, an improvement in sensitivity of 11 dB requires a signal gain of almost 18 dB, and an improvement of 8 dB requires a signal gain of 10 dB. It is evident that a system noise figure of 3,5 dB cannot easily be achieved with a preamplifier noise figure of 3 dB, because an excessive preamplifier gain would be necessary. Refer to Table J.1 for example noise figures.

Because it will severely limit the system's linearity performance, it is not advisable to use preamplifiers with a gain of 30 dB or more.

Table J.1 – Examples of preamplifier and measuring receiver data and resulting system noise figures

Preamplifier				Measuring receiver		System
Noise factor	Noise figure	Gain factor	Gain	Noise factor	Noise figure	Noise figure
F_1	$10 \lg F_1$	g_1	G_1	F_2	$10 \lg F_2$	$10 \lg F_{\text{tot}}$
	dB		dB		dB	dB
2	3	10,4	10,2	6,3	8	4
2	3	10	10	31,6	15	7
2	3	60	17,8	31,6	15	4

J.3 Linearity specifications and precautions in measurement

The dynamic range of preamplifiers is defined by the 1 dB compression point, 3 dB compression point, and saturation point. To avoid distortion caused by the input signal, the signal should ideally stay below the 1 dB compression point during the entire measurement time.

An example screenshot of the transfer function of an amplifier is shown in Figure J.2. The response of such an amplifier using a sinusoidal signal in time domain and frequency domain is shown in Figure J.3. The numbers on the axes in Figures J.2, J.3 and J.4 are generic in nature (quantization values) and do not represent specific units.

Figure J.3 shows that the sinusoidal signal is distorted in time domain, which is due to the nonlinear effects of the preamplifier. The frequency domain display shows that the level is decreased at 100 MHz, and that further harmonics exist. A corresponding simulation for a broadband pulse is shown in Figure J.4.

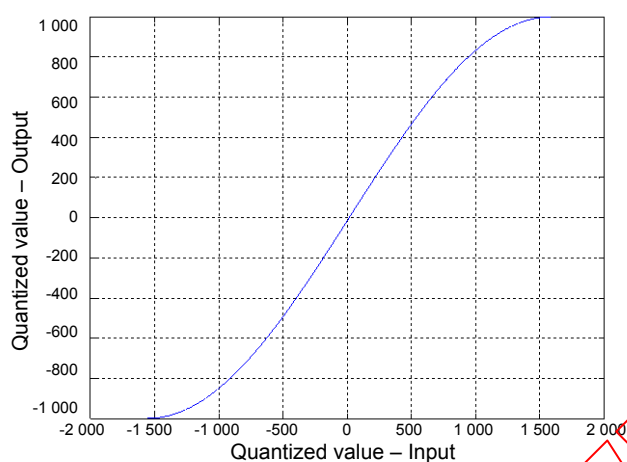
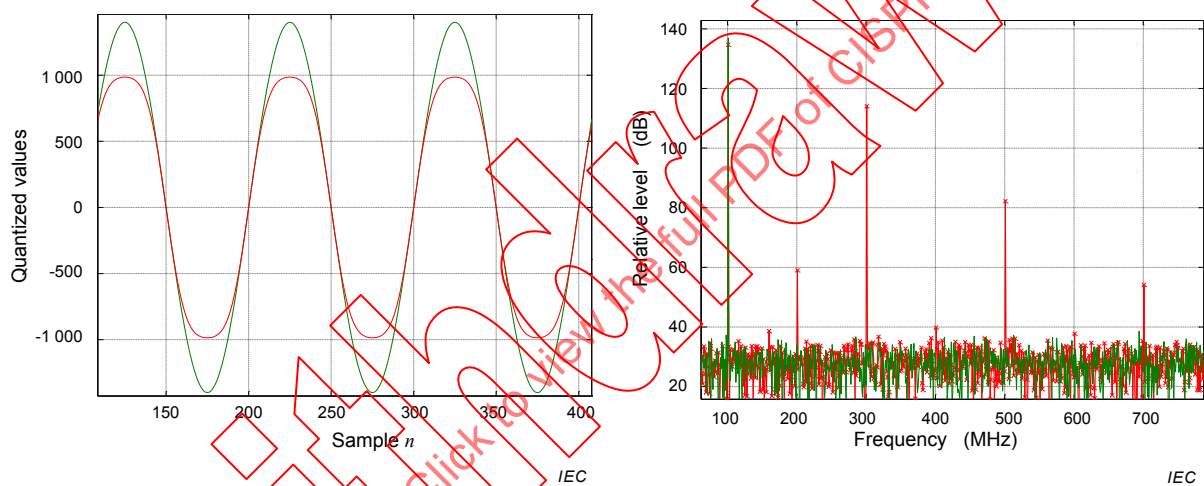
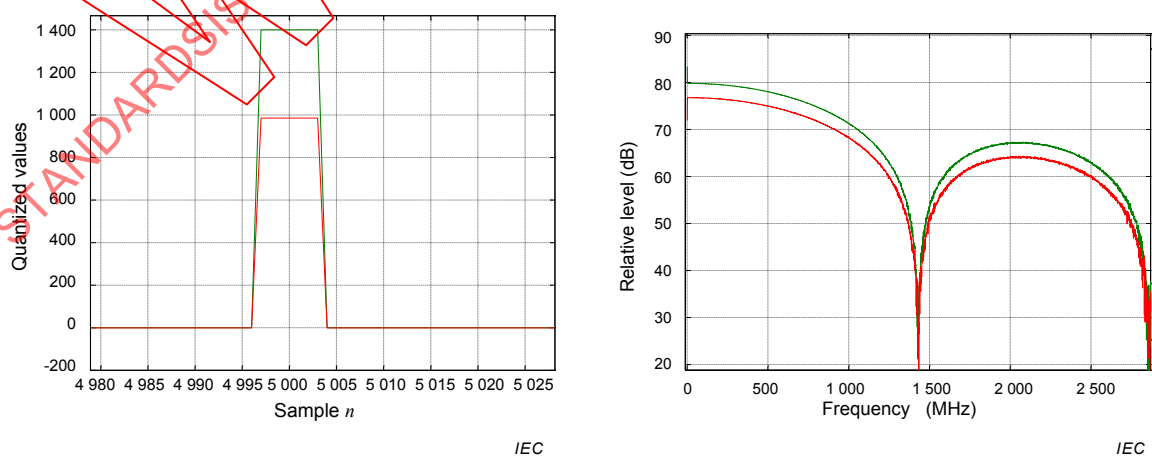


Figure J.2 – Transfer function of an amplifier



Green = normalized input signal; red = output signal

Figure J.3 – Response for a sinusoidal signal



Green = normalized input signal; red = output signal

Figure J.4 – Response for an impulse

Comparing Figures J.3 and J.4, it can be seen that the saturation level in the time domain is exactly the same. However in the frequency domain the effects of saturation of the external preamplifier are different. For the impulsive signal, the amplitude level is decreased, invalidating the measurement result. For sinusoidal signals, the amplitude of the fundamental is decreased, while further harmonics are generated by the nonlinear effect of the external preamplifier; the measurement result is also invalidated.

The performance of the system, i.e. system noise level and overload capability, will depend on the characteristics of both the preamplifier and the measuring receiver. For narrowband signals, generally the 1 dB compression point of the preamplifier output exceeds the 1 dB compression point of the measuring receiver input. Preselection of the measuring receiver will improve system linearity for the measurement of broadband impulsive signals. Therefore, two types of systems are taken into consideration: systems with, and without, preselection at the measuring receiver input.

A broadband overload detector, which is effective at the input of some measuring receivers without preselection, is used to detect signal levels at the 1 dB compression point of the first mixer, to alert the user of linearity problems. The overload detector can also be used as an indicator to assure valid measurement results. Similar overload detection is recommended for wideband FFT based measuring systems to avoid over-range of the wideband A/D converter (see J.4).

Further precautions for measurements include a prediction of the available overload factor for the measurement of impulsive disturbances. Apart from gain versus frequency and noise figure, the 1 dB compression point of the preamplifier and the complete system, consisting of preamplifier and measuring receiver, shall be specified. For CISPR Bands C/D, the relationship between the 1 dB compression point for sine wave signals and the peak value of the broadband CISPR pulse signal with a bandwidth of 2 GHz gives a bandwidth factor F_{bw} of 85 dB [$F_{bw} = 20 \lg(2\,000/0,12)$]. Figures J.5 and J.6 show the deviations from linearity of a preamplifier with a 1 dB compression point of 112 dB(μ V), for an unmodulated sine wave and impulsive signals.

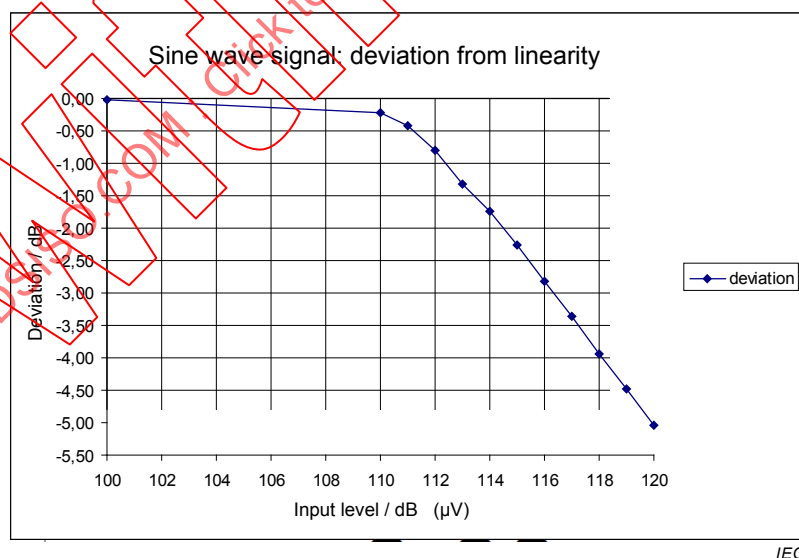
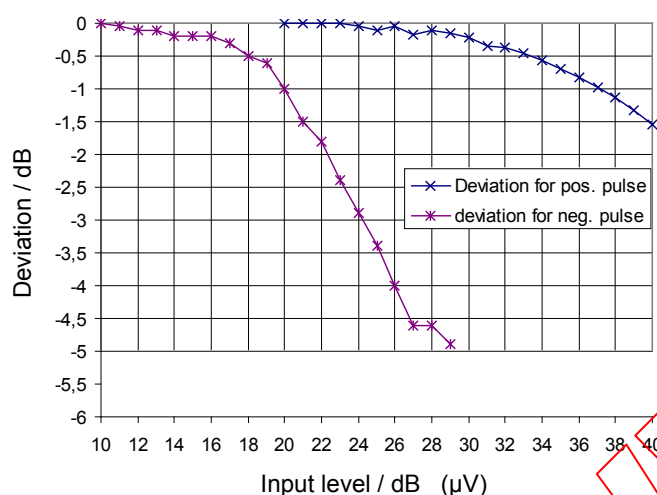


Figure J.5 – Deviation from linear gain for an unmodulated sine wave (example)



NOTE Using $F_{bw} = 85$ dB, the peak value of the positive pulse signal with a PRF of 100 Hz is at around $37 \text{ dB}(\mu\text{V}) + 12 \text{ dB} + 85 \text{ dB} = 134 \text{ dB}(\mu\text{V})$, i.e. around 22 dB above the 1 dB compression point of Figure J.5. 12 dB is the quasi peak weighting factor, i.e. the difference between peak and quasi peak for a PRF of 100 Hz.

Figure J.6 – Deviation from linear gain for a broadband impulsive signal as measured with the quasi-peak detector (example)

The flatness of the deviation curve for positive pulses in Figure J.6 is misleading, because the amplifier nonlinearity is masked by the amplifier's own intermodulation products. This effect can be demonstrated using a band-stop filter with a notch depth of greater than 40 dB (band-stop filter as specified in 4.6) at the input of the preamplifier. For an acceptable operation (error contribution less than 1 dB by intermodulation), the notch depth shall remain at least 20 dB during the intermodulation test. The value of 20 dB is obtained with quasi-peak measurements at a PRF of 100 Hz; the PRF of 100 Hz is a compromise.

Ideally the 20 dB notch depth would be needed for quasi-peak measurements at all PRFs. This is shown in Figure J.7 for the preamplifier used above with 10 dB gain, where the 20 dB depth is retained as long as the peak level of the input signal is less than $37 \text{ dB}(\mu\text{V})$, and the peak level of the output signal is less than $46 \text{ dB}(\mu\text{V})$ (blue curve). For a PRF of 100 Hz, a peak level of $37 \text{ dB}(\mu\text{V})$ corresponds to a quasi-peak level of $25 \text{ dB}(\mu\text{V})$. Thus while the 1 dB compression point for the broadband impulsive signal in Figure J.6 "positive pulse" looks like being at $37 \text{ dB}(\mu\text{V})$ quasi-peak, the preamplifier is already overloaded. The input signal should be at least 12 dB lower, i.e. at $25 \text{ dB}(\mu\text{V})$ quasi-peak, to avoid excessive intermodulation.

In Figure J.6 the "positive pulse" also shows that a simple overload test with a switchable 10 dB attenuator at the preamplifier input may not properly indicate the overload in case of impulsive signals, because the output level can still follow the input level, while the preamplifier input signal is up to 20 dB above the 1 dB compression point. The simple test may work for sine wave signals. A better characterization of the system with respect to impulsive signals is obtained using the band-stop filter intermodulation test. If the band-stop filter intermodulation test is not available, the 1 dB compression point of the preamplifier, referred to its input, should be used to characterize the system.

NOTE The band-stop filter intermodulation test is intended to characterize the system, e.g. done by the system provider. It would be impractical to use a band-stop filter test in each EMC test lab during an emission test.

Note that during the band-stop filter intermodulation test, it shall be assured that the measuring receiver used as an indicator at the output of the preamplifier is not overloaded. Figure J.8 shows that the notch depth result from a CISPR intermodulation test of a measuring receiver with preselection still exceeds 30 dB with an input signal (quasi peak) of $55 \text{ dB}(\mu\text{V})$, which corresponds to an input level (quasi peak) of $45 \text{ dB}(\mu\text{V})$ to a 10 dB preamplifier. Using a measuring receiver with built-in broadband preamplifier may not show

the linearity of the external preamplifier correctly, due to overload of the measuring receiver, as shown in Figure J.9 and J.10, whereas with preselection the output will be linear.

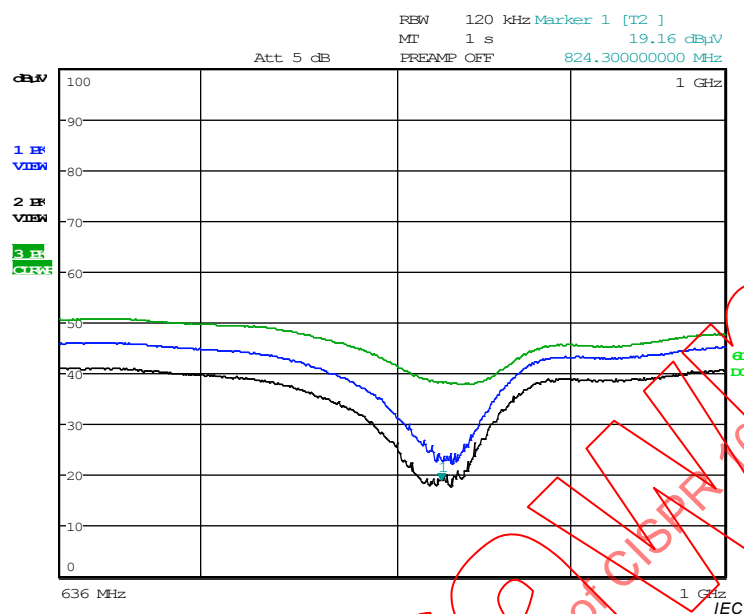


Figure J.7 – Screenshot of a band-stop filter test for a preamplifier at around 818 MHz

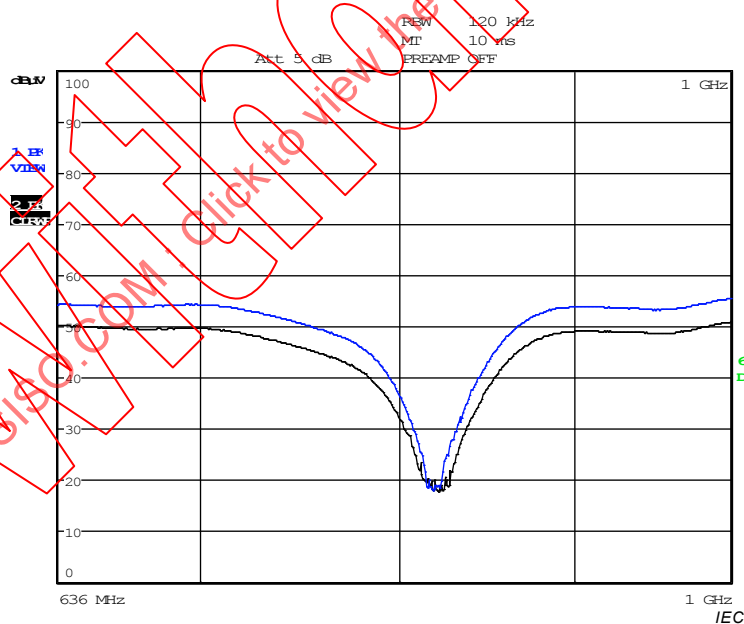


Figure J.8 – Band-stop filter test result with the measuring receiver at 818 MHz

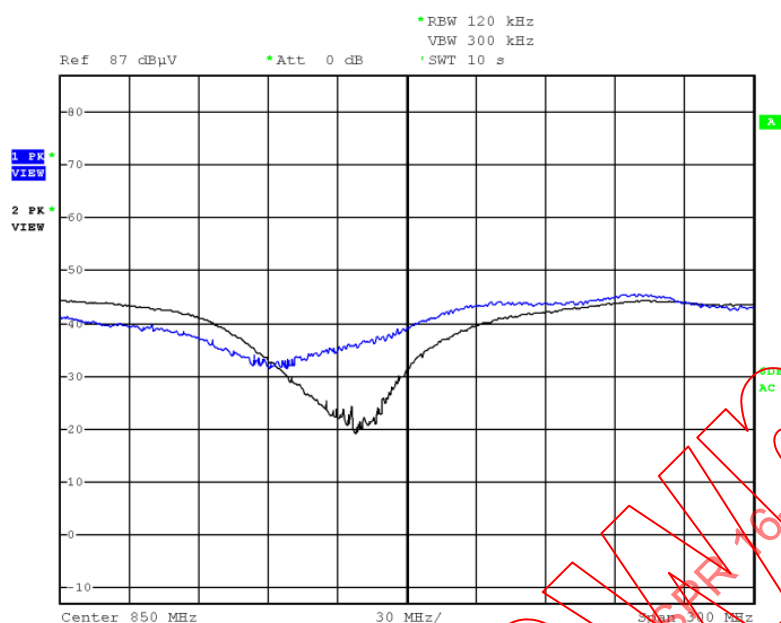
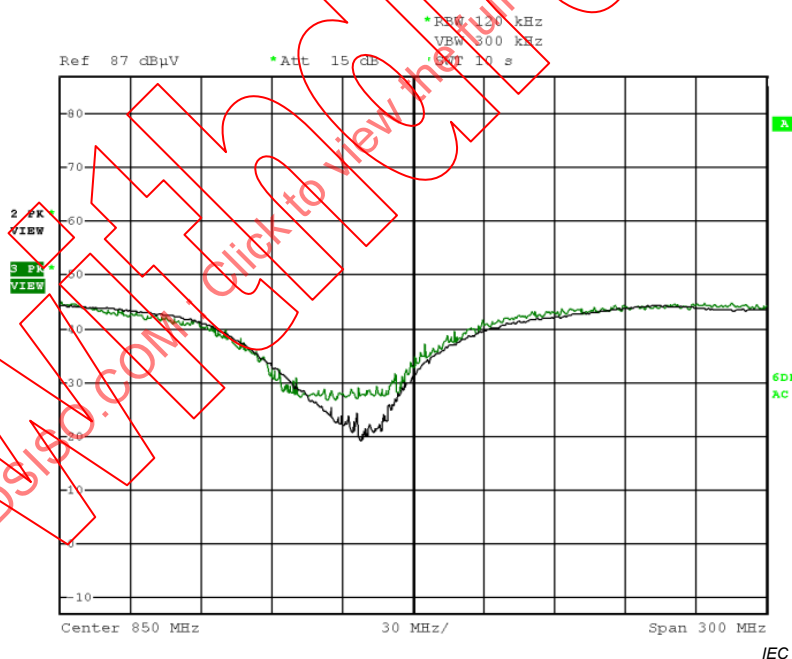


Figure J.9 – Band-stop filter test results for the same 10 dB preamplifier but a different receiver with preselection (black) and without preselection (blue)



NOTE A 15 dB attenuator between external preamplifier and receiver was used to avoid overload of the receiver without preselection; however the receiver's noise level then hides the notch.

