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

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

ICS 33.100.10

ISBN 978-2-8891-0010-1

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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

Spécifications 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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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

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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 third edition cancels and replaces the second edition published in 2006, and its Amendments 1 (2006) and 2 (2007). It is a technical revision.

This main technical change with respect to the previous edition consists of the addition of new provisions for the use of spectrum analyzers for compliance measurements.

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*.

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

FDIS	Report on voting
CISPR/A/867/FDIS	CISPR/A/881/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 maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

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- withdrawn;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

The contents of the corrigenda 1 (October 2010) and 2 (October 2011) 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 publication using a colour printer.

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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 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 test sites for 30 MHz to 1 000 MHz

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.

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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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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.

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, CISPR 16-2-2 or CISPR 16-2-3.

2 Normative references

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

CISPR 11:2009, *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*
Amendment 1 (2008)

CISPR 16-2-1:2008, *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, *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, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 2-3: Methods of measurement of disturbances and immunity – Radiated disturbance measurements*

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CISPR/TR 16-3:2003, *Specification for radio disturbance and immunity measuring apparatus and methods – Part 3: CISPR technical reports*
Amendment 1 (2005)
Amendment 2 (2006)

IEC 60050-161:1990, *International Electrotechnical Vocabulary (IEV) – Chapter 161: Electromagnetic compatibility*
Amendment 1 (1997)
Amendment 2 (1998)

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 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 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 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:

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

NOTE 1 Impulse area, sometimes referred to as impulse strength, is typically expressed in µVs or dB(µVs).

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

3.6
impulse bandwidth
B_{imp}

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

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,

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

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

NOTE See A.2 for further information.

3.7
measuring receiver
instrument, such as a tunable voltmeter, an EMI receiver or a spectrum analyzer 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 2 See Annex I for further information.

3.8
mechanical time constant of a critically damped indicating instrument
T_{M}

$$T_{\text{M}} = \frac{T_{\text{L}}}{2\pi} \qquad (4)$$

where T_{L} is the period of free oscillation of the instrument with all damping removed.

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

$$T_{\text{M}}^2\left(\frac{d^2\alpha}{dt^2}\right) + 2T_{\text{M}}\frac{d\alpha}{dt} + \alpha = ki \qquad (5)$$

where

α is the deflection;

i is the current through the instrument; and

k is a constant.

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

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

a) the period of free oscillation having been adjusted to $2\pi T_M$, 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 overswing 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 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 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 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 Weighting factor is expressed in dB.

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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

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.

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)].

The source impedances of the pulse generator and the signal generator shall both be the same. A tolerance of ±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) 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

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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, the relationship between amplitude and repetition frequency is in accordance with Figure 1. 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.