Figure J.10 – Band-stop filter test results for the same 10 dB preamplifier but with the receiver of Figure J.9 with preselection (black) and without preselection (green)

When an external broadband preamplifier is used with a measuring receiver, the user cannot expect proper weighting of broadband impulsive signals by such a measuring system using average, rms-average and quasi-peak detection at low pulse repetition frequencies. Therefore, the user shall determine the operating range between noise level and the 1 dB compression point for broadband impulsive signals for the peak detector of the measurement

system. This determination allows a prediction of the lowest PRF for proper weighting of broadband impulsive signals using each individual detector.

Figure J.11 shows the weighting functions of the detectors specified in CISPR 16-1-1 for CISPR Bands C/D, and an example 'Noise' line to illustrate the operating range between noise level and 1 dB compression point. In the example, the peak detector noise level is 15 dB below the 1 dB compression point. For the quasi-peak detector, the noise level is approximately 5 dB lower, i.e. the operating range is approximately 5 dB wider. For the rms-average and average detectors, the noise level is approximately 10 dB lower, which increases the operating range to about 25 dB in the example.

To draw the noise line shown in Figure J.11, the peak level V_p is used from the band-stop filter test in Figure J.7 and the average detector noise level V_{Nav} determined. The difference $V_p - V_{Nav}$ marks the crossing of the "Noise" line with the "Average" line. For the 10 dB preamplifier above, $V_p = 37 \text{ dB}(\mu\text{V})$, $V_{Nav} = -14 \text{ dB}(\mu\text{V})$ for a noise figure of 4 dB and $V_p - V_{Nav} = 51 \text{ dB}$. The noise line in Figure J.11 is drawn from an example where $V_p - V_{Nav} = 27 \text{ dB}$.

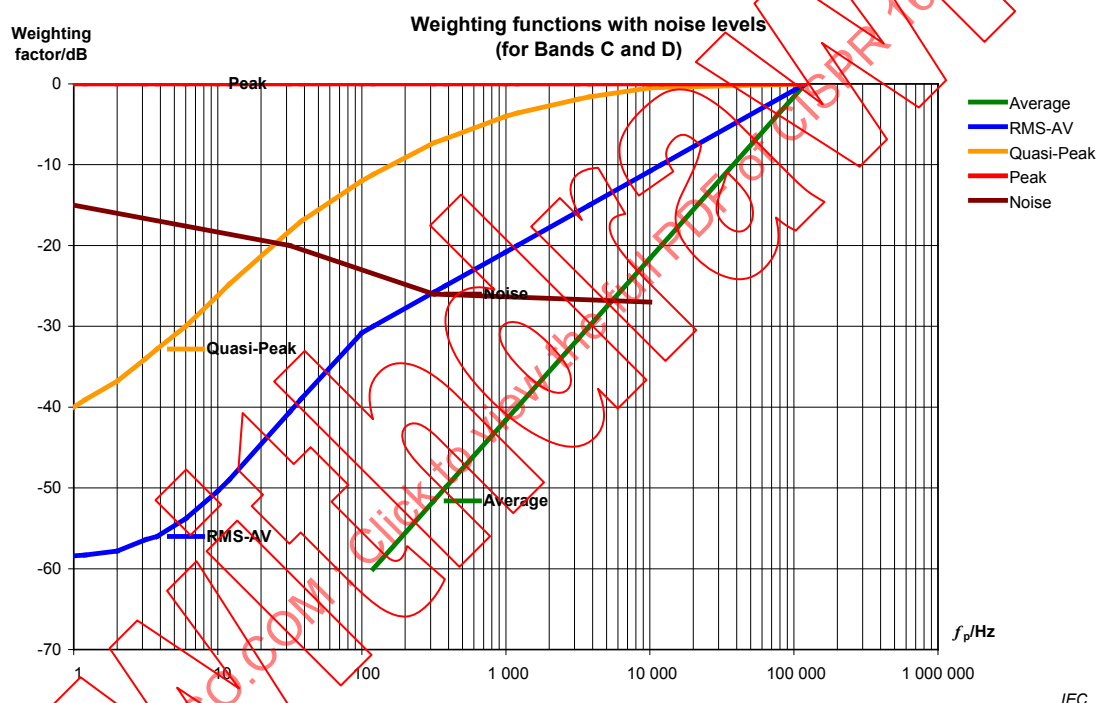


Figure J.11 – Weighting functions of the various CISPR detectors with a noise curve to illustrate the remaining operating ranges for broadband impulsive signals (example)

From Figure J.11, the critical PRF can be seen at which the impulsive signal level, with peak level at the 1 dB compression point, is equal to the noise level. However for an accurate measurement, the signal level needs to be approximately 6 dB above the noise level (the actual value depends on the PRF). As a consequence, in this example quasi-peak measurements can be carried out above a PRF of about 60 Hz. For the rms-average and average detectors, the critical PRFs are near 1 kHz and 10 kHz, respectively. For practical measurements, a linearity check is recommended using the weighting factor at the critical PRF. For this example, the linearity check is as follows:

- For the quasi-peak measurement: the critical PRF of 60 Hz is exceeded if the difference between peak and quasi-peak values is less than 15 dB.
- For the rms-average and average measurements: the critical PRFs of 1 kHz and 10 kHz are exceeded if the difference between peak and rms-average or average detector results are less than 20 dB.

However, if the measurements are made close to the noise level, the differences might be reduced by the noise level, which will give the impression of PRFs higher than actual.

J.4 Detecting the overload of an external preamplifier in a wideband FFT based measuring system

Detecting whether the preamplifier is in the linear range during the measurement can be performed for sinusoidal as well as impulsive signals, by taking the maximum of the preamplifier output signal then comparing it with a given threshold level corresponding to the 1 dB compression point. The maximum (positive) and minimum (negative) voltage of the signal in the time domain shall be sampled continuously during the measurement time, and compared to that threshold level. The 1 dB compression point is defined for a sinusoidal signal yielding an output 1 dB lower than expected, as shown in Figure J.5.

During a measurement, a measuring apparatus that digitizes the signal of the output of the external preamplifier can be used to detect whether an over-range has occurred. For the preceding example, a threshold level of a normalized value in Figure J.2 'Input' of about 900 would be appropriate to avoid nonlinear effects. The threshold level should be identified by the system manufacturer depending on the application. For example, the measurement of harmonics of intentional radiators requires a better linearity (lower threshold) than the measurement of impulsive disturbance. A measuring apparatus that digitizes the input signal shall fulfil the following requirements, to allow a correct decision:

- a) continuous (gapless) acquisition during the measurement time;
- b) selectable threshold level;
- c) broadband acquisition of the entire measurement band, e.g. up to 1 GHz.

Typical instruments that fulfil such requirements include broadband FFT-based measurement instruments with over-range detection, as described in CISPR TR 16-3, and oscilloscopes in single-shot trigger mode. Over-range detection is used to avoid exceeding the operating range of the wideband A/D converter.

Annex K (normative)

Calibration requirements for measuring receivers

K.1 General

When performing EMI measurements it is essential to use measuring equipment that meets the specifications called out in this standard such that the expected measurement instrumentation uncertainty for conducted and radiated disturbance measurements as well as disturbance power measurements can be achieved. In addition, the results of these measurements shall be traceable (see 3.17) to national or internationally accepted standards. These requirements can be met by selecting measuring equipment that is correctly calibrated. The calibration requirements described in this annex are only applicable to the test instrumentation (i.e. EMI receivers and spectrum analysers) covered in this standard.

The EMC test laboratory is responsible for the selection and use of adequate measuring equipment as well as the purchase of accredited (or otherwise deemed appropriate) calibration services. A clear understanding of the calibration requirements related to measuring equipment is essential to determine the necessary specifics of calibration service in the purchasing process and to review the obtained service upon receipt of the equipment back from the calibration laboratory, before it is placed back into service at the test laboratory.

K.2 Calibration and verification

Calibration is defined as a set of operations that establishes, by reference to standards, the relationship that exists, under specified conditions, between an indication of an instrument under calibration and a result of a measurement using the corresponding traceable reference standard. Applied to the measuring receiver this means that a calibration procedure consisting of various steps is used to determine the actual values of various calibration parameters through measurements under specified environmental conditions, using measuring equipment that was calibrated by an accredited (or otherwise deemed appropriate) calibration laboratory. The results of these calibration measurements are used to determine if the instrument under calibration meets the specifications published by the manufacturer.

The calibration process itself does not necessarily require the instrument under calibration to be adjusted. However, adjustments may be required if the calibration process determines that the instrument does not meet the manufacturer's specifications. The goal of the instrument calibration process is the determination of compliance of a measuring receiver under calibration with its published specifications in a traceable manner (see 3.17).

"Verification" should not be confused with "intermediate checks" (also called confidence checks); the latter consists of a set of operations aimed at providing evidence of the proper functioning of a test instrument. An intermediate check of a measuring receiver can differ considerably from the calibration process because the purpose of these two activities is entirely different.

K.3 Calibration and verification specifics

Calibration of a measuring receiver requires a specific process that defines the various measurements to determine if the receiver meets its specifications. In general, this calibration process has also been used by the receiver manufacturer to establish the receiver specifications. Therefore, only the manufacturer's calibration process or verification process in accordance with this standard shall be applied by a calibration laboratory or test laboratory performing its own calibrations to determine whether the receiver meets its specifications at

the time of calibration or the requirements called out in this standard. This requirement applies to measuring receivers only.

If a process different from the manufacturer's calibration process or verification process in accordance with this standard is used, it shall be verifiably validated and it shall be stated in the calibration certificate that the process used deviates from the calibration process defined by the manufacturer. For ancillary equipment such as AMNs, AANs, absorbing clamps and antennas, the calibration procedures documented in other relevant parts of CISPR 16 shall be applied.

The calibration process for measuring receivers also defines the following essential parameters that shall be used for proper calibration:

- a) the specific set-up of the receiver under calibration for each measurement in the calibration process (e.g. in the case of an EMI receiver or spectrum analyzer the tuning frequency, attenuator setting, resolution bandwidth setting, and other parameters, for each measurement to be performed);
- b) the required test set-up for the measurement of a specific parameter (e.g. the use of power splitters for ratio measurements and any other required measuring equipment);
- c) the required accuracy of measuring equipment used to perform the measurements of the calibration process (e.g. required amplitude accuracy and frequency accuracy);
- d) the actual number of measurements to be performed and their sequence. For many types of measuring receiver this sequence is mandatory and cannot be changed because the measurements of some parameters require the measurements of previous calibration parameters to be completed. In addition, it is possible that the interpretation of a test result for a calibration parameter is dependent on the test result of a previous measurement in the calibration sequence;
- e) the required environmental conditions (e.g. required ambient temperature and relative humidity), if deemed necessary by the manufacturer.

Only if the manufacturer's calibration process is used can the results of the calibration measurements be compared to the published specifications. Consequently, the calibration laboratory or the test laboratory performing its own calibrations (also called internal calibrations) should use the manufacturer's calibration process for a specific measuring receiver. If an alternative process is used, it shall be verifiably validated and it shall be stated in the calibration certificate that this process deviates from the calibration process defined by the manufacturer.

K.4 Measuring receiver specifics

This standard specifies measuring receiver requirements using a "black box" approach. This means that the instrument shall show a specific response when a defined signal is applied to its input. Therefore, the demonstration of compliance of measuring receivers with specifications defined in this standard can be provided through the manufacturer's calibration process or the procedures and measuring equipment defined in this standard.

In case compliance of a measuring receiver is determined with the specifications in this standard, the following minimum set of parameters shown in Table K.1 shall be included in the verification process.

Table K.1 – Verification parameter summary

Parameter	Subclause in CISPR 16-1-1	Suggested Frequencies
VSWR	4.2, 5.2, 6.2, 7.2	VSWR to be determined for 0 dB and ≥ 10 dB input attenuation at the following tuning frequencies: 100 kHz, 15 MHz, 475 MHz and 8,5 GHz
Sine wave voltage accuracy	4.3, 5.4, 6.4, 7.4	Verification at the following tuning frequencies: start frequency, stop frequency and centre frequency of CISPR Bands A/B/C and D/E
Response to pulses	4.4, 5.5, 6.5, 7.5	Verification at the following tuning frequencies: start frequency, stop frequency and centre frequency of CISPR Bands A/B/C and D/E
Selectivity	4.5, 5.6, 6.6, 7.6	Verification at the following tuning frequencies: centre frequency of CISPR Bands A/B/C and D/E

The parameters summarized in Table K.1 are only applicable to the frequency ranges covered by the instrument under verification and its implemented detector functions. Specifics described in the referenced subclauses apply in their entirety as well as the stated tolerances.

It is to be noted that the requirements called out in this standard constitute a subset of all the specifications the receiver manufacturer publishes. In addition, some requirements in this standard may be stated in a way that differs from the manufacturer's specifications (e.g. CW frequency accuracy in this standard versus a combination of absolute amplitude accuracy at a reference frequency and frequency response).

If evidence of compliance with the requirements presented in this standard cannot be directly provided through the manufacturer's calibration process, due to differences in the form of the stated specifications, the verification of these requirements shall be requested by the test laboratory in addition to the actual receiver calibration based on the manufacturer's calibration process.

K.5 Partial calibration of measuring receivers

Oftentimes the complete functionality of a measuring receiver is not utilized when performing emission measurements. For economic reasons test laboratories therefore may decide to have encompassed by the purchased calibration service only functions that are actually used to perform measurements. Care shall be taken when specifying such a partial or limited calibration service because the calibration of the identified functions may require calibration of other functions as a prerequisite. Such dependencies shall be determined by the test laboratory or the calibration laboratory through a review of the manufacturer's calibration procedure. If the test laboratory does not have access to the manufacturer's calibration procedure, this review shall be requested from the calibration laboratory as part of the calibration service purchase.

K.6 Determination of compliance of a measuring receiver with applicable specifications

Compliance of a measuring receiver with the specifications of the manufacturer or with the tolerances specified in CISPR standards requires that measurement results reported in calibration certificates are below an upper limit, or above a lower limit, or between an upper and lower limit. The uncertainty of the calibration or verification measurement has a direct impact on the pass/fail determination. Therefore, the measurement uncertainty shall be taken into account when determining compliance of a measuring receiver with its stated

specifications. The application of measurement uncertainty to a measurement result can lead to one of the four cases described as follows and depicted in Figure K.1:

- the measurement result is within the specified limit range by a margin larger than the expanded uncertainty value applicable to the calibration measurement;
- the measurement result is within the specified limit range by a margin less than the expanded uncertainty value applicable to the calibration measurement;
- the measurement result is outside of the specified limit range by a margin less than the expanded uncertainty value applicable to the calibration measurement; or
- the measurement result is outside of the specified limit range by a margin larger than the expanded uncertainty value applicable to the calibration measurement, and the specification is not met.

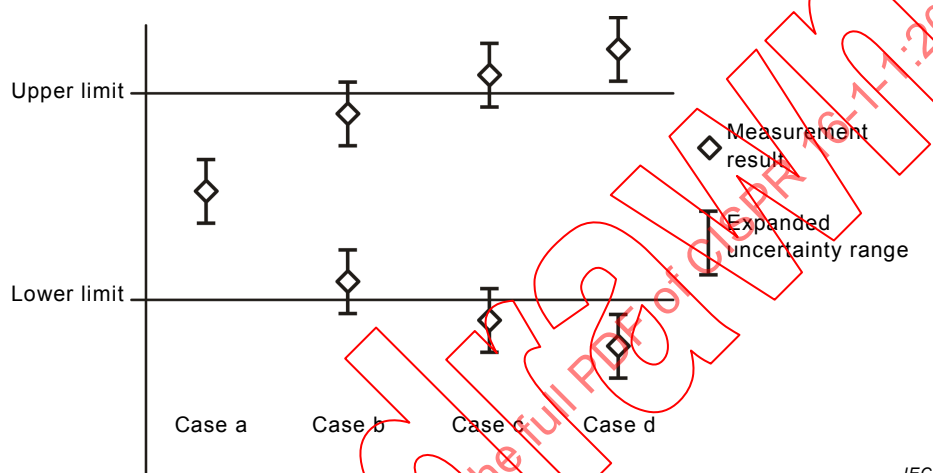


Figure K.1 – Compliance determination process with application of measurement uncertainty

The four cases in Figure K.1 shall be interpreted as follows:

- specification is met;
- and c) the result is inconclusive, a definitive compliance statement is not possible;
- specification is not met.

Bibliography

- [1] CISPR 15, *Limits and methods of measurement of radio disturbance characteristics of electrical lighting and similar equipment*
- [2] CISPR 16-1-2:2014, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-2: Radio disturbance and immunity measuring apparatus – Coupling devices for conducted disturbance measurements*
- [3] CISPR 16-1-3:2004, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-3: Radio disturbance and immunity measuring apparatus – Ancillary equipment – Disturbance power*
- [4] CISPR 16-1-4:2010, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-4: Radio disturbance and immunity measuring apparatus – Antennas and test sites for radiated disturbance measurements*
- [5] CISPR 16-1-5:2014, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 1-5: Radio disturbance and immunity measuring apparatus – Antenna calibration sites and reference test sites for 5 MHz to 18 GHz*
- [6] CISPR 16-2 (all parts), *Specification for radio disturbance and immunity measuring apparatus and methods*
- [7] CISPR 16-2-4:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-4: Methods of measurement of disturbances and immunity – Immunity measurements*
- [8] CISPR 16-4 (all parts), *Specification for radio disturbance and immunity measuring apparatus and methods*
- [9] CISPR TR 16-4-1:2009, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-1: Uncertainties, statistics and limit modelling – Uncertainties in standardized EMC tests (only available in English)*
- [10] CISPR 16-4-2:2011, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 4-2: Uncertainties, statistics and limit modelling – Measurement instrumentation uncertainty*
- [11] CISPR TR 16-4-3:2004, *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*
- [12] CISPR TR 16-4-4:2007, *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*
- [13] CISPR 22, *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement*
- [14] CISPR 25, *Vehicles, boats and internal combustion engines – Radio disturbance characteristics – Limits and methods of measurement for the protection of on-board receivers*
- [15] CISPR 32, *Electromagnetic compatibility of multimedia equipment – Emission requirements*
- [16] ISO IEC Guide 98-3:2008, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)*

- [17] ISO IEC Guide 99:2007, *International vocabulary of metrology – Basic and general concepts and associated terms (VIM)*
 - [18] EN 50065-1, *Signalling on low-voltage electrical installations in the frequency range 3 kHz to 148,5 kHz – Part 1: General requirements, frequency bands and electromagnetic disturbances*
 - [19] GESELOWITZ, dB., *Response of ideal radio noise meter to continuous sine-wave, recurrent impulses, and random noise*, IRE Transactions, RFI, May, 1961, vol. RFI-3, no. 1, p. 2-11 (only available in English)
 - [20] RAUSCHER, C., *Fundamentals of Spectrum Analysis*, 5th edition, 2011, ISBN 978-3-939837-01-5 (available from Rohde & Schwarz Bookshop, <http://www.books.rohde-schwarz.com/>)
 - [21] SABAROFF, S., *Impulse excitation of a cascade of series tuned circuits*, Proceedings of the IRE, December 1944, vol. 32, p. 758-760 (only available in English)
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COMMISSION ÉLECTROTECHNIQUE INTERNATIONALE
COMITÉ INTERNATIONAL SPÉCIAL DES PERTURBATIONS RADIOÉLECTRIQUES

**SPÉCIFICATION DES MÉTHODES ET DES APPAREILS DE MESURE
DES PERTURBATIONS RADIOÉLECTRIQUES ET DE L'IMMUNITÉ
AUX PERTURBATIONS RADIOÉLECTRIQUES –**

**Partie 1-1: Appareils de mesure des perturbations radioélectriques
et de l'immunité aux perturbations radioélectriques –
Appareils de mesure**

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La Norme internationale CISPR 16-1-1 a été établie par le sous-comité A du CISPR: Mesures des perturbations radioélectriques et méthodes statistiques.

Cette quatrième édition annule et remplace la troisième édition parue en 2010, l'Amendement 1:2010 et l'Amendement 2:2014. Cette édition constitue une révision technique.

La modification technique majeure suivante par rapport à l'édition précédente porte sur l'ajout d'une nouvelle Annexe normative relative aux exigences d'étalonnage des récepteurs de mesure.

Elle a le statut de publication fondamentale en CEM en accord avec le Guide 107 de l'IEC, *Compatibilité électromagnétique – Guide pour la rédaction des publications sur la compatibilité électromagnétique*.