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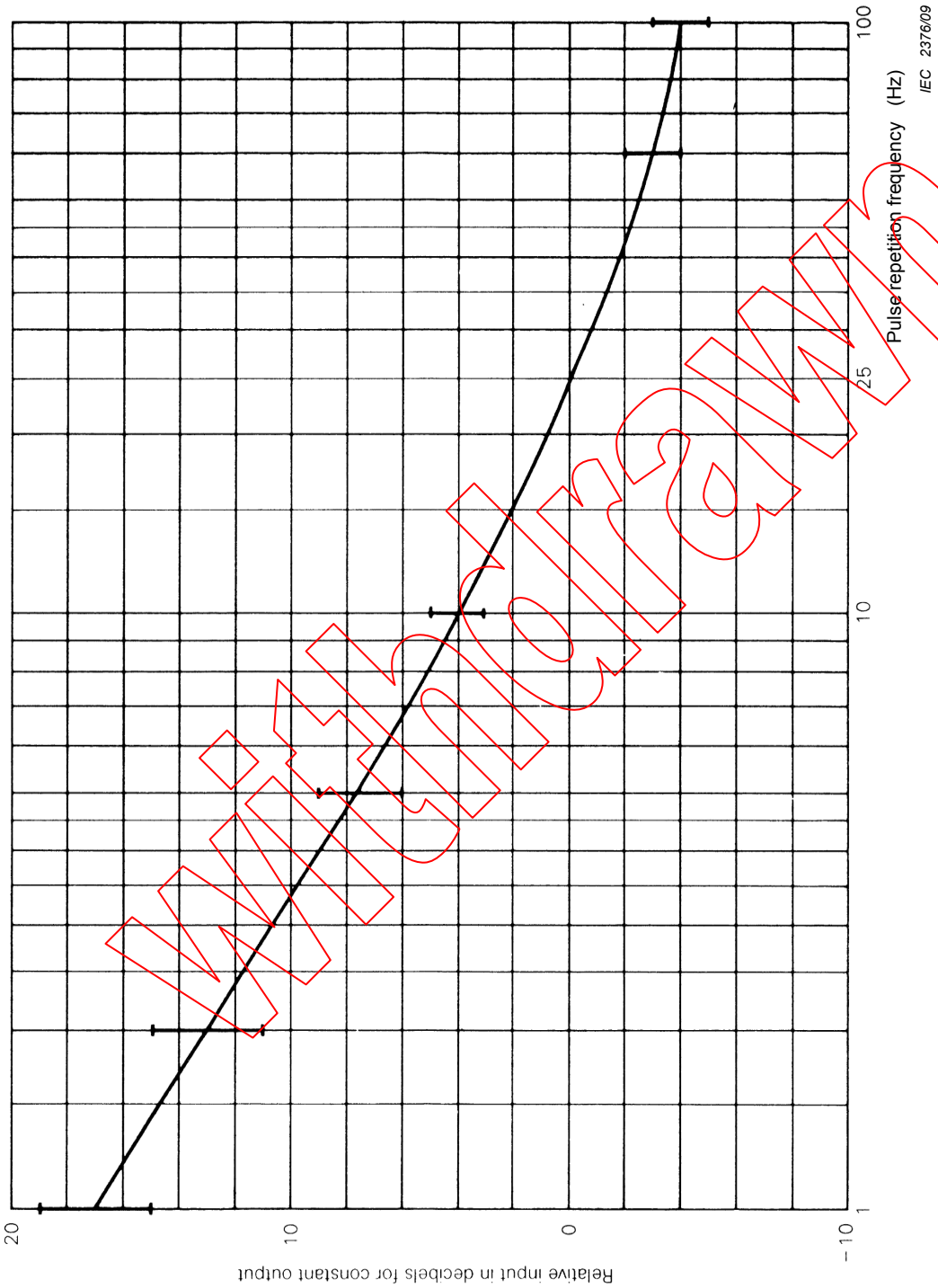

Figure 1a) – Pulse response curve (Band A)

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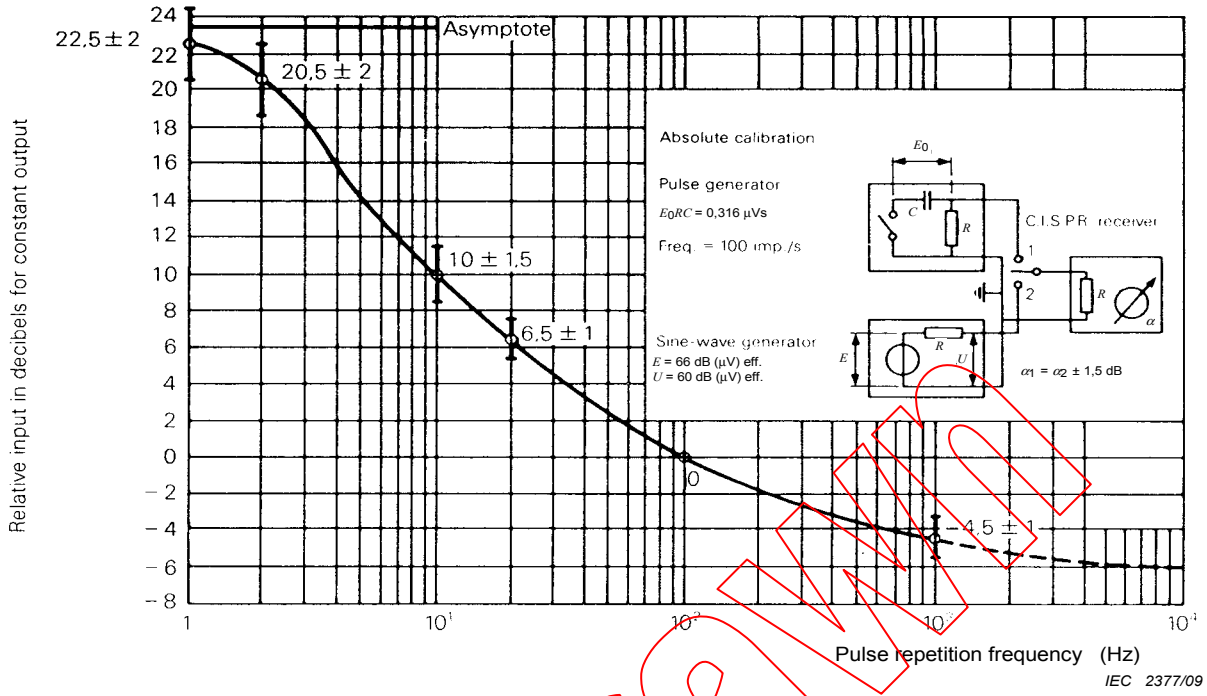

Figure 1b) – Pulse response curve (Band B)

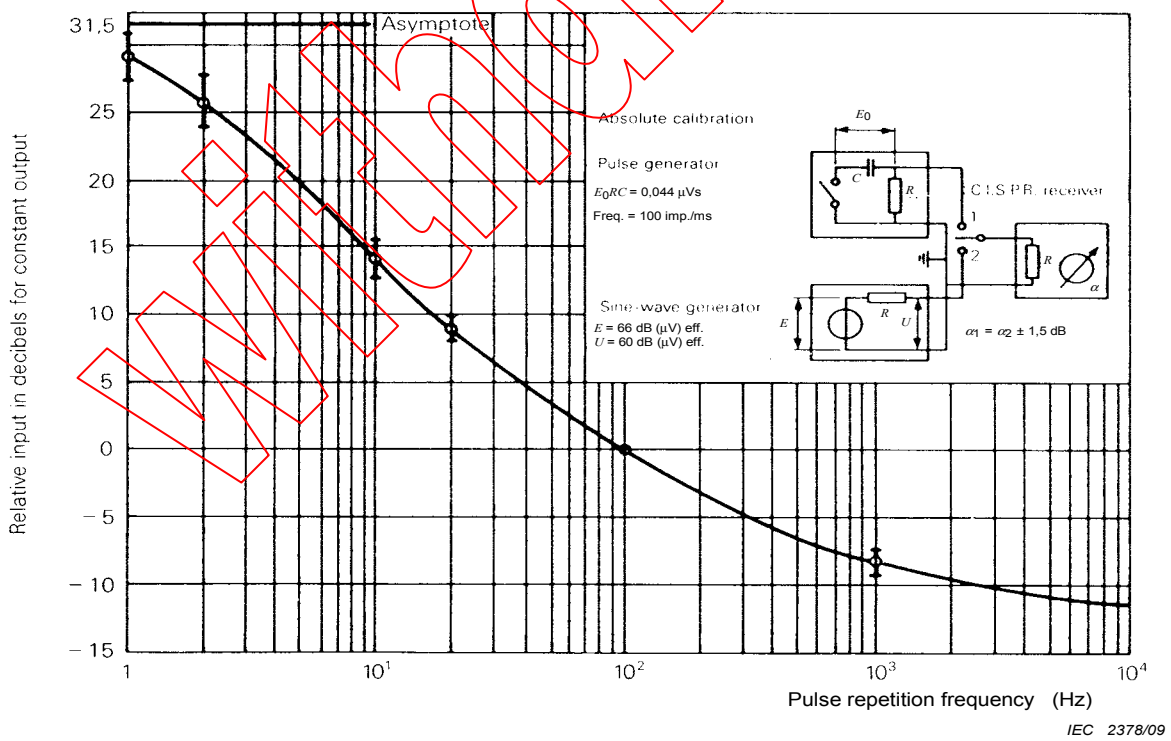

Figure 1c) – Pulse response curve (Bands C and D)