Le texte de cette norme est issu des documents suivants:

FDIS	Rapport de vote
CISPR/A/1118/FDIS	CISPR/A/1135/RVD

Le rapport de vote indiqué dans le tableau ci-dessus donne toute information sur le vote ayant abouti à l'approbation de cette norme.

Cette publication a été rédigée selon les Directives ISO/IEC, Partie 2.

Une liste de toutes les parties de la série CISPR 16, publiées sous le titre général *Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques*, peut être consultée sur le site web de l'IEC.

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- reconduite,
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- remplacée par une édition révisée, ou
- amendée.

Le contenu de la feuille d'interprétation d'avril 2018 (en anglais uniquement) a été pris en considération dans cet exemplaire.

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INTRODUCTION

La série CISPR 16, publiée sous le titre général *Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques* comprend les normes et les rapports suivants:

- CISPR 16-1 – six parties traitant des spécifications des appareils de mesure;
- CISPR 16-2 – cinq parties traitant des méthodes de mesure;
- CISPR 16-3 – une seule publication contenant différents rapports techniques (TR) avec des informations sur le contexte de la CISPR et sur les perturbations radioélectriques en général;
- CISPR 16-4 – cinq parties traitant des incertitudes, des statistiques et de la modélisation des limites.

La CISPR 16-1 est constituée des cinq parties suivantes, publiées sous le titre général *Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques*:

- Partie 1-1: Appareils de mesure
- Partie 1-2: Matériels auxiliaires – Perturbations conduites
- Partie 1-3: Matériels auxiliaires – Puissance perturbatrice
- Partie 1-4: Matériels auxiliaires – Perturbations rayonnées
- Partie 1-5: Emplacements d'étalonnage d'antenne et emplacements d'essai de référence pour la plage comprise entre 5 MHz et 18 GHz
- Partie 1-6: Étalonnage des antennes CEM

La Commission Electrotechnique Internationale (IEC) attire l'attention sur le fait qu'il est déclaré que la conformité avec les dispositions du présent document peut impliquer l'utilisation d'un brevet intéressant le récepteur de mesure avec détecteur de valeur moyenne efficace (brevet DE 10126830) traité à l'Article 7.

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SPÉCIFICATION DES MÉTHODES ET DES APPAREILS DE MESURE DES PERTURBATIONS RADIOÉLECTRIQUES ET DE L'IMMUNITÉ AUX PERTURBATIONS RADIOÉLECTRIQUES –

Partie 1-1: Appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Appareils de mesure

1 Domaine d'application

La présente partie de la CISPR 16 spécifie les caractéristiques et les performances des appareils de mesure des champs radioélectriques dans la plage de fréquences de 9 kHz à 18 GHz. Des exigences pour les appareils spécialisés de mesure de perturbations non continues sont également spécifiées.

NOTE Conformément au Guide 107 de l'IEC, la CISPR 16-1-1 est une norme CEM fondamentale destinée à être utilisée par les comités de produits de l'IEC. Comme indiqué dans le Guide 107, les comités de produits ont la responsabilité de déterminer l'applicabilité de cette norme CEM. Le CISPR et ses sous-comités sont prêts à coopérer avec les comités de produits à l'évaluation de la valeur des essais d'immunité particuliers pour leurs produits.

Les spécifications de la présente norme s'appliquent aux récepteurs de perturbations électromagnétiques (EMI) et aux analyseurs de spectre. Le terme "récepteur de mesure" utilisé dans la présente norme fait référence à la fois aux récepteurs EMI et aux analyseurs de spectre. Les exigences d'étalonnage des récepteurs de mesure sont détaillées dans l'Annexe J.

Des lignes directrices supplémentaires concernant l'utilisation des analyseurs de spectre et des récepteurs à balayage peuvent être trouvées dans l'Annexe B de l'une quelconque des normes suivantes: CISPR 16-2-1:2014, CISPR 16-2-2:2010 ou CISPR 16-2-3:2010.

2 Références normatives

Les documents suivants sont cités en référence de manière normative, en intégralité ou en partie, dans le présent document et sont indispensables pour son application. Pour les références datées, seule l'édition citée s'applique. Pour les références non datées, la dernière édition du document de référence s'applique (y compris les éventuels amendements).

CISPR 11:2015, *Appareils industriels, scientifiques et médicaux – Caractéristiques de perturbations radioélectriques – Limites et méthodes de mesure*

CISPR 14-1:2005, *Compatibilité électromagnétique – Exigences pour les appareils électrodomestiques, outillages électriques et appareils analogues – Partie 1: Emission*

CISPR 14-1:2005/AMD1:2008

CISPR 14-1:2005/AMD2:2011

CISPR 16-2-1:2014, *Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Partie 2-1: Méthodes de mesure des perturbations et de l'immunité – Mesures des perturbations conduites*

CISPR 16-2-2:2010, *Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Partie 2-2: Méthodes de mesure des perturbations et de l'immunité – Mesure de la puissance perturbatrice*

CISPR 16-2-3:2010, *Spécifications des méthodes et des appareils de mesure des perturbations radioélectriques et de l'immunité aux perturbations radioélectriques – Partie 2-3: Méthodes de mesure des perturbations et de l'immunité – Mesures des perturbations rayonnées*

CISPR 16-2-3:2010/AMD1:2010

CISPR 16-2-3:2010/AMD2:2014

CISPR TR 16-3:2010, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 3: CISPR technical reports* (disponible en anglais seulement)

CISPR TR 16-3:2010/AMD1:2012

CISPR TR 16-3:2010/AMD2:2015

IEC 60050-161:1990, *Vocabulaire Electrotechnique International (VEI) – Chapitre 161:*

Compatibilité électromagnétique

IEC 60050-161:1990/AMD1:1997

IEC 60050-161:1990/AMD2:1998

IEC 60050-161:1990/AMD3:2014

IEC 60050-161:1990/AMD4:2014

IEC 60050-161:1990/AMD5:2015

3 Termes et définitions

Pour les besoins du présent document les termes et définitions donnés dans l'IEC 60050-161, ainsi que les suivants s'appliquent.

3.1

largeur de bande

B_n

largeur de la courbe de sélectivité globale du récepteur entre deux points situés à un affaiblissement déterminé en dessous de la réponse en milieu de bande

Note 1 à l'article: n est l'affaiblissement exprimé en dB.

3.2

plage de lecture du CISPR

plage spécifiée par le fabricant, donnant les indications maximale et minimale de l'appareil de mesure, dans laquelle le récepteur de mesure satisfait aux exigences de la présente partie de la CISPR 16

3.3

constante de temps à la charge électrique

T_C

durée nécessaire, après l'application instantanée d'une tension sinusoïdale constante à l'étage précédant immédiatement l'entrée du détecteur, pour que la tension de sortie du détecteur atteigne 63 % de sa valeur finale

Note 1 à l'article: Cette constante de temps est déterminée de la façon suivante: un signal sinusoïdal, d'amplitude constante et dont la fréquence est égale à la fréquence centrale de l'amplificateur à fréquence intermédiaire, est appliqué à l'entrée de l'étage précédant immédiatement le détecteur. L'indication D , d'un instrument sans inertie (par exemple, un oscilloscope) branché à une borne du circuit amplificateur à courant continu de façon à ne pas affecter le comportement du détecteur, est notée.

Le niveau du signal est choisi de telle façon que la réponse des étages concernés reste dans la plage de fonctionnement linéaire. Un train de signaux sinusoïdaux de même niveau est ensuite appliqué, dont l'enveloppe est rectangulaire et dont la durée est limitée de sorte que l'indication correspondante soit de $0,63 D$. La durée de ce signal est égale au temps de charge du détecteur.

3.4

constante de temps à la décharge électrique

T_D

durée nécessaire, après la coupure instantanée d'une tension sinusoïdale constante appliquée à l'étage précédant immédiatement l'entrée du détecteur, pour que l'indication à la sortie du détecteur tombe à 37 % de sa valeur initiale

Note 1 à l'article: La méthode de mesure est analogue à celle de la constante de temps à la charge, mais au lieu d'appliquer un signal pendant une durée limitée, le signal est interrompu pendant une durée définie. Le temps nécessaire pour que la déviation tombe à 0,37 D est la constante de temps à la décharge du détecteur.

3.5

aire de l'impulsion

A_{imp}

aire englobée par la tension en fonction du temps d'une impulsion, définie par l'intégrale:

$$A_{\text{imp}} = \int_{-\infty}^{+\infty} V(t) dt \quad (1)$$

Note 1 à l'article: L'aire de l'impulsion, parfois appelée "tenue aux ondes de choc", s'exprime en général en μVs ou $\text{dB}(\mu\text{Vs})$.

Note 2 à l'article: La densité spectrale (D) est liée à l'aire d'impulsion et s'exprime en $\mu\text{V}/\text{MHz}$ ou $\text{dB}(\mu\text{V}/\text{MHz})$. Pour les impulsions rectangulaires de largeur T aux fréquences $f \ll 1/T$, la relation D ($\mu\text{V}/\text{MHz}$) = $\sqrt{2} \times 10^6 A_{\text{imp}}$ (μVs) s'applique.

3.6

bande passante en impulsion

B_{imp}

$$B_{\text{imp}} = \frac{A(t)_{\text{max}}}{2G_0 \times A_{\text{imp}}} \quad (2)$$

où

$A(t)_{\text{max}}$ est la crête de l'enveloppe à la sortie en fréquence intermédiaire du récepteur lorsqu'une aire d'impulsion A_{imp} est appliquée à l'entrée du récepteur;

G_0 est le gain du circuit à la fréquence centrale.

En particulier, pour deux transformateurs accordés à couplage critique,

$$B_{\text{imp}} = 1,05 B_6 = 1,31 B_3 \quad (3)$$

où B_6 et B_3 sont respectivement les largeurs de bandes aux points -6 dB et -3 dB

Note 1 à l'article: Voir A.2 pour plus d'informations.

3.7

récepteur de mesure

appareil de mesure, par exemple un voltmètre accordable, un récepteur de perturbation électromagnétique (EMI), un analyseur de spectre ou un appareil de mesure à FFT avec ou sans présélection qui satisfait aux exigences des parties applicables de la présente norme

Note 1 à l'article: Voir l'Annexe I pour plus d'informations.

3.8

constante de temps mécanique d'un appareil indicateur réglé à l'amortissement critique

T_M

$$T_M = \frac{T_L}{2\pi} \quad (4)$$

où T_L est la période d'oscillation libre de l'instrument en l'absence d'amortissement

Note 1 à l'article: Pour un instrument réglé à l'amortissement critique, l'équation de mouvement du système peut être écrite de la façon suivante:

$$T_M^2 \left(\frac{d^2 \alpha}{dt^2} \right) + 2T_M \frac{d\alpha}{dt} + \alpha = ki \quad (5)$$

où

α est la déviation;

i est le courant traversant l'instrument; et

k est une constante.

Il peut être déduit de cette relation que cette constante de temps est aussi égale à la durée de l'impulsion rectangulaire (d'amplitude constante) qui produit une déviation égale à 35 % de la déviation stabilisée produite par un courant continu de même amplitude que celle de l'impulsion rectangulaire.

Note 2 à l'article: Les méthodes de mesure et de réglage sont déduites de l'une des méthodes suivantes:

- la période d'oscillation libre ayant été réglée à $2\pi T_M$, l'amortissement est ajusté de façon à avoir $\alpha T = 0,35 \alpha_{\max}$
- lorsque la période de l'oscillation ne peut pas être mesurée, l'amortissement est réglé de façon à être juste en dessous de la valeur critique, afin que le dépassement ne soit pas supérieur à 5 % et que le moment d'inertie du mouvement soit tel que $\alpha T = 0,35 \alpha_{\max}$.

3.9

réserve de linéarité

rapport du niveau correspondant à la plage de fonctionnement linéaire pratique d'un circuit (ou d'un groupe de circuits) et du niveau correspondant à la déviation pleine échelle de l'appareil indicateur

Note 1 à l'article: Le niveau maximal pour lequel la réponse stabilisée d'un circuit (ou d'un groupe de circuits) ne s'écarte pas de plus de 1 dB de la linéarité idéale définit la plage de fonctionnement linéaire pratique du circuit (ou du groupe de circuits).

3.10

tension symétrique

tension de perturbation radioélectrique apparaissant entre les deux fils dans un circuit bifilaire, tel qu'une alimentation monophasée. Cette tension est parfois appelée tension de mode différentiel. Si V_a est la tension vectorielle entre une des bornes d'alimentation et la terre et V_b la tension vectorielle entre l'autre borne d'alimentation et la terre, la tension symétrique est la différence vectorielle ($V_a - V_b$)

3.11

pondération (d'une perturbation par impulsion, par exemple)

conversion (la plupart du temps réduction) qui dépend de la fréquence de répétition d'impulsions (PRF) d'un niveau de tension d'impulsion détecté en crête en une indication qui correspond à l'effet d'interférence sur la réception radio

Note 1 à l'article: Pour le récepteur analogique, la gêne psychophysique de l'interférence est une grandeur subjective (sonore ou visuelle, généralement pas un certain nombre d'incompréhensions d'un texte parlé).

Note 2 à l'article: Pour le récepteur numérique, l'effet d'interférence est une grandeur objective qui peut être définie soit par le taux d'erreur critique sur les bits (BER) ou la probabilité d'erreur critique sur les bits (BEP) pour

lesquels une correction d'erreur parfaite peut encore apparaître, soit par un autre paramètre objectif et reproductible.

3.11.1

mesure de perturbation pondérée

mesure de perturbation utilisant un détecteur de pondération

3.11.2

caractéristique de pondération

le niveau de tension de crête en fonction de la PRF pour un effet constant sur un système de radiocommunication spécifique, c'est-à-dire que la perturbation est pondérée par le système de radiocommunication lui-même

3.11.3

détecteur de pondération

détecteur qui offre une fonction de pondération acceptée

3.11.4

facteur de pondération

valeur de la fonction de pondération par rapport à une PRF de référence ou par rapport à la valeur de crête

Note 1 à l'article: Le facteur de pondération est exprimé en dB.

3.11.5

fonction de pondération

courbe de pondération

relation entre le niveau de tension d'entrée de crête et la PRF pour l'indication de niveau constant d'un récepteur de mesure avec un détecteur de pondération, c'est-à-dire la courbe de réponse d'un récepteur de mesure à des impulsions répétées

3.12

mesure du temps

T_m

temps effectif, cohérent pour un résultat de mesure à une fréquence donnée (dans certains domaines, appelé temps de maintien)

- pour le détecteur crête, le temps effectif pour détecter le niveau maximum de l'enveloppe du signal
- pour le détecteur quasi-crête, le temps effectif pour mesurer le maximum de l'enveloppe pondérée
- pour le détecteur moyen, le temps effectif pour moyenner l'enveloppe du signal
- pour le détecteur de valeur efficace, le temps effectif pour déterminer la valeur efficace de l'enveloppe du signal

3.13

étalonnage

opération qui, dans des conditions spécifiées, établit en une première étape une relation entre les valeurs et les incertitudes de mesure associées qui sont fournies par des étalons et les indications correspondantes avec les incertitudes associées, puis utilise en une seconde étape cette information pour établir une relation permettant d'obtenir un résultat de mesure à partir d'une indication

Note 1 à l'article: Un étalonnage peut être exprimé sous la forme d'un énoncé, d'une fonction d'étalonnage, d'un diagramme d'étalonnage, d'une courbe d'étalonnage ou d'une table d'étalonnage. Dans certains cas, il peut consister en une correction additive ou multiplicative de l'indication avec une incertitude de mesure associée.

Note 2 à l'article: Il convient de ne pas confondre l'étalonnage avec l'ajustage d'un système de mesure, souvent appelé improprement "auto-étalonnage", ni avec la vérification de l'étalonnage.

Note 3 à l'article: La seule première étape dans la définition est souvent perçue comme étant l'étalonnage.

[SOURCE: ISO/IEC Guide 99:2007, 2.39] [17]¹

3.14

vérification

fourniture de preuves tangibles qu'une entité donnée satisfait à des exigences spécifiées

EXEMPLE Vérifier si les fonctions d'un appareil de mesure ou d'un matériel auxiliaire, tel qu'un dispositif d'absorption en mode commun (CMAD, Common Mode Absorption Device), satisfont aux spécifications énoncées, telles que celles données dans une fiche technique.

[SOURCE: ISO/IEC Guide 99:2007, 2.44, modifiée – ajout d'un exemple] [17]

3.15

ajustage (d'un système de mesure)

ensemble d'opérations réalisées sur un système de mesure pour qu'il fournisse des indications prescrites correspondant à des valeurs données des grandeurs à mesurer

Note 1 à l'article: Divers types d'ajustage d'un système de mesure sont le réglage de zéro, le réglage de décalage, le réglage d'étendue (appelé aussi réglage de gain).

Note 2 à l'article: Il convient de ne pas confondre l'ajustage d'un système de mesure avec son étalonnage, qui est un préalable à l'ajustage.

Note 3 à l'article: Après un ajustage d'un système de mesure, le système doit en général être de nouveau étalonné.

[SOURCE: ISO/IEC Guide 99:2007, 3.11] [17]

3.16

correction

compensation d'un effet systématique connu

Note 1 à l'article: Voir l'ISO/IEC Guide 98-3:2008, 3.2.3 [16] pour une explication du concept d'effet systématique.

Note 2 à l'article: La modification peut prendre différentes formes, telles que l'addition d'une valeur ou la multiplication par un facteur, ou peut se déduire d'une table.

[SOURCE: ISO/IEC Guide 99:2007, 2.53] [17]

3.17

traçabilité (métrologique)

propriété d'un résultat de mesure selon laquelle ce résultat peut être relié à une référence par l'intermédiaire d'une chaîne ininterrompue et documentée d'étalonnages dont chacun contribue à l'incertitude de mesure

[SOURCE: ISO/IEC Guide 99:2007, 2.41] [17]

4 Récepteurs de mesure de quasi-crête pour la plage de fréquences de 9 kHz à 1 000 MHz

4.1 Généralités

Les spécifications du récepteur dépendent de la fréquence d'utilisation. Il existe une spécification de récepteur couvrant la plage de fréquences de 9 kHz à 150 kHz (Bande A), une couvrant la gamme de 150 kHz à 30 MHz (Bande B), une couvrant la gamme de 30 MHz à 300 MHz (Bande C), et une couvrant la gamme de 300 MHz à 1 000 MHz (Bande D). Les caractéristiques fondamentales d'un appareil de mesure de quasi-crête sont données à l'Annexe H.

¹ Les chiffres entre crochets renvoient à la Bibliographie.

Les analyseurs de spectre et les appareils de mesure à FFT qui satisfont aux exigences du présent article peuvent être utilisés pour les mesures de conformité. Pour les mesures d'émissions, les appareils de mesure à FFT doivent échantillonner et évaluer le signal de manière continue au cours de la période de mesure.

4.2 Impédance d'entrée

Le circuit d'entrée des récepteurs de mesure doit être asymétrique. Lorsque les réglages des commandes du récepteur sont dans la plage de lecture du CISPR, l'impédance d'entrée nominale doit être de 50 Ω avec un rapport d'ondes stationnaires (ROS) ne dépassant ni 2,0:1 lorsque l'affaiblissement en radiofréquence (RF) est de 0 dB ni 1,2:1 lorsque l'affaiblissement RF est de 10 dB ou plus.

Impédance d'entrée symétrique dans la plage de fréquences de 9 kHz à 30 MHz: pour permettre des mesures symétriques, un transformateur d'entrée symétrique est utilisé. L'impédance d'entrée préférentielle dans la plage de fréquences comprises entre 9 kHz et 150 kHz est de 600 Ω . Cette impédance d'entrée symétrique peut être incorporée soit dans le réseau fictif symétrique nécessaire au couplage avec le récepteur, soit dans le récepteur de mesure.

4.3 Précision de la tension sinusoïdale

La précision des mesures en tension sinusoïdale doit être meilleure que ± 2 dB lorsque l'appareil mesure un signal sinusoïdal avec une impédance de source résistive de 50 Ω .

4.4 Réponses aux impulsions

4.4.1 Réponse en amplitude (étalonnage absolu)

En se référant au Tableau 1, la réponse du récepteur de mesure à des impulsions ayant une aire en circuit ouvert a) μ Vs (microvolt-seconde) f.é.m. sous une impédance de source de 50 Ω ayant un spectre uniforme jusqu'à au moins b) MHz, répétées à une fréquence de c) Hz doit être, à toutes les fréquences d'accord, égale à la réponse à un signal sinusoïdal non modulé, à la fréquence d'accord et ayant une f.é.m. de 2 mV en valeur efficace [66 dB(μ V)].

Si des préamplificateurs externes sont utilisés, voir l'Annexe J pour les exigences applicables.