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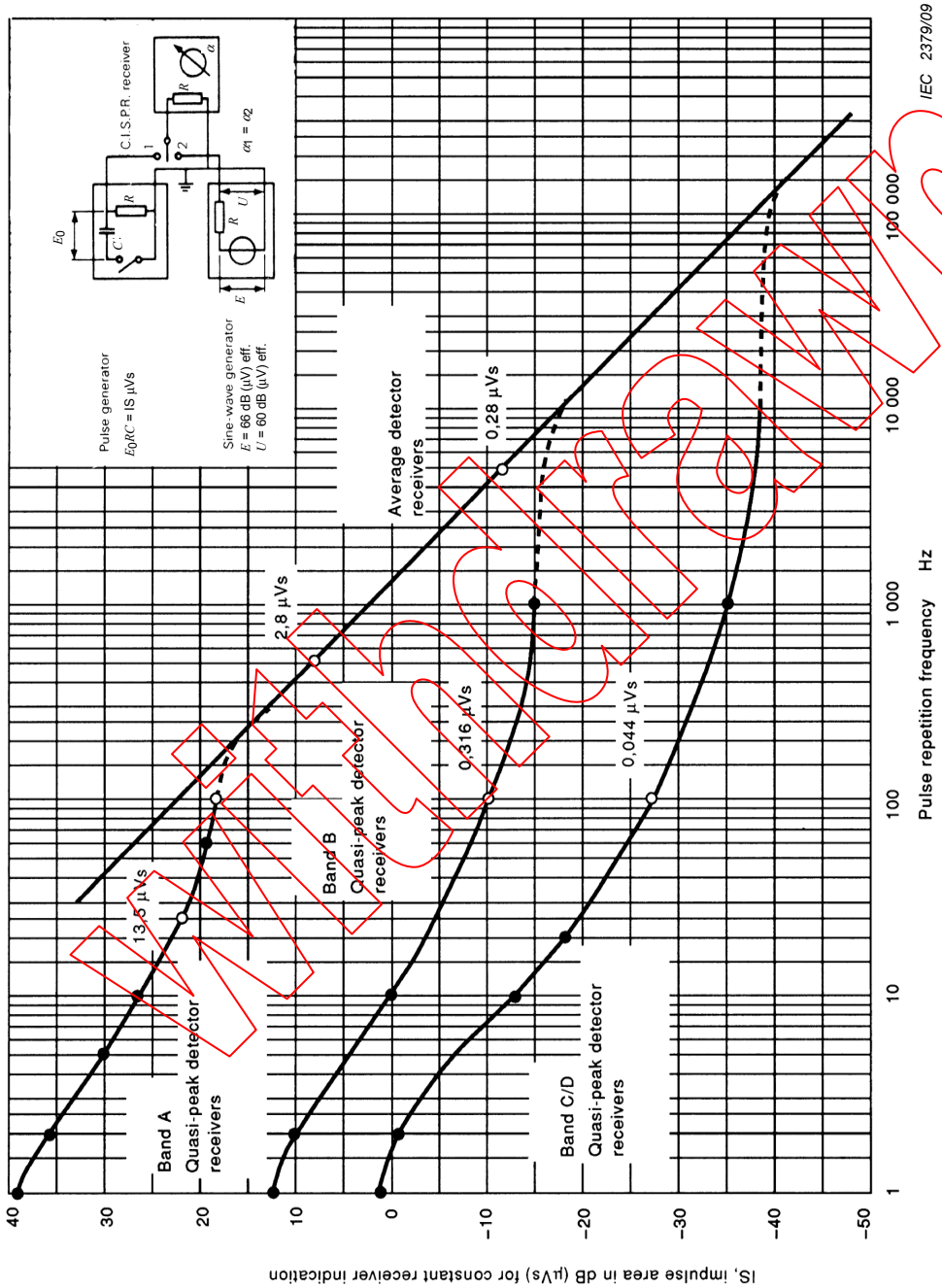

NOTE 'IS' is the abbreviation used for A_{imp} in previous editions

Figure 1d) – Theoretical pulse response curve of quasi-peak detector receivers and average detector receiver (see 6.5.4)

Figure 1 – Pulse response curves

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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, Annex B of CISPR 16-2-2, or Annex B of CISPR 16-2-3.