Les impédances de source du générateur d'impulsions et du générateur de signaux doivent être identiques. Une tolérance de $\pm 1,5$ dB doit être autorisée sur le niveau de la tension sinusoïdale.

Tableau 1 – Caractéristiques des impulsions d'essais pour les récepteurs de mesure de quasi-crête

Plage de fréquences	a) μ Vs	b) MHz	c) Hz
9 kHz à 150 kHz	13,5	0,15	25
0,15 MHz à 30 MHz	0,316	30	100
30 MHz à 300 MHz	0,044	300	100
300 MHz à 1 000 MHz	0,044	1 000	100

NOTE Les Annexes B et C décrivent les méthodes pour la détermination des caractéristiques de sortie d'un générateur d'impulsions destiné à être utilisé dans les essais des exigences du présent paragraphe.

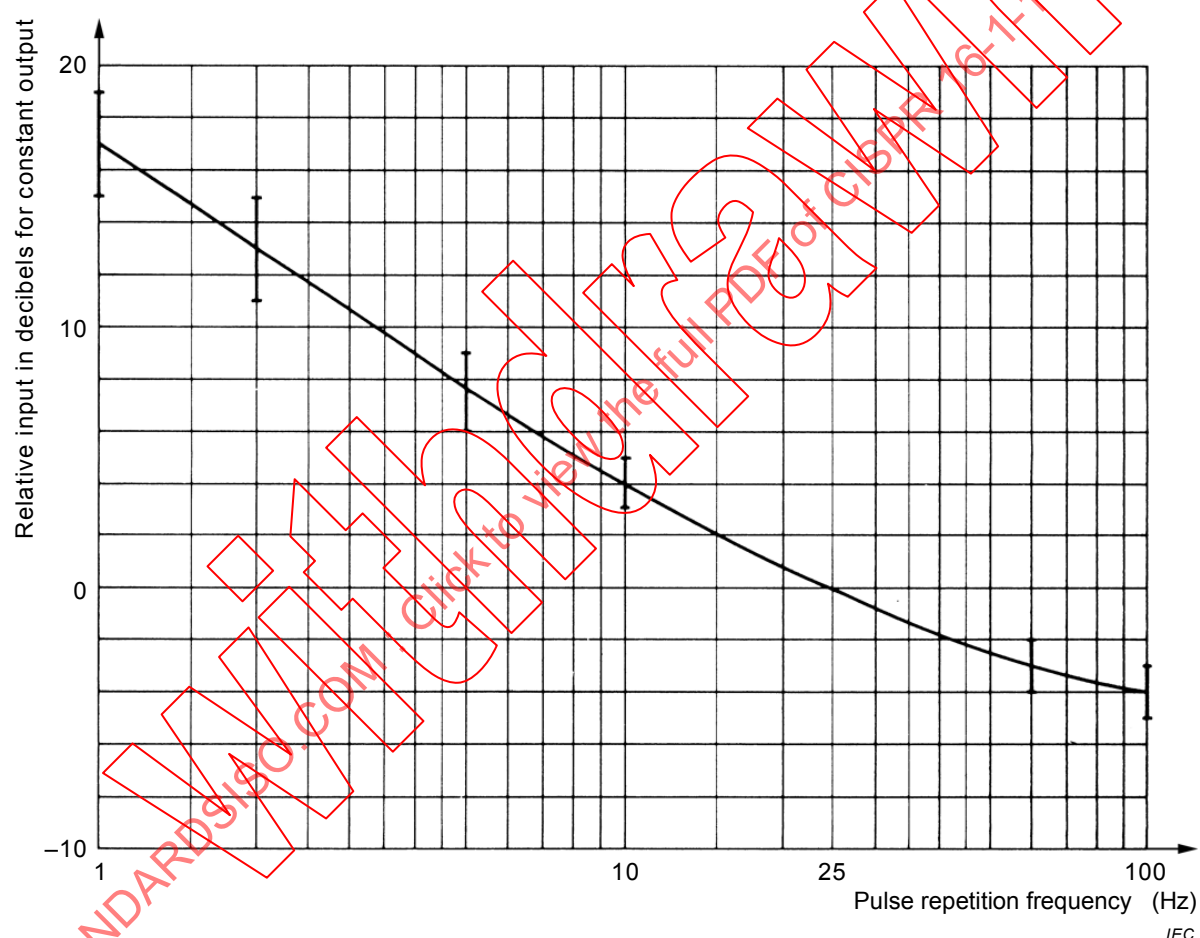
4.4.2 Variations en fonction de la fréquence de répétition (étalonnage relatif)

La réponse du récepteur de mesure à des impulsions répétées doit être telle que, pour une indication constante du récepteur de mesure de 20 dB(μ V), par exemple, la relation entre

l'amplitude d'impulsion et la fréquence de répétition soit conforme à la Figure 1, à la Figure 2, à la Figure 3 et à la Figure 4.

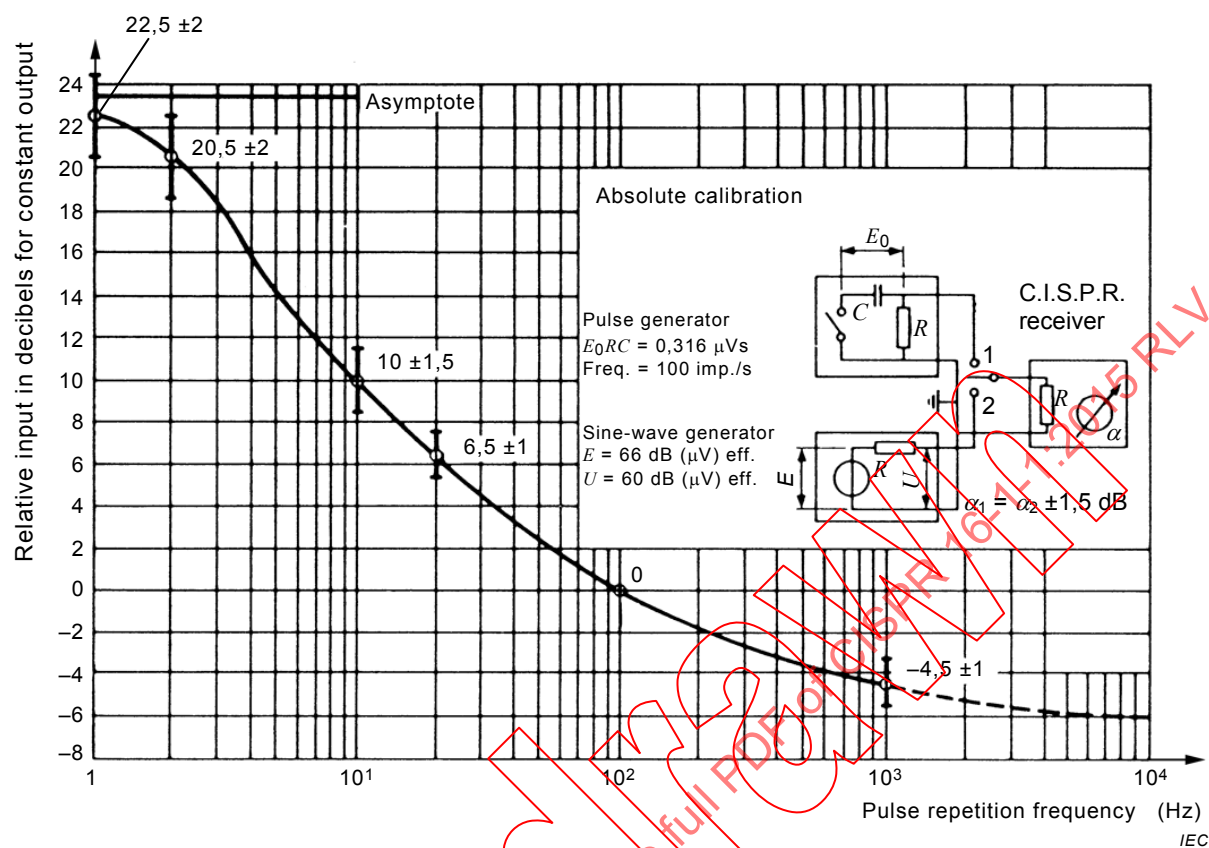
En alternative, la réponse du récepteur de mesure à des impulsions répétées doit être telle que, pour un réglage de tension constant des fréquences du générateur d'impulsions de 50 dB(μV), par exemple, aux fréquences de répétition de 25 Hz (Bande A) et de 100 Hz (Bandes B, C et D), la relation entre l'indication et la fréquence de répétition du récepteur soit conforme à la Figure 1, à la Figure 2, à la Figure 3 et à la Figure 4 dans des conditions de signe opposé.

Pour toutes les mesures, un rapport signal sur bruit suffisant est exigé. L'utilisation d'un atténuateur de 10 dB en sortie du générateur d'impulsions est recommandée.



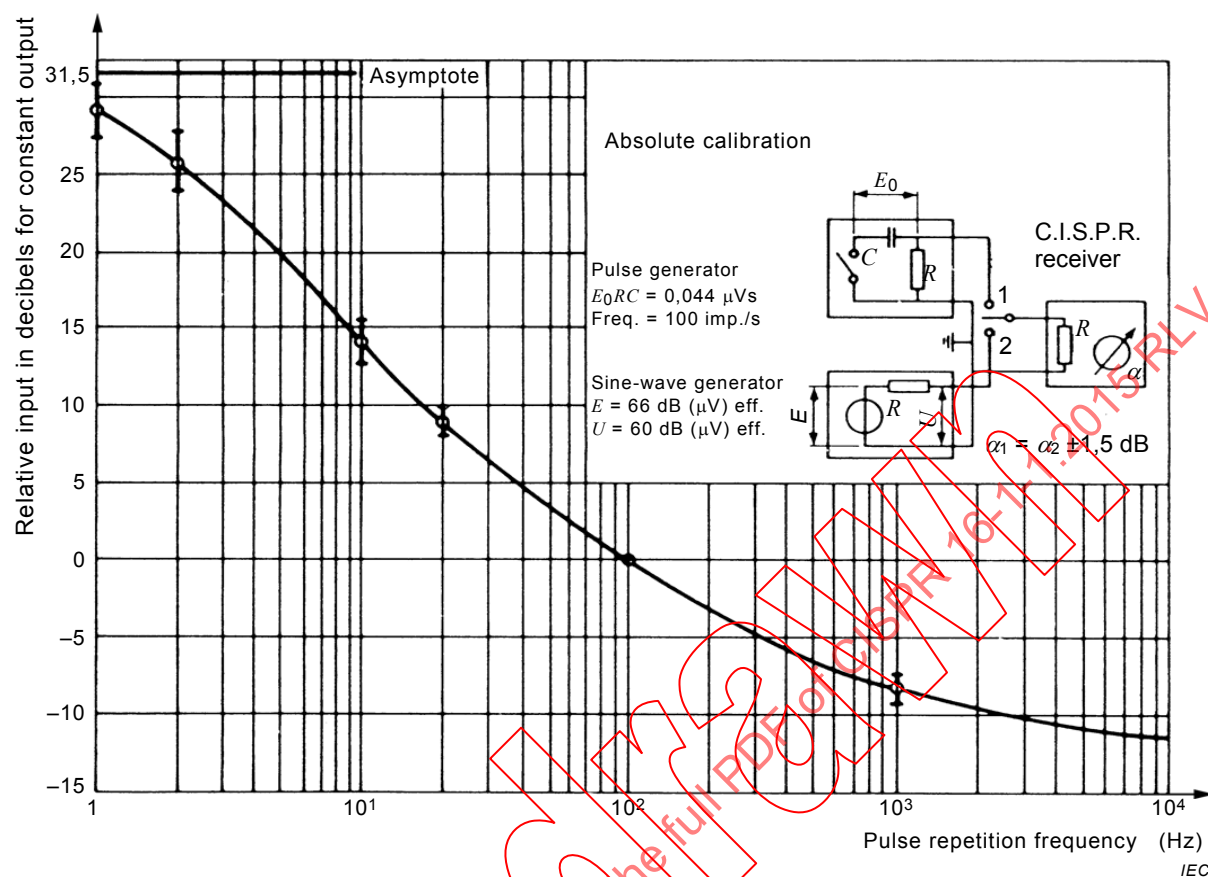
Anglais	Français
Relative input in decibels for constant output	Entrée relative en décibels pour la sortie constante
Pulse repetition frequency (Hz)	Fréquence de répétition d'impulsion (Hz)

Figure 1 – Courbe de réponse aux impulsions (Bande A)



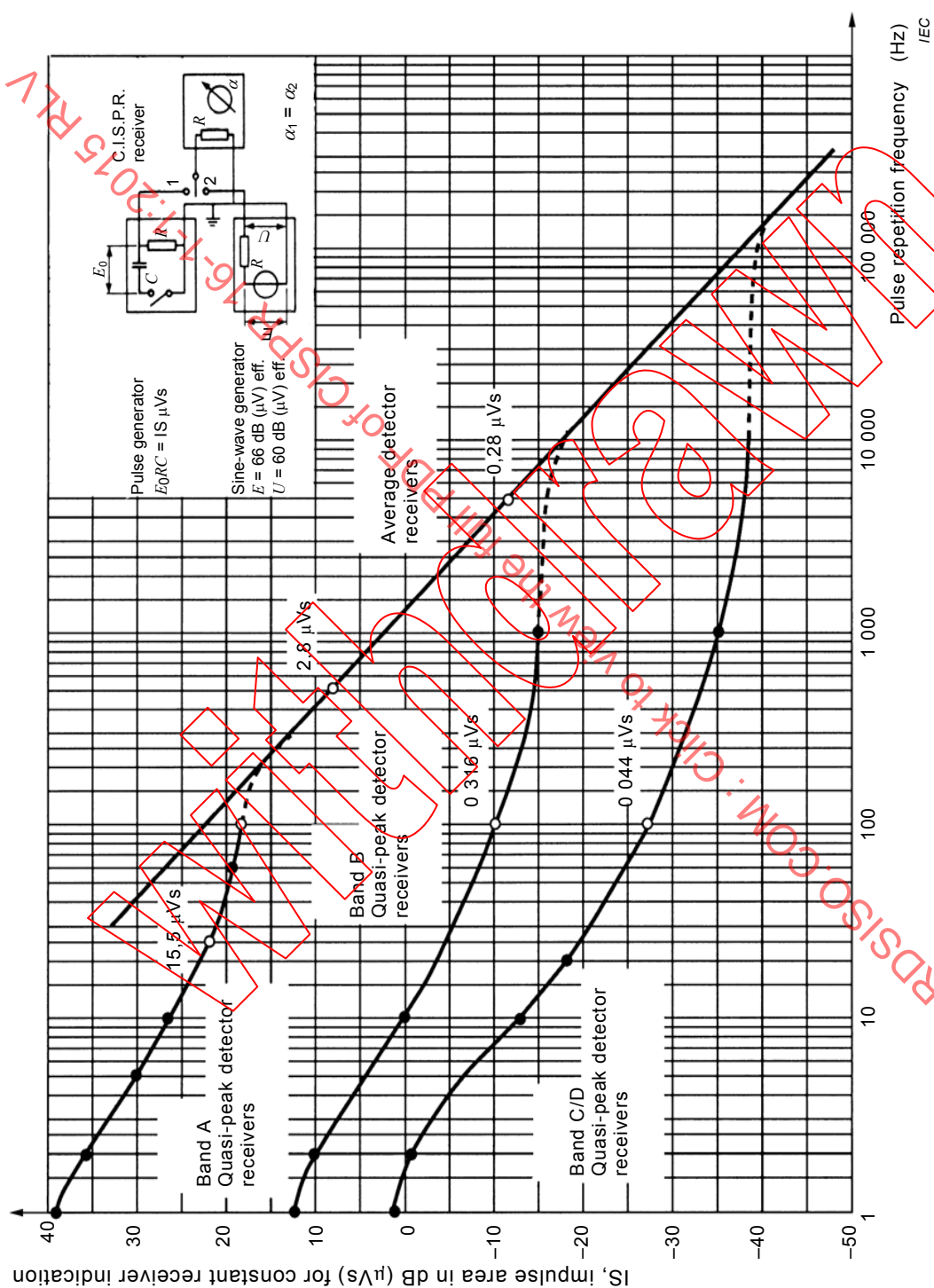
Anglais	Français
Relative input in decibels for constant output	Entrée relative en décibels pour la sortie constante
Absolute calibration	Étalonnage absolu
Pulse generator	Générateur d'impulsions
CISPR receiver	Récepteur CISPR
Sine-wave generator	Générateur d'onde sinusoïdale
Pulse repetition frequency	Fréquence de répétition d'impulsion
Asymptote	Asymptote

Figure 2 – Courbe de réponse aux impulsions (Bande B)



Anglais	Français
Relative input in decibels for constant output	Entrée relative en décibels pour la sortie constante
Absolute calibration	Étalonnage absolu
Pulse generator	Générateur d'impulsions
CISPR receiver	Récepteur CISPR
Sine-wave generator	Générateur d'onde sinusoïdale
Pulse repetition frequency	Fréquence de répétition d'impulsion
Asymptote	Asymptote

Figure 3 – Courbe de réponse aux impulsions (Bandes C et D)



Anglais	Français
IS, impulse area in dB (μ Vs) for constant receiver indication	IS, aire d'impulsion en dB (μ Vs) pour indication de récepteur constante
Band A Quasi-peak detector receivers	Bande A Récepteurs à détecteur de quasi-crête
Band B Quasi-peak detector receivers	Bande B Récepteurs à détecteur de quasi-crête
Average detector receivers	Récepteurs à détecteur de valeur moyenne
Band C/D Quasi-peak detector receivers	Bande C/D Récepteurs à détecteur de quasi-crête
Pulse generator	Générateur d'impulsions
Sine-wave generator	Générateur d'onde sinusoïdale
CISPR receiver	Récepteur CISPR
Pulse repetition frequency	Fréquence de répétition d'impulsion

NOTE "IS" est l'abréviation utilisée pour V_{top} dans les éditions antérieures

Figure 4 – Courbe de réponse théorique aux impulsions de récepteurs à détecteur de quasi-crête et de valeur moyenne (voir 6.5.4)

La courbe de réponse d'un récepteur de mesure particulier doit être comprise dans les limites définies dans la figure appropriée et quantifiée au Tableau 2. Pour les analyseurs de spectre sans présélection, les exigences du Tableau 2 pour les fréquences de répétition d'impulsions inférieures à 20 Hz ne sont pas applicables. L'utilisation de tels appareils pour les essais de conformité est soumise à des conditions. Si de tels analyseurs de spectres sont utilisés pour les mesures, l'utilisateur doit vérifier et documenter que l'équipement en essai n'émet pas de signaux à large bande à des fréquences de répétition d'impulsions de 20 Hz ou moins. Une détermination de l'adéquation d'un analyseur de spectre aux essais doit être réalisée en appliquant la procédure donnée dans l'Annexe B de la CISPR 16-2-1:2014, l'Annexe B de la CISPR 16-2-2:2010, ou l'Annexe B de la CISPR 16-2-3:2010.

La réponse impulsionnelle est réduite en raison de la surcharge à l'entrée du récepteur aux fréquences supérieures à 300 MHz. Les valeurs marquées d'un astérisque (*) au Tableau 2 sont facultatives et ne sont pas essentielles.

Tableau 2 – Réponses aux impulsions des récepteurs de mesure de quasi-crête

Fréquence de répétition Hz	Niveau relatif équivalent en dB de l'impulsion pour une bande de fréquences données			
	Bande A 9 kHz à 150 kHz	Bande B 0,15 MHz à 30 MHz	Bande C 30 MHz à 300 MHz	Bande D 300 MHz à 1 000 MHz
1 000	Note 4	$-4,5 \pm 1,0$	$-8,0 \pm 1,0$	$-8,0 \pm 1,0$
100	$-4,0 \pm 1,0$	0 (réf.)	0 (réf.)	0 (réf.)
60	$-3,0 \pm 1,0$	–	–	–
25	0 (réf.)	–	–	–
20	–	$+6,5 \pm 1,0$	$+9,0 \pm 1,0$	$+9,0 \pm 1,0$
10	$+4,0 \pm 1,0$	$+10,0 \pm 1,5$	$+14,0 \pm 1,5$	$+14,0 \pm 1,5$
5	$+7,5 \pm 1,5$	–	–	–
2	$+13,0 \pm 2,0$	$+20,5 \pm 2,0$	$+26,0 \pm 2,0$	$+26,0 \pm 2,0^*$
1	$+17,0 \pm 2,0$	$+22,5 \pm 2,0$	$+28,5 \pm 2,0$	$+28,5 \pm 2,0^*$
Impulsion isolée	$+19,0 \pm 2,0$	$+23,5 \pm 2,0$	$+31,5 \pm 2,0$	$+31,5 \pm 2,0^*$

* Ces valeurs sont facultatives et non essentielles.

NOTE 1 L'influence des caractéristiques du récepteur sur sa réponse aux impulsions est traitée à l'Annexe D.

NOTE 2 Les relations entre les réponses aux impulsions d'un récepteur de quasi-crête et celles de récepteurs équipés d'autres types de détecteur sont données en 5.5, 6.5 et 7.5.

NOTE 3 Les courbes de réponse théorique aux impulsions des récepteurs à détecteur de quasi-crête et de valeur moyenne combinées sur une échelle absolue sont données à la Figure 4. L'ordonnée de la Figure 4 indique l'aire de l'impulsion en circuit ouvert, en dB(μVs) correspondant à la tension d'onde sinusoïdale en court-circuit de 66 dB(μV) en valeur efficace. L'indication sur un récepteur de mesure avec une entrée adaptée aux générateurs d'étalonnage est donc de 60 dB(μV). Lorsque la largeur de bande de mesure est inférieure à la fréquence de répétition des impulsions, les courbes de la Figure 4 sont valables lorsque le récepteur est accordé sur une raie discrète du spectre.

NOTE 4 Aucune réponse au-dessus de 100 Hz ne peut être spécifiée dans la plage de fréquences de 9 kHz à 150 kHz en raison du chevauchement des impulsions dans l'amplificateur à fréquence intermédiaire.

NOTE 5 L'Annexe A traite de la détermination de la courbe de réponse aux impulsions répétitives.

4.5 Sélectivité

4.5.1 Sélectivité globale (bande passante)

La courbe représentant la sélectivité globale du récepteur de mesure doit être dans les limites indiquées à la Figure 5, à la Figure 6 ou à la Figure 7.

La sélectivité doit être décrite par la variation, en fonction de la fréquence, de l'amplitude de la tension sinusoïdale d'entrée qui produit une indication constante sur le récepteur de mesure.

NOTE Pour la mesure des appareils exigeant une plus grande sélectivité à la transition entre 130 kHz et 150 kHz (par exemple pour les appareils pour la transmission de signaux sur le réseau électrique tels que définis dans l'EN 50065-1), un filtre passe-haut peut être ajouté avant le récepteur de mesure pour obtenir la sélectivité combinée du récepteur de mesure CISPR et du filtre passe-haut comme indiqué au Tableau 3.

Tableau 3 – Sélectivité combinée du récepteur de mesure CISPR et du filtre passe-haut

Fréquence kHz	Atténuation relative dB
150	≤ 1
146	≤ 6
145	≥ 6
140	≥ 34
130	≥ 81

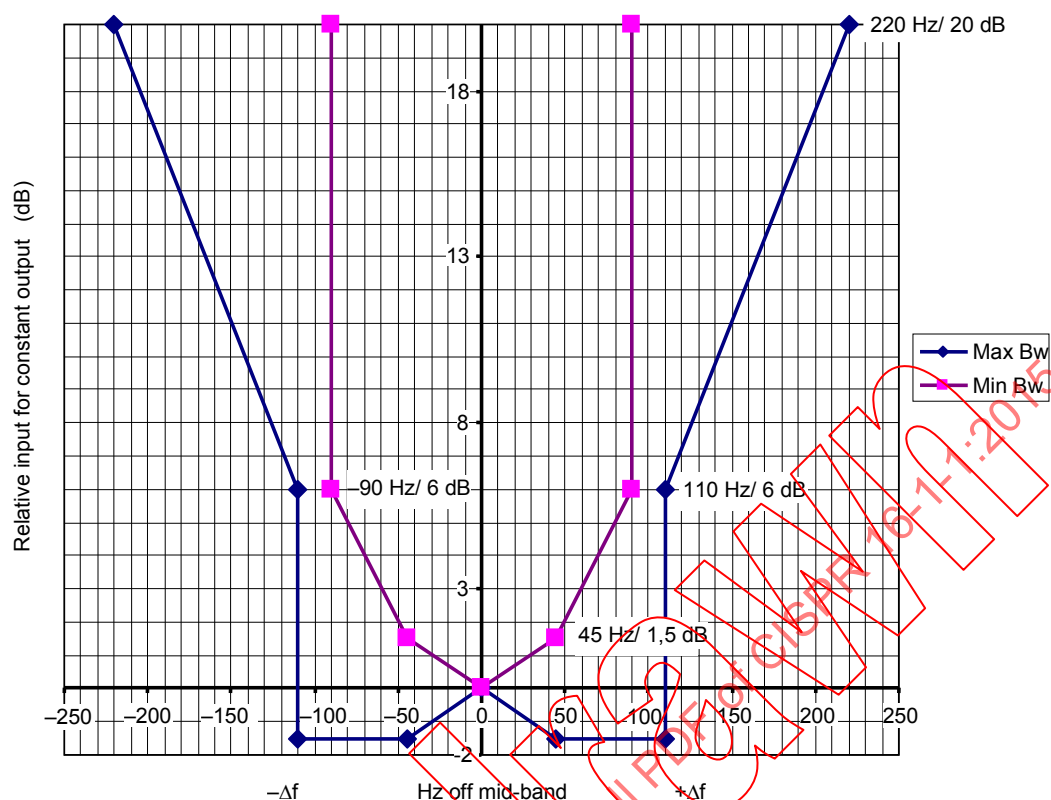
Il convient que le récepteur de mesure avec le filtre passe-haut satisfasse aux exigences de la présente norme.

4.5.2 Taux de rejet à la fréquence intermédiaire

Le rapport entre la tension sinusoïdale d'entrée à la fréquence intermédiaire et la tension sinusoïdale d'entrée à la fréquence d'accord qui produit la même indication sur le récepteur de mesure ne doit pas être inférieur à 40 dB. Si plusieurs fréquences intermédiaires sont utilisées, cette exigence doit être satisfaite pour chaque fréquence intermédiaire.

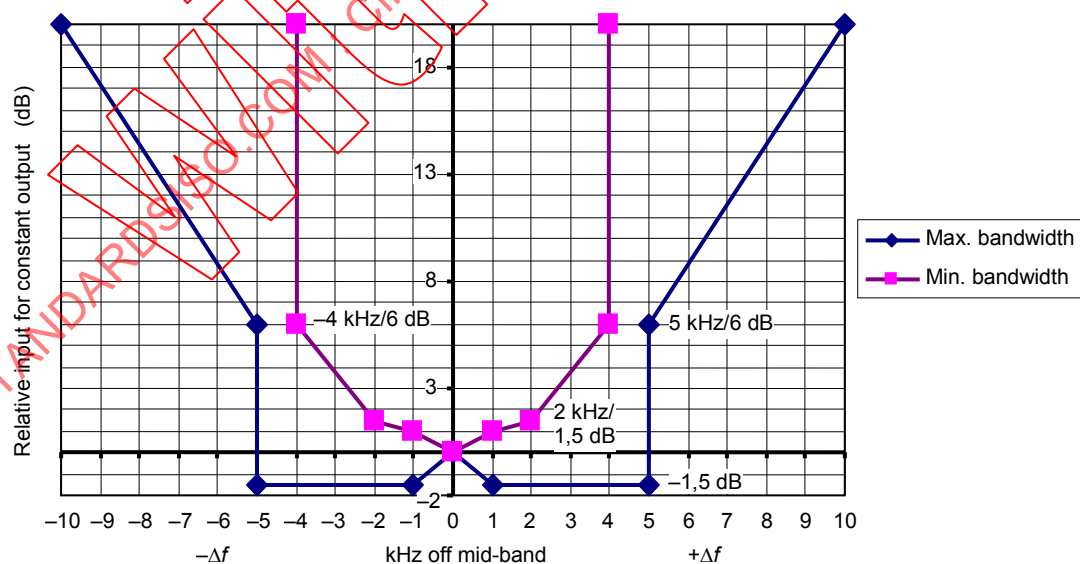
4.5.3 Taux de rejet à la fréquence conjuguée

Le rapport entre la tension sinusoïdale d'entrée à la fréquence conjuguée et la tension sinusoïdale d'entrée à la fréquence d'accord qui produit la même indication sur le récepteur de mesure ne doit pas être inférieur à 40 dB. Si plusieurs fréquences intermédiaires sont utilisées, cette exigence doit être satisfaite aux fréquences conjuguées correspondant à chaque fréquence intermédiaire.



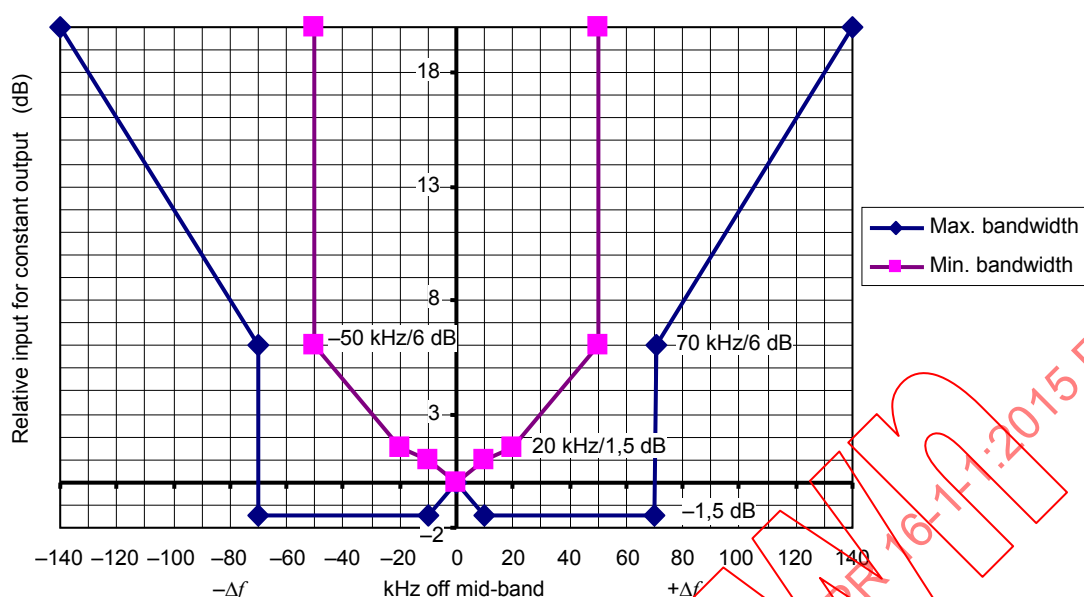
Anglais	Français
Relative input for constant output (dB)	Entrée relative pour la sortie constante (dB)
Max Bw	Largeur de bande max
Min Bw	Largeur de bande mini
Hz off mid-band	Désaccord (Hz)

Figure 5 – Limites de la sélectivité globale – Bande passante (voir 4.5.1, 5.6, 6.6, 7.6) (Bande A)



Anglais	Français
Relative input for constant output (dB)	Entrée relative pour la sortie constante (dB)
Max Bandwidth	Largeur de bande max
Min Bandwidth	Largeur de bande min
Hz off mid-band	Désaccord (Hz)

Figure 6 – Limites de la sélectivité globale – Bande passante (voir 4.5.1, 5.6, 6.6, 7.6) (Bande B)



Anglais	Français
Relative input for constant output (dB)	Entrée relative pour la sortie constante (dB)
Max Bandwidth	Largeur de bande max
Min Bandwidth	Largeur de bande min
Hz off mid-band	Désaccord (Hz)

**Figure 7 – Limites de la sélectivité globale –
Bande passante (voir 4.5.1, 5.6, 6.6, 7.6) (Bandes C et D)**

4.5.4 Autres réponses parasites

Le rapport entre la tension sinusoïdale d'entrée aux fréquences autres que celles spécifiées en 4.5.2 et 4.5.3 et la tension sinusoïdale d'entrée à la fréquence d'accord qui produit la même indication sur le récepteur de mesure ne doit pas être inférieur à 40 dB. Des exemples des fréquences auxquelles de telles réponses parasites peuvent se produire sont donnés ci-dessous:

$$\left(\frac{1}{m}\right)(nf_L \pm f_i) \text{ et } \left(\frac{1}{k}\right)(f_0) \quad (6)$$

où

m, n, k sont des nombres entiers;

f_L est la fréquence de l'oscillateur local;

f_i est la fréquence intermédiaire;

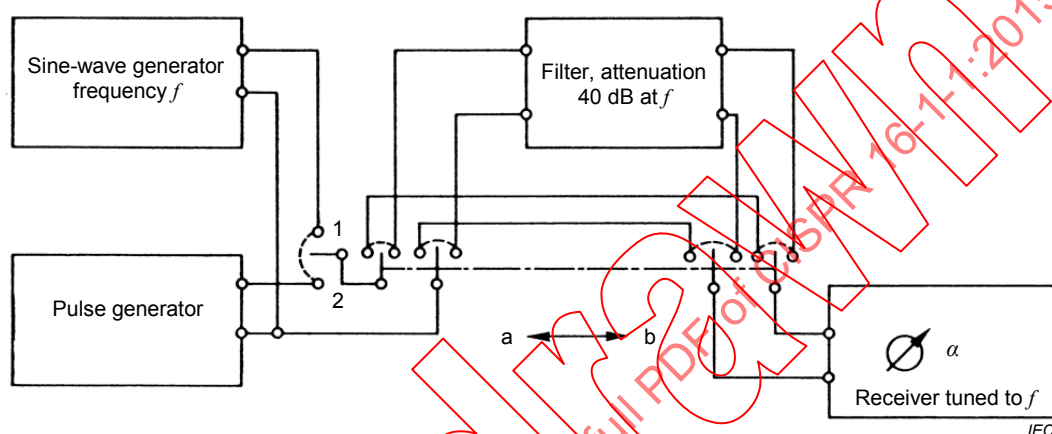
f_0 est la fréquence d'accord.

NOTE Si plusieurs fréquences intermédiaires sont utilisées, les fréquences f_L et f_i peuvent correspondre à chacune des fréquences de l'oscillateur local et des fréquences intermédiaires utilisées. De plus, des réponses parasites peuvent se produire lorsqu'aucun signal d'entrée n'est appliqué au récepteur de mesure; par exemple, quand les harmoniques des oscillateurs locaux présentent un écart de fréquence égal à l'une des fréquences intermédiaires. Les exigences du présent paragraphe ne peuvent donc pas s'appliquer dans ces derniers cas. Les effets de ces réponses parasites sont traités en 4.7. Il s'agit par exemple de sources de signaux parasites les oscillateurs locaux (ou leurs harmoniques), les horloges internes, les cartes électroniques d'ordinateur ainsi que les produits issus du mélange de ces sources avec le signal d'entrée dans le récepteur.

4.6 Limitation des effets d'intermodulation

L'influence des effets d'intermodulation sur la réponse du récepteur de mesure doit être réduite le plus possible. La méthode suivante doit être appliquée pour déterminer l'adéquation d'un appareil de mesure.

Installer l'appareil comme indiqué à la Figure 8. Le générateur d'impulsions a un spectre essentiellement uniforme jusqu'à la fréquence 3), mais inférieur d'au moins 10 dB à la fréquence 4) des fréquences données dans le Tableau 4. Le filtre coupe-bande a un affaiblissement à la fréquence d'essai d'au moins 40 dB. Sa largeur de bande, B_6 , par rapport à l'affaiblissement maximal du filtre doit être comprise entre les fréquences 1) et 2) données dans le Tableau 4.



Anglais	Français
Sine-wave generator frequency f	Fréquence f du générateur d'ondes sinusoïdales
Filter, attenuation 40 dB at f	Filtre, affaiblissement de 40 dB à f
Pulse generator	Générateur d'impulsions
Receiver tuned to f	Récepteur accordé à f

NOTE Suite au débat en 4.6, les réponses du récepteur de mesure sont:

$$\alpha_{1a} = \alpha_{2a}$$

$$\alpha_{1b} = \alpha_{1a} - 40 \text{ dB}$$

$$\alpha_{2b} = \alpha_{2a} - 36 \text{ dB}$$

Figure 8 – Schéma pour l'essai des effets d'intermodulation

Tableau 4 – Caractéristiques de largeur de bande pour l'essai d'intermodulation des récepteurs de mesure de quasi-crête

Plage de fréquences	1) kHz	2) kHz	3) MHz	4) MHz
9 kHz à 150 kHz (Bande A)	0,4	4	0,15	0,3
0,15 MHz à 30 MHz (Bande B)	20	200	30	60
30 MHz à 300 MHz (Bande C)	500	2 000	300	600
300 MHz à 1 000 MHz (Bande D)	500	6 000	1 000	2 000

Brancher la sortie du générateur d'onde sinusoïdale directement à l'entrée du récepteur de mesure et le régler pour obtenir une indication convenable. Remplacer le générateur d'onde sinusoïdale par le générateur d'impulsions et le régler pour obtenir la même indication. La fréquence de répétition des impulsions doit être de 100 Hz pour la bande A et de 1 000 Hz pour les autres bandes.

Le générateur d'impulsions étant branché comme indiqué ci-dessus, la mise en circuit du filtre doit introduire un affaiblissement au moins égal à 36 dB pour les récepteurs de mesure et d'au moins 20 dB pour les analyseurs de spectres sans présélection.

4.7 Limitation du bruit du récepteur et des signaux parasites internes

4.7.1 Bruit aléatoire

Le bruit de fond ne doit pas introduire d'erreur supérieure à 1 dB.

NOTE Le point auquel le bruit de fond produit une erreur de 1 dB peut être déterminé par l'application d'un signal S de telle sorte que l'indication de l'appareil de mesure soit largement supérieure (par exemple 40 dB) au niveau de bruit N . En réduisant le niveau du signal S , l'appareil de mesure va atteindre un point S_1 , tel que $(S_1 + N)$ dévie de 1 dB par rapport à la caractéristique linéaire.

4.7.2 Onde entretenue

L'existence de réponses parasites telles que celles décrites dans la note de 4.5.4 ne doit pas introduire d'erreur de mesure supérieure à 1 dB pour tout signal injecté dans le récepteur de mesure. Cette exigence doit être considérée remplie si le récepteur satisfait à 4.7.1 lorsqu'il est soumis à l'essai décrit en 4.7.1.

4.8 Efficacité d'écran

4.8.1 Généralités

L'efficacité d'écran est une mesure de l'aptitude d'un récepteur de mesure à fonctionner dans un champ électromagnétique sans dégradation. L'exigence s'applique aux récepteurs fonctionnant dans "la plage de lecture du CISPR" spécifiée par le fabricant comme indiqué en 3.2.

Le blindage du récepteur doit être tel que, lorsque ce dernier se trouve dans un champ électromagnétique ambiant de 3 V/m (non modulé) à n'importe quelle fréquence comprise entre 9 kHz et 1 000 MHz, l'erreur entraînée ne doit pas dépasser 1 dB, au maximum et au minimum de la plage de lecture du CISPR spécifiée par le fabricant du récepteur. Dans les cas où le récepteur de mesure ne satisfait pas à l'exigence des 3 V/m, la valeur du champ et la fréquence auxquelles l'erreur dépasse 1 dB doivent être indiquées par le fabricant. L'essai doit être effectué comme décrit ci-dessous.

Le récepteur est placé à l'intérieur d'une enceinte blindée. Un signal d'entrée est appliqué au récepteur par l'intermédiaire d'un câble de 2 m de longueur bien blindé (par exemple câble semi-rigide) à travers un connecteur de traversée monté sur la paroi de l'enveloppe et raccordé à un générateur de signaux placé à l'extérieur de l'enveloppe. Le niveau du signal d'entrée doit être réglé au maximum puis au minimum de la plage de lecture du CISPR, spécifiée par le fabricant du récepteur. Toutes les autres prises coaxiales du récepteur doivent être chargées par leur impédance caractéristique.

Seuls les câbles essentiels (par exemple câbles d'alimentation et câbles d'entrée) nécessaires à l'utilisation normale du récepteur de mesure dans sa configuration minimale (à l'exclusion des options telles que casques d'écoute) doivent être connectés pendant l'essai. Les câbles doivent avoir la longueur et la disposition correspondant à l'utilisation habituelle.

L'intensité du champ ambiant au voisinage du récepteur de mesure doit être mesurée par un mesureur de champ.

L'indication de l'appareil de mesure du récepteur en présence du champ électromagnétique ambiant ne doit pas différer de plus de 1 dB de celle donnée par l'appareil de mesure en l'absence du champ.

4.8.2 Limitation des émissions radioélectriques produites par le récepteur de mesure

4.8.2.1 Émissions conduites

La tension perturbatrice RF à tout point de connexion pour une ligne extérieure (pas uniquement aux bornes d'alimentation) ne doit pas dépasser les limites des appareils de classe B, spécifiées dans la CISPR 11. La mesure de la tension perturbatrice RF n'est toutefois pas exigée pour les conducteurs intérieurs des connexions blindées destinées aux appareils blindés. La puissance injectée par l'oscillateur local mesurée à l'entrée du récepteur de mesure, fermée sur son impédance caractéristique, ne doit pas dépasser 34 dB(pW) ce qui est équivalent à 51 dB(μ V) dans 50 Ω .