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 ± 1,0	–8,0 ± 1,0	–8,0 ± 1,0
100	–4,0 ± 1,0	0 (ref.)	0 (ref.)	0 (ref.)
60	–3,0 ± 1,0	–	–	–
25	0 (ref.)	–	–	–
20	–	+6,5 ± 1,0	+9,0 ± 1,0	+9,0 ± 1,0
10	+4,0 ± 1,0	+10,0 ± 1,5	+14,0 ± 1,5	+14,0 ± 1,5
5	+7,5 ± 1,5	–	–	–
2	+13,0 ± 2,0	+20,5 ± 2,0	+26,0 ± 2,0	+26,0 ± 2,0*
1	+17,0 ± 2,0	+22,5 ± 2,0	+28,5 ± 2,0	+28,5 ± 2,0*
Isolated pulse	+19,0 ± 2,0	+23,5 ± 2,0	+31,5 ± 2,0	+31,5 ± 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 1d. The ordinate of Figure 1d 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 1d 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 2 a), b) or c).

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 1 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 be added in front of the

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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.

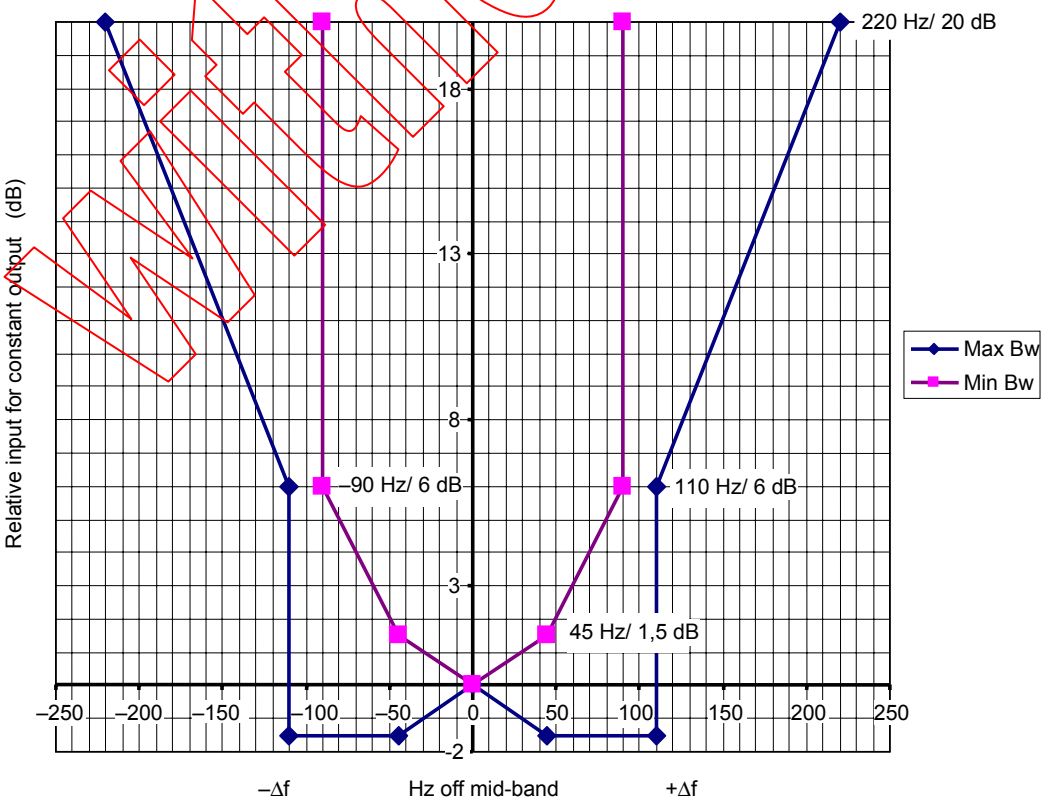

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Figure 2a) – Limits of overall selectivity – Pass band (see 4.5.1, 5.6, 6.6, 7.6) (Band A)