4.8.2.2 Émissions rayonnées

Le champ RF rayonné par le récepteur de mesure ne doit pas dépasser les limites des appareils de classe B, spécifiées dans la CISPR 11 pour la plage de fréquences de 9 kHz à 1 000 MHz. Les limites doivent également s'appliquer aux bandes de fréquences indiquées au Tableau 1 (fréquences ISM) de la même publication. Dans la plage de fréquences de 1 GHz à 18 GHz, la limite de 45 dB(pW) doit s'appliquer, sur la base des mesures ERP.

Avant d'effectuer des mesures d'émission conduite ou rayonnée, il est essentiel de vérifier que la contribution au bruit des appareils d'essai (par exemple commande de l'ordinateur) n'affecte pas les résultats de mesure.

4.9 Moyens de branchement à un analyseur de perturbations discontinues

Pour toutes les bandes, le récepteur de mesure de perturbations doit avoir une sortie à fréquence intermédiaire si l'appareil doit être utilisé pour la mesure des perturbations discontinues. La charge de cette sortie ne doit pas affecter l'indication de l'appareil de mesure.

5 Récepteurs de mesure avec détecteur de crête pour la plage de fréquences comprises entre 9 kHz et 18 GHz

5.1 Généralités

Le présent article définit les exigences applicables aux récepteurs de mesure utilisant un détecteur de crête lorsqu'ils sont utilisés pour la mesure des perturbations de type impulsif ou modulées en impulsion.

Les analyseurs de spectre et les appareils de mesure à FFT qui satisfont aux exigences du présent article peuvent être utilisés pour les mesures de conformité. Pour les mesures d'émissions, les appareils de mesure à FFT doivent échantillonner et évaluer le signal de manière continue au cours de la période de mesure.

5.2 Impédance d'entrée

L'accès d'entrée des récepteurs de mesure doit être asymétrique. Pour les réglages du récepteur se situant dans la plage de lecture du CISPR, l'impédance d'entrée nominale doit être de 50 Ω avec un ROS inférieur ou égal aux valeurs du Tableau 5.

Tableau 5 – Exigences relatives au ROS pour l'impédance d'entrée des récepteurs

Plage de fréquences	Affaiblissement RF dB	ROS
9 kHz à 1 GHz	0	2,0 à 1
9 kHz à 1 GHz	≥10	1,2 à 1
1 GHz à 18 GHz	0	3,0 à 1
1 GHz à 18 GHz	≥10	2,0 à 1

Impédance d'entrée symétrique dans la plage de fréquences de 9 kHz à 30 MHz: un transformateur d'entrée symétrique doit être utilisé pour les mesures symétriques (c'est-à-dire non raccordées à la terre). (L'impédance d'entrée préférentielle est de 600 Ω dans la plage de fréquences comprises entre 9 kHz et 150 kHz.) L'impédance d'entrée symétrique peut être incorporée soit dans le réseau fictif symétrique exigé pour le couplage avec le récepteur, soit dans le récepteur de mesure lui-même.

5.3 Caractéristiques fondamentales

5.3.1 Largeur de bande

Pour tout type de perturbations à large bande, la valeur réelle de la largeur de bande doit être donnée lorsque le niveau de perturbation est mentionné et que la largeur de bande est comprise dans les limites du Tableau 6.

Tableau 6 – Exigences de largeur de bande pour les récepteurs de mesure avec détecteur de crête

Plage de fréquences	Largeur de bande B_6	Largeur de bande de référence
9 kHz à 150 kHz (Bande A)	100 Hz à 300 Hz ^a	200 Hz (B_6)
0,15 MHz à 30 MHz (Bande B)	8 kHz à 10 kHz ^a	9 kHz (B_6)
30 MHz à 1 000 MHz (Bandes C et D)	100 kHz à 500 kHz ^a	120 kHz (B_6)
1 GHz à 18 GHz (Bande E)	300 kHz à 2 MHz ^a	1 MHz ^b (B_{imp})

^a Comme la réponse d'un récepteur de mesure à détection de crête aux impulsions non chevauchantes est proportionnelle à sa largeur de bande en impulsions, soit la largeur de bande réelle est mentionnée dans le résultat, soit le niveau peut être mentionné comme étant situé "dans une largeur de bande de 1 MHz", calculée en divisant la valeur mesurée par la largeur de bande en impulsions exprimée en MHz (voir 3.6). Pour d'autres types de perturbations à large bande, cette procédure peut introduire une erreur. Par conséquent, les données mesurées avec la largeur de bande de référence doivent prévaloir.

^b La largeur de bande sélectionnée doit être définie comme la largeur de bande en impulsions du récepteur de mesure avec une tolérance de ±10 %.

5.3.2 Rapport des constantes de temps de charge et de décharge

Afin d'obtenir sur l'indicateur de mesure une lecture à 10 % près de la valeur vraie de la crête à une fréquence de répétition de 1 Hz, le rapport entre la constante de temps de décharge et la constante de temps de charge doit être supérieur ou égal aux valeurs suivantes:

- a) $1,89 \times 10^4$ dans la plage de fréquences comprises entre 9 kHz et 150 kHz;
- b) $1,25 \times 10^6$ dans la plage de fréquences comprises entre 150 kHz et 30 MHz;
- c) $1,67 \times 10^7$ dans la plage de fréquences comprises entre 30 MHz et 1 000 MHz;
- d) $1,34 \times 10^8$ dans la plage de fréquences comprises entre 1 GHz et 18 GHz.

Si le récepteur d'essai est équipé d'une fonctionnalité de maintien de la valeur de crête, la durée de maintien doit pouvoir être réglée à des valeurs comprises entre 30 ms et 3 s.

NOTE Pour les récepteurs qui utilisent les techniques de maintien de crête (et une décharge forcée après le temps de maintien) ou de détection numérique de crête, l'exigence relative au rapport des constantes de temps à la charge et à la décharge n'est pas pertinente. Une fonction de maintien de maximum de l'affichage peut être utilisée pour les signaux avec des amplitudes variables dans le temps.

Si un analyseur de spectre est utilisé pour les mesures de crête, la bande vidéo ($B_{\text{vidéo}}$) doit être réglée sur une valeur supérieure ou égale à la bande de résolution ($B_{\text{résol}}$). Pour les mesures de crête, le résultat peut être lu sur l'afficheur de l'analyseur de spectre, avec le détecteur fonctionnant soit dans le mode linéaire, soit dans le mode logarithmique.

5.3.3 Réserve de linéarité

Pour les récepteurs de mesure de crête, il n'est pas nécessaire que la réserve de linéarité soit aussi élevée que pour d'autres types de récepteurs de mesure. Pour la plupart des détecteurs à lecture directe, la réserve de linéarité doit être légèrement supérieure à l'unité. La réserve de linéarité doit être adaptée aux constantes de temps utilisées (voir 5.3.2).

5.4 Précision de la tension sinusoïdale

La précision des mesures de tension sinusoïdale doit être meilleure que ± 2 dB ($\pm 2,5$ dB au-dessus de 1 GHz) lorsque l'appareil mesure un signal d'entrée sinusoïdal à l'aide d'une impédance de source résistive de 50 Ω .

5.5 Réponses aux impulsions

Jusqu'à 1 000 MHz, la réponse du récepteur de mesure aux impulsions de f.é.m. dont l'aire d'impulsion est de $1,4/B_{\text{imp}}$ mVs (où B_{imp} est en Hz) sous une impédance de source de 50 Ω , doit être égale à la réponse à un signal sinusoïdal non modulé à la fréquence d'accord ayant une f.é.m. de 2 mV en valeur efficace [66 dB(μ V)]. Les impédances de source du générateur d'impulsions et du générateur de signaux doivent être identiques. Les impulsions doivent avoir un spectre uniforme conformément au Tableau 2. Une tolérance de $\pm 1,5$ dB est autorisée pour le niveau de tension sinusoïdale et cette exigence s'applique à toutes les fréquences de répétition d'impulsion pour lesquelles aucune impulsion de chevauchement ne se produit à la sortie de l'amplificateur en fréquence intermédiaire.

NOTE 1 Les Annexes B et C décrivent les méthodes de détermination des caractéristiques de sortie des générateurs d'impulsions destinés à être utilisés pour le contrôle des exigences du présent paragraphe.

NOTE 2 À une cadence de répétition de 25 Hz pour la bande A et de 100 Hz pour les autres bandes, les relations entre les indications d'un récepteur de mesure de crête et celles d'un récepteur de mesure de quasi-crête avec la largeur de bande préférentielle sont données au Tableau 7.

Tableau 7 – Réponses comparatives aux impulsions des récepteurs de mesure de crête et de quasi-crête pour une même largeur de bande (plage de fréquences comprises entre 9 kHz et 1 000 MHz)

Fréquence	A_{imp} mVs	B_{imp} Hz	Rapport crête/quasi-crête (dB) pour une fréquence de répétition des impulsions	
			25 Hz	100 Hz
Bande A	$6,67 \times 10^{-3}$	$0,21 \times 10^3$	6,1	–
Bande B	$0,148 \times 10^{-3}$	$9,45 \times 10^3$	–	6,6
Bandes C et D	$0,011 \times 10^{-3}$	$126,0 \times 10^3$	–	12,0

NOTE 1 La réponse aux impulsions est basée sur l'utilisation de la largeur de bande de référence uniquement (voir Tableau 6).

NOTE 2 Les valeurs contenues dans ce tableau résultent de la spécification nominale des fonctions de pondération du détecteur. Par conséquent, la vérification par un laboratoire d'étalonnage n'est pas exigée.

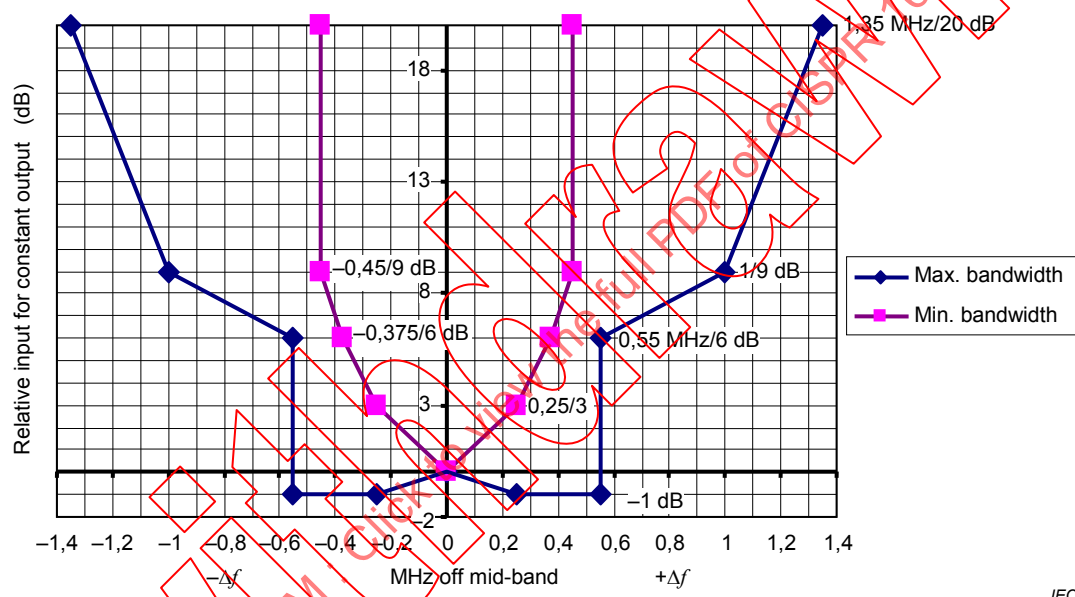
Au-dessus de 1 GHz, l'aire de l'impulsion exigée est définie à l'aide d'une porteuse modulée en impulsion à la fréquence d'essai, étant donné que les générateurs d'impulsions ayant un spectre uniforme jusqu'à 18 GHz ne sont pas réalisables. Voir E.6.

5.6 Sélectivité

Comme les exigences de largeur de bande décrites en 5.3.1 permettent de s'écarter des largeurs de bande données à la Figure 5, à la Figure 6 et à la Figure 7, les courbes de sélectivité s'appliquent aux récepteurs de mesure de crête en termes de forme seulement, et l'axe des fréquences doit être mis à l'échelle en conséquence. Par exemple, $B_0/2$ correspond à 100 Hz dans la Figure 5.

Les exigences de 4.5.2, 4.5.3 et 4.5.4 s'appliquent.

La courbe représentant la sélectivité globale de la largeur de bande de référence du récepteur de mesure pour la bande E doit se situer dans les limites de la Figure 9.



Anglais	Français
Relative input for constant output (dB)	Entrée relative pour la sortie constante (dB)
Max Bandwidth	Largeur de bande max
Min Bandwidth	Largeur de bande min
Hz off mid-band	Désaccord (Hz)

NOTE 1 Les limites pour la largeur de bande d'impulsion ne peuvent pas être représentées sur le diagramme car l'atténuation de filtre correspondante dépend du type de filtre. En conséquence, les limites pour les largeurs de bande à 6 dB et à 9 dB ont été données pour illustration.

NOTE 2 Les limites pour la sélectivité globale ont été déduites de celles de l'équipement utilisé au moment de l'introduction de l'exigence sur la sélectivité.

Figure 9 – Limites pour la sélectivité globale – Bande passante (Bande E)

5.7 Effets d'intermodulation, bruit du récepteur et blindage

Pour la plage de fréquences en dessous de 1 GHz, les exigences décrites en 4.6, 4.7 et 4.8 s'appliquent. Les Paragraphes 4.7 et 4.8.2 s'appliquent aussi à la bande E.

De plus, ce qui suit s'applique pour la bande E.

- Les exigences pour les effets d'intermodulation sont à l'étude.
- Filtre de présélection pour la bande E: lors de la mesure des signaux parasites de niveau faible en présence d'un signal fondamental fort pour certains appareils en essai, insérer un filtre au niveau de l'entrée du récepteur de mesure (à l'intérieur ou à l'extérieur) qui donne un affaiblissement adéquat à la fréquence fondamentale pour éviter de surcharger et d'endommager les circuits d'entrée du récepteur et de produire des harmoniques et des signaux d'intermodulation.
- Plusieurs filtres peuvent être exigés en présence de plusieurs fréquences fondamentales.

NOTE Un affaiblissement par un filtre de 30 dB à la fréquence fondamentale de l'appareil en essai est en général suffisant.

Les exigences relatives à l'efficacité d'écran, c'est-à-dire à l'immunité aux perturbations rayonnées ambiantes élevées, sont à l'étude.

6 Récepteurs de mesure avec détecteur de valeur moyenne pour la plage de fréquences comprises entre 9 kHz et 18 GHz

6.1 Généralités

Les récepteurs de mesure de valeur moyenne ne sont généralement pas utilisés pour la mesure des perturbations par impulsion. Ce type de récepteur a un détecteur conçu pour indiquer la valeur moyenne de l'enveloppe du signal traversant les étages en amont du détecteur. Le détecteur de valeur moyenne est utilisé pour la mesure de signaux à bande étroite afin de s'affranchir des problèmes associés soit à la modulation, soit à la présence de bruit à large bande.

Les analyseurs de spectre et les appareils de mesure à FFT qui satisfont aux exigences du présent article peuvent être utilisés pour les mesures de conformité. Pour les mesures d'émissions, les appareils de mesure à FFT doivent échantillonner et évaluer le signal de manière continue au cours de la période de mesure.

6.2 Impédance d'entrée

L'accès d'entrée du récepteur de mesure doit être asymétrique. Pour les réglages du récepteur de commande se situant dans la plage de lecture du CISPR, l'impédance d'entrée nominale doit être de 50 Ω avec un ROS ne dépassant pas les valeurs indiquées au Tableau 5.

Impédance d'entrée symétrique (équilibrée) dans la plage de fréquences comprises entre 9 kHz et 150 kHz: utiliser un transformateur d'entrée équilibré pour les mesures symétriques (c'est-à-dire non raccordées à la terre). (L'impédance d'entrée préférentielle est de 600 Ω dans la plage de fréquences comprises entre 9 kHz et 150 kHz). L'impédance d'entrée symétrique peut être incorporée soit dans le réseau fictif symétrique exigé pour le couplage avec le récepteur, soit dans le récepteur de mesure lui-même.

6.3 Caractéristiques fondamentales

6.3.1 Largeur de bande

Les largeurs de bande doivent être comprises dans les valeurs montrées au Tableau 8.

Tableau 8 – Exigences de largeur de bande pour les récepteurs de mesure avec détecteur de valeur moyenne

Plage de fréquences	Largeur de bande B_6	Largeur de bande de référence
9 kHz à 150 kHz (Bande A)	100 Hz à 300 Hz ^a	200 Hz (B_6)
150 kHz à 30 MHz (Bande B)	8 kHz à 10 kHz ^a	9 kHz (B_6)
30 MHz à 1 000 MHz (Bandes C et D)	100 kHz à 500 kHz ^a	120 kHz (B_6)
1 GHz à 18 GHz (Bande E)	300 kHz à 2 MHz ^a	1 MHz ^b (B_{imp})
^a La question de la largeur de bande est débattue en E.1. Si une largeur de bande autre que la largeur de bande de référence est utilisée, cela doit être mentionné là où le niveau de perturbation est indiqué.		
^b La largeur de bande sélectionnée doit être définie comme au Tableau 6.		

6.3.2 Réserve de linéarité

Pour les récepteurs dotés de détecteurs de valeur moyenne, la réserve de linéarité des circuits précédant le détecteur, pour une fréquence de répétition de n Hz doit être B_{imp}/n , avec B_{imp} en Hz.

Le récepteur ne doit pas être en surcharge pour des cadences d'impulsions supérieures ou égales à 25 Hz pour la bande A, 500 Hz pour la bande B et 5 000 Hz pour les bandes C et D.

NOTE En général, avec ce type de récepteur, une réserve de linéarité suffisante ne peut pas être fournie pour empêcher un fonctionnement non linéaire du récepteur à des cadences d'impulsions très basses (la réponse à une impulsion unique n'est pas définie).

6.4 Précision de la tension sinusoïdale

La précision des mesures de tension sinusoïdale doit être meilleure que ± 2 dB ($\pm 2,5$ dB au-dessus de 1 GHz) lorsque le récepteur mesure un signal sinusoïdal avec une impédance de source résistive de 50 Ω .

6.5 Réponses aux impulsions

6.5.1 Généralités

NOTE Les Annexes B et C décrivent les méthodes de détermination des caractéristiques de sortie des générateurs d'impulsions destinés à être utilisés pour le contrôle des exigences du présent article dans la plage de fréquences en dessous de 1 GHz.

6.5.2 Réponse en amplitude

Jusqu'à 1 000 MHz, le détecteur de valeur moyenne est défini de la façon suivante (moyenne linéaire): la réponse du récepteur de mesure à des impulsions de f.é.m. de fréquence de répétition n Hz, et d'aire d'impulsion égale à $1,4/n$ mVs sous une impédance de source de 50 Ω , doit être égale à la réponse à un signal sinusoïdal non modulé à la fréquence d'accord ayant une f.é.m. de 2 mV en valeur efficace [66 dB(μ V)]. Les impédances de source du générateur d'impulsions et du générateur de signaux doivent être identiques. Les impulsions doivent avoir un spectre uniforme conformément aux données montrées au Tableau 2. Une tolérance de 1,5 dB/–1,5 dB est autorisée sur le niveau de tension sinusoïdale.

NOTE 1 Aux fréquences de répétition de 25 Hz, 100 Hz, 500 Hz, 1 000 Hz et 5 000 Hz, la relation entre les indications d'un récepteur de mesure de valeur moyenne et celle d'un récepteur de mesure de quasi-crête de même largeur de bande, en supposant des facteurs de surcharge adéquats et un niveau de sortie constant, est donnée au Tableau 9.

Tableau 9 – Réponses comparatives aux impulsions des récepteurs de mesure de valeur moyenne et de quasi-crête pour une même largeur de bande

Plage de fréquences du récepteur de mesure	Rapport des lectures quasi-crête/valeur moyenne (dB) pour une fréquence de répétition des impulsions				
	25 Hz	100 Hz	500 Hz	1 000 Hz	5 000 Hz
9 kHz à 150 kHz (Bande A)	12,4				
0,15 MHz à 30 MHz (Bande B)		(32,9)	22,9	(17,4)	
30 MHz à 1 000 MHz (Bandes C et D)				(38,1)	26,3
NOTE 1 La réponse aux impulsions est basée sur l'utilisation de la largeur de bande de référence uniquement (voir Tableau 8).					
NOTE 2 Les valeurs entre parenthèses sont données pour information uniquement.					
NOTE 3 Les valeurs indiquées dans ce tableau résultent de la spécification nominale des fonctions de pondération du détecteur. Par conséquent, la vérification par un laboratoire d'étalonnage n'est pas exigée.					

Au-dessus de 1 GHz (Bande E), deux modes du détecteur (de pondération) de valeur moyenne sont définis: linéaire et logarithmique:

Pour le détecteur de valeur moyenne linéaire, la réponse du récepteur de mesure à des impulsions de f.é.m. de fréquence de répétition n Hz, et d'aire d'impulsion égale à $1,4/n$ mVs sous une impédance de source de 50Ω , doit être égale à la réponse d'un signal sinusoïdal non modulé à la fréquence d'accord ayant une f.é.m. de 2 mV de valeur efficace [66 dB(μ V)]. L'impulsion doit être définie comme une porteuse modulée en impulsion. La valeur de n doit être de 50 000 Hz. Une tolérance de $\pm 1,5$ dB est autorisée sur le niveau de tension sinusoïdale.

Pour le détecteur de valeur moyenne logarithmique, la réponse du récepteur de mesure à des impulsions de fréquence de répétition 333 kHz (inverse de la période de 3 μ s) d'aire d'impulsion égale à 6,7 nVs f.é.m. sous une impédance de source de 50Ω , doit être égale à la réponse à un signal sinusoïdal non modulé à la fréquence d'accord ayant une f.é.m. de 2 mV en valeur efficace [66 dB(μ V)]. Une tolérance de ± 4 dB est autorisée sur le niveau de tension sinusoïdale (la tolérance de 10 % de la largeur de bande provoque une variation possible d'environ $\pm 2,5$ dB).

Pour davantage de précisions, voir E.6.

La détection de valeur moyenne peut être obtenue avec des analyseurs de spectre configurés avec une largeur de bande vidéo $B_{\text{video}} \ll B_{\text{resol}}$, afin d'obtenir un calcul de moyenne adéquat reposant sur la fréquence de répétition du signal mesuré. Pour les mesures basées sur une réduction de la bande vidéo, s'assurer que la durée de balayage est suffisamment longue pour permettre au filtre de la bande vidéo de répondre de façon correcte.

NOTE 2 Pour les mesures (pondérées) moyennes en mode linéaire, le résultat correspondra au niveau moyen du signal mesuré. Si un affichage logarithmique est utilisé, le résultat correspondra à la moyenne des valeurs logarithmiques du signal mesuré. En conséquence, pour un signal d'onde carrée de valeurs successives de 20 dB(μ V) et 60 dB(μ V), le niveau obtenu en mode logarithmique est de 40 dB(μ V), alors qu'en mode linéaire, le niveau 54,1 dB(μ V) représente la valeur moyenne réelle du signal.

6.5.3 Variation avec la fréquence de répétition

La réponse d'un récepteur de mesure équipé d'un détecteur de valeur moyenne linéaire à des impulsions répétées doit être telle que, pour une indication constante sur le récepteur de mesure, la relation entre l'amplitude et la fréquence de répétition soit conforme à la règle suivante:

Amplitude proportionnelle à (fréquence de répétition)⁻¹

Une tolérance de +3 dB à –1 dB est autorisée dans la plage de fréquences comprise entre la plus faible fréquence de répétition utilisable et une fréquence égale à $B_3/2$, tel que déterminé à partir des considérations de surcharge.

NOTE 1 Les courbes de réponse théorique aux impulsions des récepteurs à détecteur de quasi-crête et de valeur moyenne, combinées sur une échelle absolue, sont données en Figure 4. La réponse du récepteur de mesure équipé d'un détecteur de valeur moyenne logarithmique à des impulsions répétées (au-dessus de 1 GHz) est influencée par le niveau de bruit entre les impulsions. Avec les valeurs suivantes:

- $L_{\log Av}$ est le niveau indiqué par le détecteur de valeur moyenne logarithmique;
- T_P est la durée de l'impulsion;
- L_P est le niveau d'impulsion en dB(μV);
- T_N est la durée du niveau de bruit;
- L_N est le niveau de bruit en dB(μV);

la relation approximative suivante s'applique alors:

$$L_{\log Av} = \frac{T_P L_P + T_N L_N}{T_P + T_N} \quad (7)$$

EXEMPLE: Si le niveau d'impulsion L_P est de 85 dB(μV) et le niveau de bruit L_N est de 8 dB(μV), $T_P = 1/B_{imp} = 1 \mu s$, le taux d'impulsion n est de 100 000 Hz, alors $T_N = 9 \mu s$. À partir de cette équation, $L_{\log Av} = 15,7$ dB(μV). En réalité, $L_{\log Av}$ est plus élevé puisque T_P est plus élevée, parce que le signal d'impulsion à la sortie f.i. ne descend pas au niveau de bruit immédiatement après 1 μs.

NOTE 2 Une tolérance est à l'étude.

6.5.4 Réponse aux perturbations à bande étroite intermittentes, instables et dérivantes

La réponse aux perturbations à bande étroite intermittentes, instables et dérivantes doit être telle que le résultat de la mesure soit équivalent à la lecture crête d'un appareil de mesure ayant une constante de temps de 160 ms pour les Bandes A et B et de 100 ms pour les Bandes C et D, comme représenté à la Figure 11. La constante de temps est telle qu'elle est définie en A.3.2. Cela peut être obtenu par un réseau de simulation de l'appareil de mesure à la suite du détecteur d'enveloppe du récepteur. La lecture crête peut être prise, par exemple, par une surveillance permanente de la sortie de l'appareil de mesure en utilisant un convertisseur analogique/numérique (A/N) et un microprocesseur comme ceux représentés à la Figure 10.

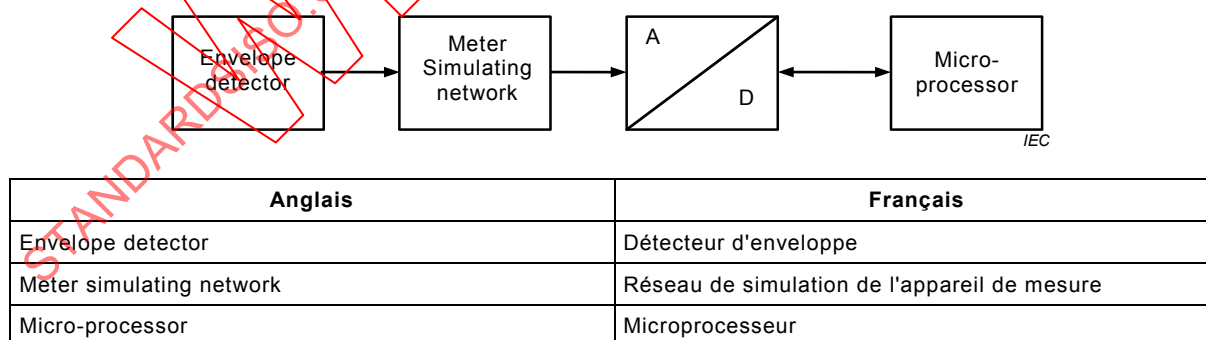


Figure 10 – Schéma fonctionnel d'un détecteur de valeur moyenne

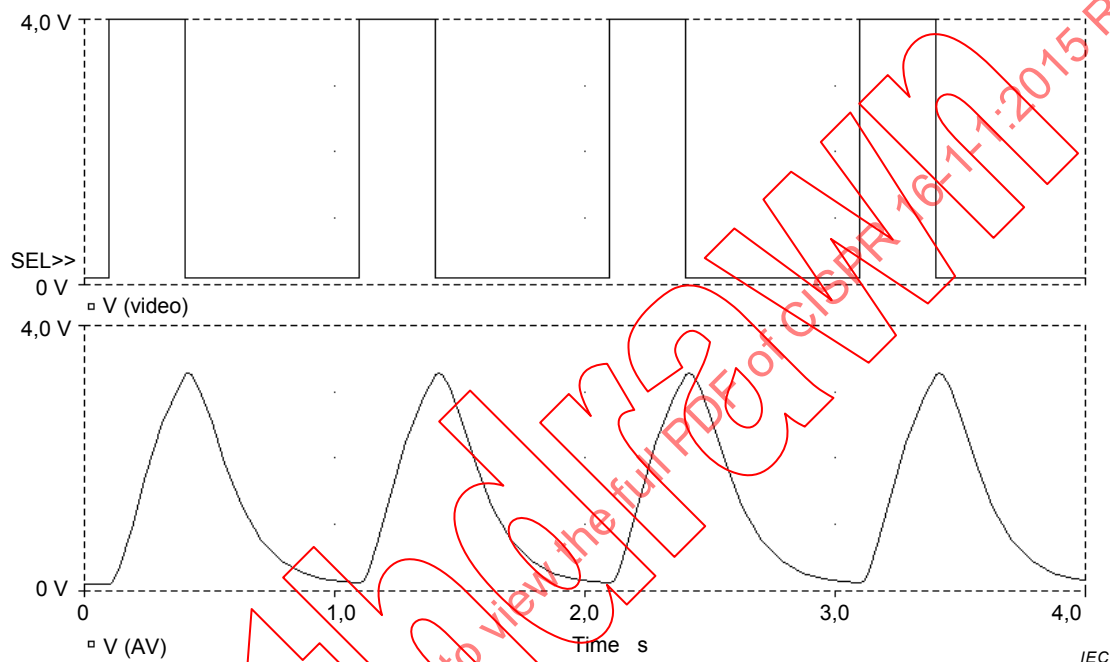
Pour les récepteurs de bande E, la constante de temps du dispositif de mesure pour le détecteur de valeur moyenne logarithmique est de 100 ms. Pour le détecteur de valeur moyenne logarithmique, les exigences sont à l'étude.

Il se déduit de l'exigence ci-dessus qu'un récepteur de mesure de valeur moyenne doit donner les valeurs maximales de lecture du Tableau 10 pour un signal d'entrée sinusoïdal RF modulé par des impulsions rectangulaires répétées de la durée et de la période indiquées dans le tableau. Une tolérance de ±1,0 dB est autorisée pour cette exigence.

Tableau 10 – Valeurs maximales des récepteurs de mesure de valeur moyenne pour une entrée sinusoïdale à modulation d'impulsion comparées à la réponse à une onde sinusoïdale continue de même amplitude

Impulsions rectangulaires périodiques pour la modulation	Récepteur bandes A/B $T_M = 0,16 \text{ s}$	Récepteur bandes C/D $T_M = 0,1 \text{ s}$
Durée = T_M Période = 1,6 s	0,353 (= -9,0 dB)	0,353 (= -9,0 dB)

NOTE En Bande E, ceci s'applique au détecteur de valeur moyenne linéaire uniquement.



Anglais	Français
Time	Temps

NOTE 1 La réponse représentée est obtenue par un signal intermittent à bande étroite d'une durée de 0,3 s et de 1 Hz de fréquence de répétition, lorsqu'une constante de temps de 100 ms est utilisée. Si la constante de temps est de 160 ms, les crêtes à la sortie du réseau de simulation de l'appareil de mesure sont plus faibles.

NOTE 2 La réponse aux perturbations intermittentes à bande étroite peut aussi être définie pour le détecteur de valeur moyenne logarithmique fonctionnant avec une certaine bande vidéo, par exemple, 10 Hz, et la fonction de maintien du maximum de l'affichage du spectre.

Figure 11 – Capture d'écran montrant la réponse du réseau de simulation de l'appareil de mesure à un signal à bande étroite intermittent

6.6 Sélectivité

Pour les récepteurs présentant une largeur de bande de 200 Hz (pour la plage de fréquences comprises entre 9 kHz et 150 kHz) ou une largeur de bande de 9 kHz (pour la plage de fréquences comprises entre 0,15 MHz et 30 MHz), la sélectivité globale doit être comprise dans les limites données respectivement à la Figure 5 et à la Figure 6. Pour les récepteurs présentant une largeur de bande de 120 kHz (pour la plage de fréquences comprises entre 30 MHz et 1 000 MHz), la sélectivité globale doit être comprise dans les limites données à la Figure 7. Pour les récepteurs ayant d'autres largeurs de bande, la Figure 5, la Figure 6 et la Figure 7 ne décrivent que la forme, et l'axe des fréquences doit être mis à l'échelle en conséquence. La courbe représentant la sélectivité globale de la largeur de bande de référence du récepteur de mesure pour la bande E doit se situer dans les limites de la Figure 9.

Les exigences de 4.5.2, 4.5.3 et 4.5.4 s'appliquent.

NOTE Pour la mesure des appareils exigeant une plus grande sélectivité à la transition entre 130 kHz et 150 kHz (pour les appareils pour la transmission de signaux sur le réseau électrique tels que définis dans l'EN 50065-1 [18]², par exemple), un filtre passe-haut peut être ajouté avant le récepteur de mesure pour obtenir la sélectivité combinée ci-après du récepteur de mesure CISPR et du filtre passe-haut:

Fréquence kHz	Atténuation relative dB
150	≤ 1
146	≤ 6
145	≥ 6
140	≥ 34
130	≥ 81

Il convient que le récepteur de mesure avec le filtre passe-haut satisfasse aux exigences de la présente norme.

6.7 Effets d'intermodulation, bruit du récepteur et blindage

Les exigences de 5.7 doivent s'appliquer.

7 Récepteurs de mesure avec détecteur de valeur moyenne efficace pour la plage de fréquences comprises entre 9 kHz et 18 GHz

7.1 Généralités

Les récepteurs de pondération de valeur moyenne efficace utilisent un détecteur de pondération qui est une combinaison d'un détecteur de valeur efficace (pour les fréquences de répétition d'impulsions supérieures à une fréquence de cassure f_c) et d'un détecteur de valeur moyenne (pour les fréquences de répétition d'impulsions inférieures à la fréquence de cassure f_c), ce qui permet d'obtenir une courbe de réponse impulsionnelle avec les caractéristiques suivantes: 10 dB/décade au-delà de la fréquence de cassure et 20 dB/décade en deçà de la fréquence de cassure.

Les analyseurs de spectre et les appareils de mesure à FFT qui satisfont aux exigences du présent article peuvent être utilisés pour les mesures de conformité. Pour les mesures d'émissions, les appareils de mesure à FFT doivent échantillonner et évaluer le signal de manière continue au cours de la période de mesure.

7.2 Impédance d'entrée

Le circuit d'entrée des récepteurs de mesure doit être asymétrique. Pour les réglages du récepteur de commande se situant dans la plage de lecture du CISPR, l'impédance d'entrée nominale doit être de 50 Ω avec un ROS ne dépassant pas les valeurs indiquées au Tableau 11.

² Les chiffres entre crochets se réfèrent à la bibliographie.

Tableau 11 – Exigences ROS de l'impédance d'entrée

Plage de fréquences	Affaiblissement RF dB	ROS
9 kHz à 1 GHz	0	2,0 à 1
9 kHz à 1 GHz	10	1,2 à 1
1 GHz à 18 GHz	0	3,0 à 1
1 GHz à 18 GHz	10	2,0 à 1

Impédance d'entrée symétrique dans la plage de fréquences de 9 kHz à 30 MHz; pour permettre des mesures symétriques, un transformateur d'entrée symétrique est utilisé. L'impédance d'entrée préférentielle est de 600 Ω dans la plage de fréquences comprises entre 9 kHz et 150 kHz. Cette impédance d'entrée symétrique peut être incorporée soit dans le réseau fictif symétrique nécessaire au couplage avec le récepteur, soit dans le récepteur de mesure.

7.3 Caractéristiques fondamentales

7.3.1 Largeur de bande

Les largeurs de bande doivent être comprises dans les valeurs du Tableau 12.

Tableau 12 – Exigences de largeur de bande pour le récepteur de mesure avec détecteur de valeur moyenne efficace

Plage de fréquences	Largeur de bande
9 kHz à 150 kHz (Bande A)	200 Hz (B_6)
150 kHz à 30 MHz (Bande B)	9 kHz (B_6)
30 MHz à 1 000 MHz (Bandes C et D)	120 kHz (B_6)
1 GHz à 18 GHz (Bande E)	1 MHz (B_{imp})
NOTE La valeur choisie dans la bande E est définie comme la largeur de bande d'impulsion du récepteur de mesure avec une tolérance de ± 10 %.	

7.3.2 Réserve de linéarité

Au-dessus de la fréquence de cassure f_c , spécifiée ci-dessous, la réserve de linéarité des circuits précédant le détecteur, pour une fréquence de répétition d'impulsion de n Hz doit être de $1,27(B_3/n)^{1/2}$, B_3 étant exprimé en Hz. En dessous de la fréquence de cassure, la réserve de linéarité pour une cadence de répétition d'impulsion de n Hz doit être supérieure à $1,27(B_3/f_c)^{1/2} \times (f_c/n)$.

NOTE 1 La "fréquence de cassure" est la fréquence de répétition d'impulsion au-delà de laquelle le détecteur de valeur moyenne efficace se comporte comme un détecteur de valeur efficace et en deçà de laquelle le détecteur de valeur moyenne efficace présente une pente de détecteur de valeur moyenne linéaire.

La fréquence minimale de répétition d'impulsion sans surcharge doit être conforme aux valeurs indiquées dans le Tableau 13.

Tableau 13 – Fréquence minimale de répétition d'impulsion sans surcharge

Plage de fréquences du récepteur de mesure	Fréquence de cassure f_c kHz	Fréquence minimale de répétition des impulsions Hz	Indications de rapport valeur de crête/valeur moyenne efficace dB
9 kHz à 150 kHz (Bande A)	0,01	5	19
0,15 MHz à 30 MHz (Bande B)	0,01	5	35,5
30 MHz à 1 000 MHz (Bandes C et D)	0,1	31,6	40,6
1 GHz à 18 GHz (Bande E)	1	316	40

NOTE 2 Avec ce type de détecteur, une réserve de linéarité suffisante ne peut généralement pas être fournie pour empêcher un fonctionnement non linéaire de l'instrument à des cadences de répétition d'impulsions très faibles pour les impulsions courtes dans les bandes C/D et E (la réponse à une impulsion unique de courte durée est seulement théoriquement définie dans ces bandes).

NOTE 3 L'Annexe A décrit le calcul de la réserve de linéarité pour le détecteur de valeur efficace. L'Annexe B décrit la détermination du spectre du générateur d'impulsions. L'Annexe C décrit la mesure précise des niveaux de sortie des générateurs d'impulsions de l'ordre de la nanoseconde.

NOTE 4 Pour la bande E, l'essai peut être réalisé avec un signal sinusoïdal à modulation d'impulsion, avec une largeur de bande occupée de par exemple 2 MHz. E.6 fournit la spécification d'un signal d'essai applicable.

7.4 Précision de la tension sinusoïdale

La précision des mesures de tension sinusoïdale doit être meilleure que ± 2 dB ($\pm 2,5$ dB au-dessus de 1 GHz) lorsque le récepteur mesure un signal sinusoïdal avec une impédance de source résistive de 50 Ω .

7.5 Réponses aux impulsions

7.5.1 Détails de construction

La fonction de détecteur peut être représentée par un détecteur de valeur efficace qui détermine de manière continue les valeurs efficaces au cours de périodes égales à l'inverse de la fréquence de cassure f_c . Ces valeurs efficaces passent ensuite par un filtre passe-bas d'ordre 2 qui correspond à l'indication amortie de manière critique qui est spécifiée pour le détecteur de quasi-crête, dont la constante de temps est définie jusqu'à 1 GHz. Pour la bande E, la constante de temps est de 100 ms. En cas de variation dans le temps, la sortie maximale du filtre passe-bas est le résultat de la mesure.

NOTE Les Annexes B, C et E décrivent des méthodes de détermination des caractéristiques de sortie des générateurs d'impulsions destinés à être utilisés pour le contrôle des exigences du présent article.

7.5.2 Réponse en amplitude

La réponse du récepteur de mesure pour la bande A aux impulsions de f.é.m. d'aire d'impulsion de $278 \times (B_3)^{-1/2}$ μ Vs à une impédance source de 50 Ω qui ont un spectre uniforme jusqu'à au moins la fréquence accordable la plus élevée de la bande A, et répétée à une fréquence de 25 Hz, doit, pour toutes les fréquences d'accord, être égale à la réponse à un signal sinusoïdal non modulé à la fréquence accordée ayant une f.é.m. 2 mV [66 dB(μ V)] en valeur efficace. Pour les récepteurs de mesure pour les bandes B, C, D et E, leurs valeurs correspondantes sont $44 \times (B_3)^{-1/2}$ μ Vs et 1 000 Hz. Les impédances de source du générateur d'impulsions et du générateur de signaux doivent être identiques. Une tolérance de $\pm 1,5$ dB est permise dans les niveaux de tension sinusoïdale prescrits ci-dessus.