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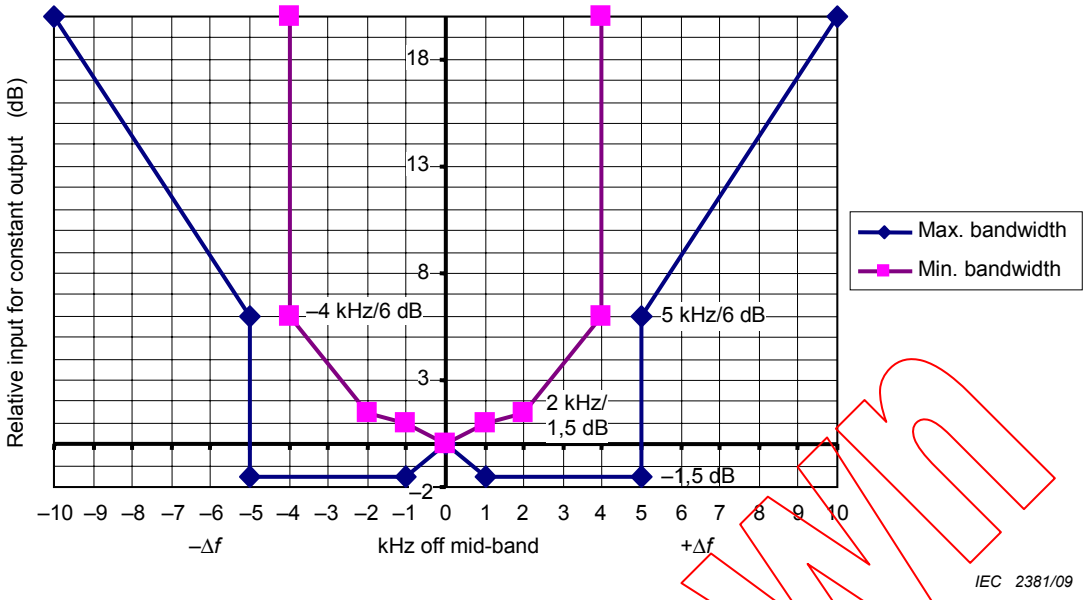

Figure 2b) – Limits of overall selectivity – Pass band (see 4.5.1, 5.6, 6.6, 7.6) (Band B)