NOTE L'Annexe A décrit le calcul du facteur de réponse impulsionnelle du détecteur de valeur efficace. A une fréquence de répétition respectivement de 25 Hz et de 100 Hz (c'est-à-dire la fréquence de répétition d'impulsion de référence de détecteur de quasi-crête), la relation entre les indications d'un récepteur de mesure de valeur moyenne efficace et un récepteur de mesure de valeur de quasi-crête de la même largeur de bande est donnée au Tableau 14.

Si des préamplificateurs externes sont utilisés, voir l'Annexe J pour les exigences applicables.

Tableau 14 – Réponse impulsionnelle relative des récepteurs de mesure en valeur moyenne efficace et en quasi-crête

Plage de fréquences du récepteur de mesure	Fréquence de répétition des impulsions Hz	Indications de rapport valeur de quasi-crête/valeur moyenne efficace dB
9 kHz à 150 kHz (Bande A)	25	4,2
0,15 MHz à 30 MHz (Bande B)	100	14,3
30 MHz à 1 000 MHz (Bandes C et D)	100	20,1

NOTE Les valeurs indiquées dans ce tableau résultent de la spécification nominale des fonctions de pondération du détecteur. Par conséquent, la vérification par un laboratoire d'étalonnage n'est pas exigée.

7.5.3 Variation avec la fréquence de répétition

La réponse du récepteur de mesure aux impulsions répétées doit être telle que, pour une indication constante sur le récepteur de mesure, la relation entre l'amplitude et la fréquence de répétition au-delà de la fréquence de cassure f_c doit être conforme à la règle suivante:

amplitude proportionnelle à (fréquence de répétition)^{-1/2}

En dessous de la fréquence de cassure f_c , la relation doit être conforme à la règle suivante:

amplitude proportionnelle à (fréquence de répétition)⁻¹.

La courbe de réponse pour un récepteur particulier doit se situer entre les limites du Tableau 15.

Tableau 15 – Réponse impulsionnelle des récepteurs de mesure en valeur moyenne efficace

Fréquence de répétition Hz	Niveau équivalent relatif d'impulsion en dB			
	Bande A	Bande B	Bandes C et D	Bande E
100 k	—	—	(-20 ± 2,0)	-20 ± 2,0
10 k	—	—	-10 ± 1,0	-10 ± 1,0
1 000	—	0 (réf.)	0 (réf.)	0 (réf.)
316	—	+5 ± 0,5	+5 ± 0,5	+10 ± 1,0
100	-6 ± 0,6	+10 ± 1,0	+10 ± 1,0	(+20 ± 2,0)
31,6	-	+15 ± 1,5	+20 ± 2,0	
25	0 (réf.)	+16 ± 1,6		
10	+4 ± 0,4	+20 ± 2,0		
5	+9 ± 0,7	+25 ± 2,3		
1	—	—		

NOTE 1 Les valeurs entre parenthèses sont données pour information uniquement.

NOTE 2 Les valeurs à 5 Hz pour les bandes A et B prennent en compte l'effet de la constante de temps de l'appareil de mesure.

7.5.4 Réponse aux perturbations à bande étroite intermittentes, instables et dérivantes

La réponse aux perturbations intermittentes à bande étroite, instables et dérivantes doit être telle que le résultat de mesure soit équivalent à la valeur de crête lue d'un appareil de mesure avec une constante de temps de 160 ms pour les Bandes A et B et de 100 ms pour les Bandes C, D et E. Cela peut être réalisé par le réseau simulant l'appareil de mesure (analogique ou numérique) auquel les valeurs efficaces décrites en 7.5.1 sont injectées comme entrée.

Il est déduit de l'exigence ci-dessus qu'un récepteur de mesure en valeur moyenne efficace doit donner la valeur lue maximale indiquée au Tableau 9 pour un signal d'entrée sinusoïdal à radiofréquence avec des impulsions rectangulaires répétées ayant la durée et la période indiquées dans le Tableau 16. Une tolérance de $\pm 1,0$ dB est autorisée pour cette exigence.

Tableau 16 – Valeur maximale des récepteurs de valeur moyenne efficace pour une entrée sinusoïdale à modulation d'impulsion comparée à la réponse à une onde sinusoïdale continue de même amplitude

Impulsions rectangulaires périodiques pour la modulation	Récepteur de bandes A/B $T_M = 0,16$ s	Récepteur de bandes C/D/E $T_M = 0,1$ s
Durée = T_M Période = 1,6 s	0,398 (= -7,9 dB)	0,353 (= -9,0 dB)
NOTE La valeur pour le récepteur de bandes A/B peut varier d'environ $\pm 0,5$ dB en raison d'un chevauchement qui varie de la durée d'impulsion de 160 ms avec la durée d'intégration de 100 ms en valeur efficace.		

7.6 Sélectivité

Les courbes de sélectivité du récepteur de pondération en valeur moyenne efficace doivent être égales à celle de la Figure 5, de la Figure 6 et de la Figure 7 pour les bandes A, B, C et D. Pour le récepteur de la bande E, la courbe de sélectivité est donnée à la Figure 9.

Les exigences de 4.5.2, 4.5.3 et 4.5.4 s'appliquent. Pour les récepteurs de la bande E, les exigences sont à l'étude.

7.7 Effets d'intermodulation, bruit du récepteur et blindage

Pour la plage de fréquences en dessous de 1 GHz, les exigences de 4.6, 4.7 et 4.8 s'appliquent. Les Paragraphes 4.7 et 4.8.2 s'appliquent aussi à la bande E.

Pour la bande E, ce qui suit s'applique:

- les exigences pour les effets d'intermodulation sont à l'étude.
- filtre de présélection: lorsque des signaux parasites de faible valeur sont mesurés en présence d'un signal fondamental fort provenant de certains appareils en essai, un filtre doit être prévu à l'entrée du récepteur de mesure pour assurer un affaiblissement approprié à la fréquence fondamentale pour protéger les circuits d'entrée du récepteur de la surcharge et des dommages et pour empêcher de générer des signaux harmoniques et d'intermodulation.

NOTE 1 Un affaiblissement par un filtre de 30 dB à la fréquence fondamentale de l'appareil en essai est en général suffisant.

NOTE 2 Plusieurs de ces filtres peuvent être exigés lorsqu'il existe plusieurs fréquences fondamentales.

Les exigences d'efficacité d'écran, c'est-à-dire l'immunité aux perturbations rayonnées ambiantes de valeur élevée, sont à l'étude.

8 Récepteurs de mesure pour la plage de fréquences comprises entre 1 GHz et 18 GHz avec fonction de mesure de la distribution de probabilité des amplitudes (DPA)

La DPA d'une perturbation est définie comme une distribution cumulative de la "probabilité de la durée nécessaire à l'amplitude d'une perturbation pour dépasser un niveau spécifié".

La DPA peut être mesurée à la sortie du détecteur d'enveloppe ou à la suite des circuits d'un récepteur de mesure RF ou d'un analyseur de spectre. Il convient que l'amplitude de la perturbation soit exprimée par rapport à la valeur du champ ou à la tension à l'entrée du récepteur. Généralement, une mesure de la DPA s'effectue à une fréquence fixe.

La fonction de mesure de la DPA est une fonction supplémentaire des appareils de mesure, et peut être soit rattachée à, soit incorporée aux appareils de mesure.

La fonction de mesure de la DPA peut être mise en œuvre en utilisant les méthodes suivantes. Une approche utilise des comparateurs et des compteurs (Figure G.1). L'appareil détermine les probabilités de dépasser un ensemble de niveaux d'amplitude préassignés (par exemple en tension). Le nombre de niveaux est identique au nombre de comparateurs. Une autre méthode possible implique l'utilisation d'un convertisseur analogique-numérique, d'un circuit logique et d'une mémoire (Figure G.2). L'appareil peut aussi fournir le schéma de la DPA pour un ensemble de niveaux d'amplitude préassignés. Le nombre de niveaux dépend de la résolution du convertisseur analogique-numérique (par exemple 256 niveaux pour un convertisseur 8 bits).

Les mesures de la DPA qui utilisent la fonction mentionnée ci-dessus sont applicables aux produits ou familles de produits si leur potentiel à engendrer des perturbations aux systèmes de communications numériques doit être déterminé (voir 4.7 de la CISPR 16-3:2010, CISPR 16-3:2010/AMD1:2012, pour les éléments de contexte général sur les spécifications de distribution de probabilité d'amplitude (DPA)).

Les spécifications suivantes s'appliquent à la fonction de mesure de la DPA. La justification de ces spécifications est donnée à l'Annexe G.

• Spécifications

- La plage dynamique de l'amplitude doit être supérieure à 60 dB.
- La précision de l'amplitude, y compris l'erreur sur la définition du niveau de seuil, doit être meilleure que $\pm 2,7$ dB.
- La durée maximale mesurable d'une perturbation doit être supérieure ou égale à 2 min. La mesure intermittente peut être utilisée si la durée du temps mort est inférieure à 1 % de la durée totale de la mesure.
- La probabilité minimale mesurable doit être de 10^{-7} .
- La fonction de mesure de la DPA doit être capable d'assigner au moins deux niveaux d'amplitude. Les probabilités correspondant à tous les niveaux préassignés doivent être mesurées simultanément. La résolution des niveaux d'amplitude préassignés doit être au minimum 0,25 dB ou mieux.
- Le taux d'échantillonnage doit être supérieur ou égal à 10 millions d'échantillons par seconde en utilisant une largeur de bande de résolution de 1 MHz.

• Spécification recommandée

- Il convient que la résolution de l'amplitude de l'affichage de la DPA soit inférieure à 0,25 dB pour un appareil de mesure de la DPA ayant un convertisseur A/N.

NOTE Les mesures de la DPA peuvent aussi s'appliquer aux plages de fréquences inférieures à 1 GHz.

9 Analyseurs de perturbations

9.1 Généralités

Les analyseurs de perturbations sont utilisés pour l'évaluation automatique de l'amplitude, du taux de répétition et de la durée des perturbations discontinues (claquements).

Un "claquement" possède les caractéristiques suivantes:

- a) l'amplitude quasi-crête dépasse la limite quasi-crête d'une perturbation continue,
- b) la durée est inférieure ou égale à 200 ms, et
- c) l'espacement entre une perturbation et la perturbation suivante ou la perturbation précédente est supérieur ou égal à 200 ms.

Une série d'impulsions courtes doit être traitée comme un claquement lorsque sa durée, mesurée entre le début de la première impulsion et la fin de la dernière impulsion, est inférieure ou égale à 200 ms et les conditions a) et c) sont remplies.

Les paramètres de temps sont déterminés à partir du signal qui dépasse le niveau de référence f.i. du récepteur de mesure.

NOTE 1 La définition et l'évaluation des claquements sont conformes à la CISPR 14-1.

NOTE 2 Les analyseurs actuels sont conçus pour être utilisés avec un récepteur de mesure de quasi-crête qui fonctionne avec un niveau de signal interne limité. Par conséquent, de tels analyseurs peuvent ne pas avoir l'interface correcte avec tous les récepteurs.

9.2 Caractéristiques fondamentales

- a) L'analyseur doit être équipé d'une voie pour mesurer la durée et l'espacement des perturbations discontinues; l'entrée de cette voie doit être connectée à la sortie f.i. du récepteur de mesure. Pour ces mesures, seule la partie de la perturbation qui dépasse le niveau de la référence f.i. du récepteur doit être prise en compte. La précision des mesures de durées doit être meilleure que $\pm 5\%$.

NOTE 1 Le niveau de la référence f.i. est la valeur correspondante à la sortie f.i. du récepteur de mesure à un signal sinusoïdal non modulé, qui donne une indication de quasi-crête égale à la limite pour des perturbations continues.

- b) L'analyseur doit être équipé d'une voie pour évaluer l'amplitude en quasi-crête d'une perturbation.
- c) L'amplitude de la voie quasi-crête doit être mesurée 250 ms après le dernier front descendant de la voie f.i.
- d) La combinaison des voies entre elles doit satisfaire à toutes les exigences de 4.2.
- e) L'analyseur doit être capable d'indiquer les informations suivantes:
 - le nombre de claquements de durée inférieure ou égale à 200 ms;
 - la durée de l'essai en minutes;
 - le taux de répétition des claquements;
 - l'incidence des perturbations autres que les claquements qui dépassent la limite en quasi-crête des perturbations continues.

NOTE 2 Un exemple d'analyseur de perturbation est représenté sous la forme d'un schéma fonctionnel à la Figure 12.

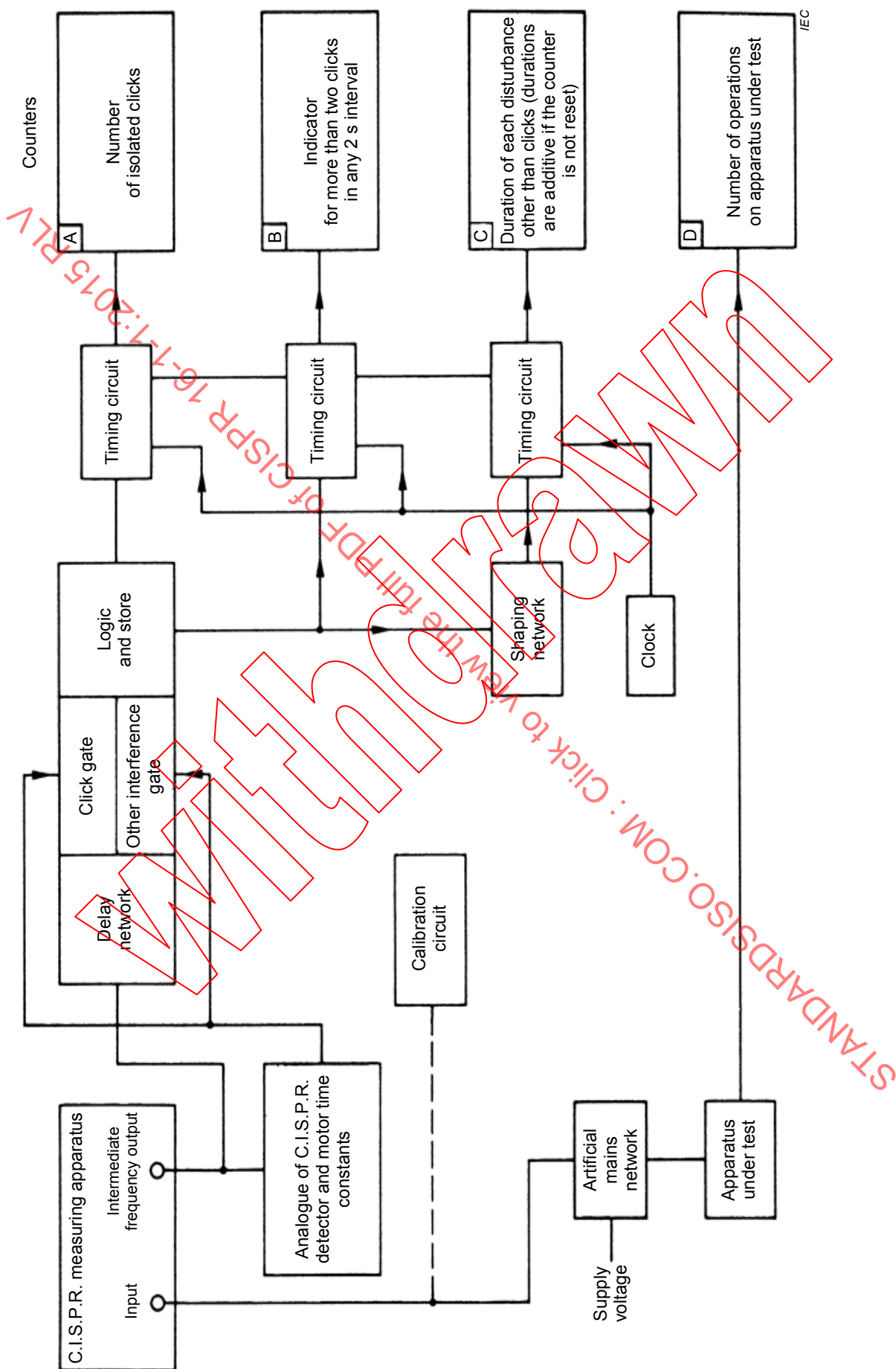
- f) Pour la validation des caractéristiques fondamentales, l'analyseur doit satisfaire aux vérifications des caractéristiques avec toutes les formes d'onde (impulsions d'essai) du Tableau 14.

La Figure 13 représente sous forme graphique les formes d'onde énumérées dans le Tableau 17.

La Figure F.1 représente sous forme graphique toutes les formes d'onde énumérées dans le Tableau F.1 pour la vérification des caractéristiques pour les exceptions aux définitions d'un claquement conformément à 4.2.3 de la CISPR 14-1:2005.

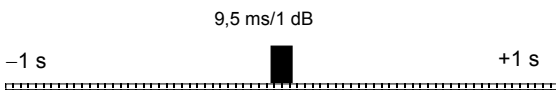
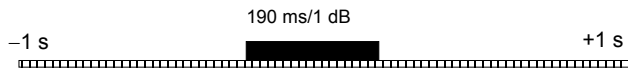
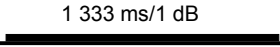
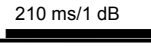
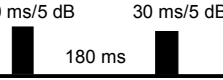
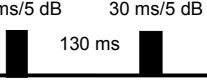
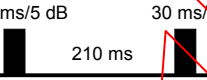
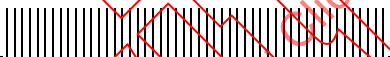
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Withdrawn



Anglais	Français
CISPR measuring apparatus	Appareils de mesure CISPR
Input	Entrée
Intermediate frequency output	Sortie à fréquence intermédiaire
Delay network	Ligne de retard
Click gate	Taux de répétition des claquements
Other interference gate	Autre taux d'interférences
Logic and store	Logique et mémoire
Timing circuit	Circuit d'horloge
Counters	Compteurs
Number of isolated clicks	Nombre de claquements distincts
Indicator for more than two clicks in any 2 s interval	Indicateur pour plus de deux claquements par intervalle de 2 s
Duration of each disturbance other than clicks (durations are additive if the counter is no reset)	Durée de chaque perturbation autre qu'un claquement (les durées s'ajoutent si le compteur n'est pas remis à zéro)
Clock	Horloge
Shaping network	Réseau de mise en forme
Calibration circuit	Circuit d'étalement
Analogue of CISPR detector and motor time constants	Équivalent du détecteur CISPR au point de vue des constantes de temps
Artificial mains network	Réseau fictif d'alimentation
Supply voltage	Tension d'alimentation
Apparatus under test	Appareil en essai
Number of operations on apparatus under test	Nombre d'opérations sur l'appareil en essai

Figure 12 – Exemple d'un analyseur des perturbations

Test No.	Test signal	Evaluation by the analyzer
1	 0,11ms/1 dB	1 click
2	 9,5 ms/1 dB -1 s +1 s	1 click
3	 190 ms/1 dB -1 s +1 s Background: noise or CISPR pulses, 200 Hz: -2,5 dB (QP)	1 click
4	 1 333 ms/1 dB Background: noise or CISPR pulses, 200 Hz: -2,5 dB (QP)	Other than click
5	 210 ms/1 dB	Other than click
6	 30 ms/5 dB 180 ms 30 ms/5 dB	Other than click
7	 30 ms/5 dB 130 ms 30 ms/5 dB	1 click
8	 30 ms/5 dB 210 ms 30 ms/5 dB	2 clicks
9	 Min. 21 pulses/0,11 ms/periodicity 10 ms/1 dB	Other than click
10	 265 ms 30 ms/25 dB 30 ms/-2,5 dB	1 click
11	 190 ms/25 dB Band B: 1 034 ms/Band C: under consideration	2 clicks
12	 190 ms/25 dB Band B: 1 166 ms/Band C: under consideration  30 ms/-2,5 dB/2 dB IF  30 ms/-2,5 dB/2 dB IF	1 click

Anglais	Français
Test No.	Essai N°
Test signal	Signal d'essai
Evaluation by the analyzer	Évaluation effectuée par l'analyseur
1 click	1 claquement
Background: noise or CISPR pulses	Bruit de fond ou impulsions CISPR
Other than click	Autre que claquement
2 clicks	2 claquements
Min. 21 pulses/0,11 ms / periodicity 10 ms/1 dB	Min. 21 impulsions/0,11 ms/périodicité 10 ms/1 dB
Band B: 1 034 ms / Band C: under consideration	Bande B: 1 034 ms/Bande C: à l'étude
Band B: 1 166 ms / Band C: under consideration	Bande B: 1 166 ms/Bande C: à l'étude

Figure 13 – Présentation graphique des signaux d'essai utilisés pour la vérification des performances de l'analyseur par rapport à la définition d'un claquement conformément au Tableau 14