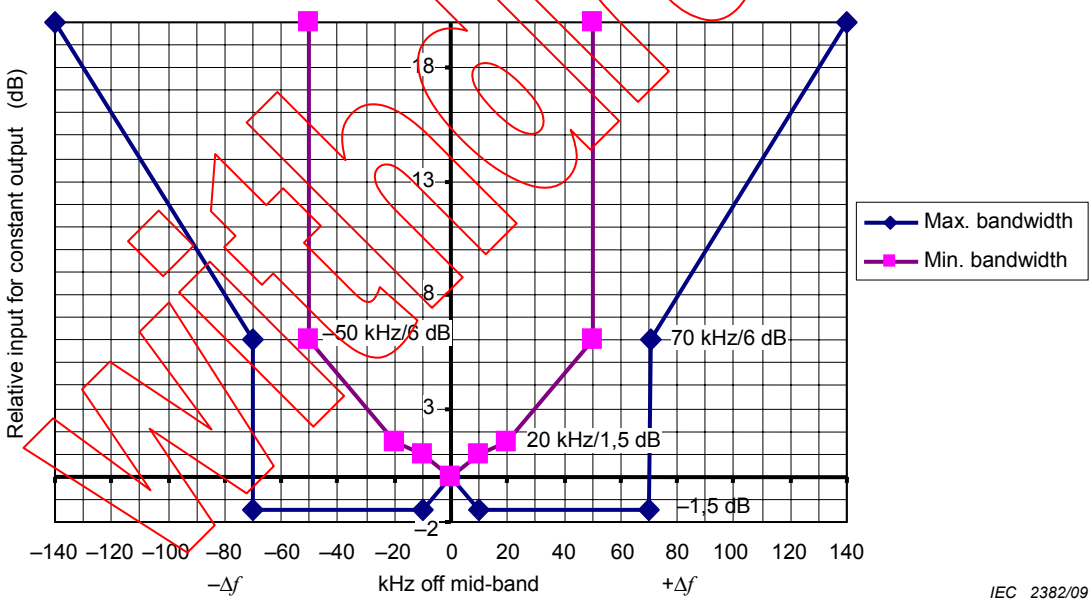

Figure 2c) – Limits of overall selectivity – Pass band (see 4.5.1, 5.6, 6.6, 7.6) Bands (C and D)

Figure 2 – Limits of overall selectivity

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:

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

where

m, n, k are integers;

f_L is the local oscillator frequency;

f_i is the intermediate frequency;

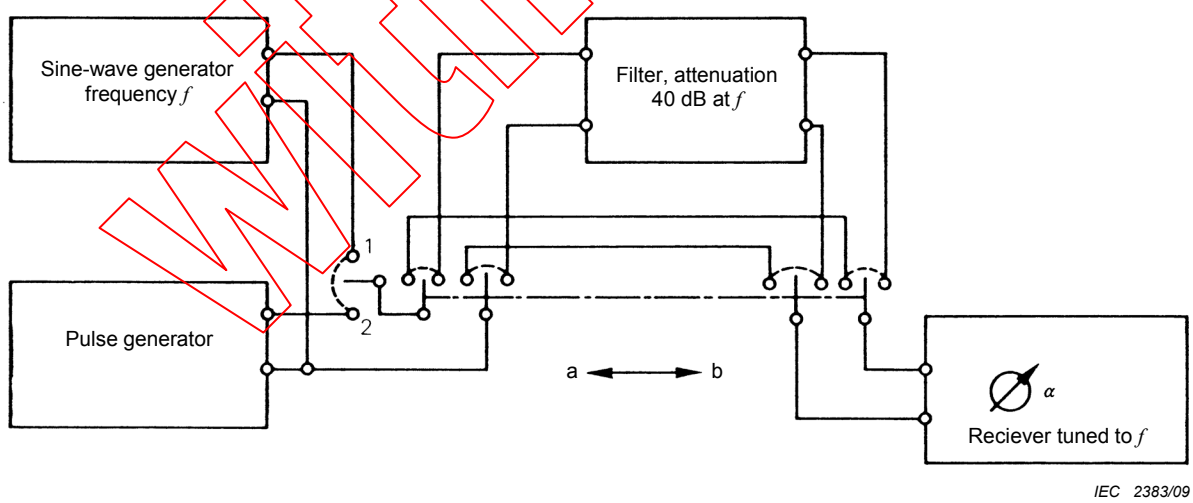
f_o is the tuned frequency.

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.

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 3. 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:

$$\alpha_{1a} = \alpha_{2a}$$

$$\alpha_{1b} = \alpha_{1a} - 40 \text{ dB}$$

$$\alpha_{2b} = \alpha_{2a} - 36 \text{ dB}$$

Figure 3 – Arrangement for testing intermodulation effects

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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 4.8.2 when tested as described in 4.8.2, 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.

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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 for the measurement of discontinuous disturbance. The loading of these outputs shall have no influence on the indication of the instrument.

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 that meet the requirements of this clause can be used for compliance measurements.

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.

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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 may be used for signals with time-varying amplitudes.

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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 (±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(µV)]. 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 ±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 The pulse response is based on the use of the reference bandwidth only (see Table 6).				

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 Figure 2 a), 2b) and 2c), 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 2 a).

The requirements in 4.5.2, 4.5.3 and 4.5.4 apply.

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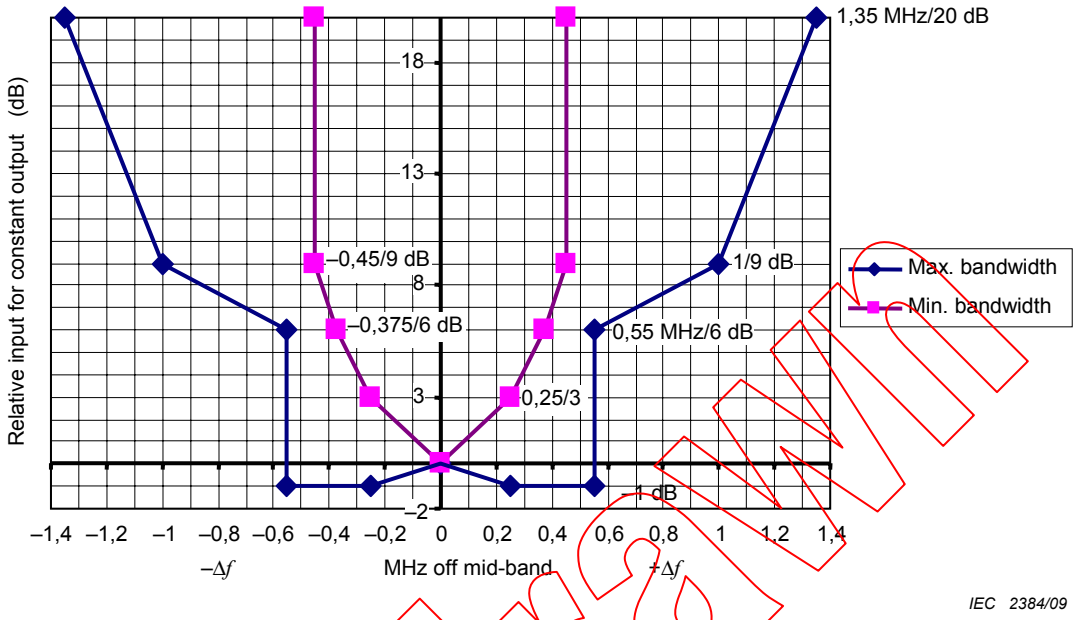
The curve representing the overall selectivity of the measuring receiver reference bandwidth for Band E shall lie within the limits of Figure 4.



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 4 – 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.

NOTE 1 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.

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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 that meet the requirements of this clause can be used for compliance measurements.

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).

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6.4 Sine-wave voltage accuracy

The accuracy of sine-wave voltage measurement shall be better than ±2 dB (±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(μV)]. 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 2,5 dB/–0,5 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.					

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(μV)]. The pulse shall be defined as a pulse-modulated carrier. The value of n shall be 50 000 Hz. A tolerance of ±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 μs) 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(μV)]. 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 ±2,5 dB).

For further details, see E.6.

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NOTE 2 Average detection can be achieved with spectrum analyzers operated with a video bandwidth $B_{video} << B_{resol}$ 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 3 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 1d). 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_{logAv} 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:

$$L_{logAv} = \frac{T_P L_P + T_N L_N}{T_P + T_N} \tag{7}$$

EXAMPLE If the pulse level L_P is 85 dB(µV) and the noise level L_N is 8 dB(µV), $T_P = 1/B_{imp} = 1$ µs, the pulse rate n is 100 000 Hz, then $T_N \approx 9$ µs. From this equation, L_{logAv} = 15,7 dB(µV). In reality, L_{logAv} 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 6. 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 5.

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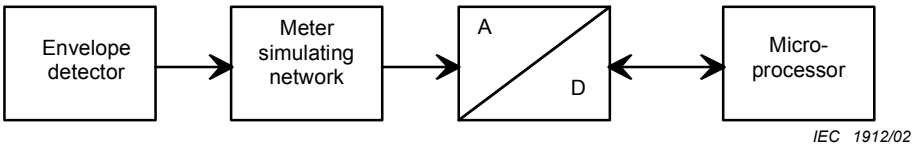


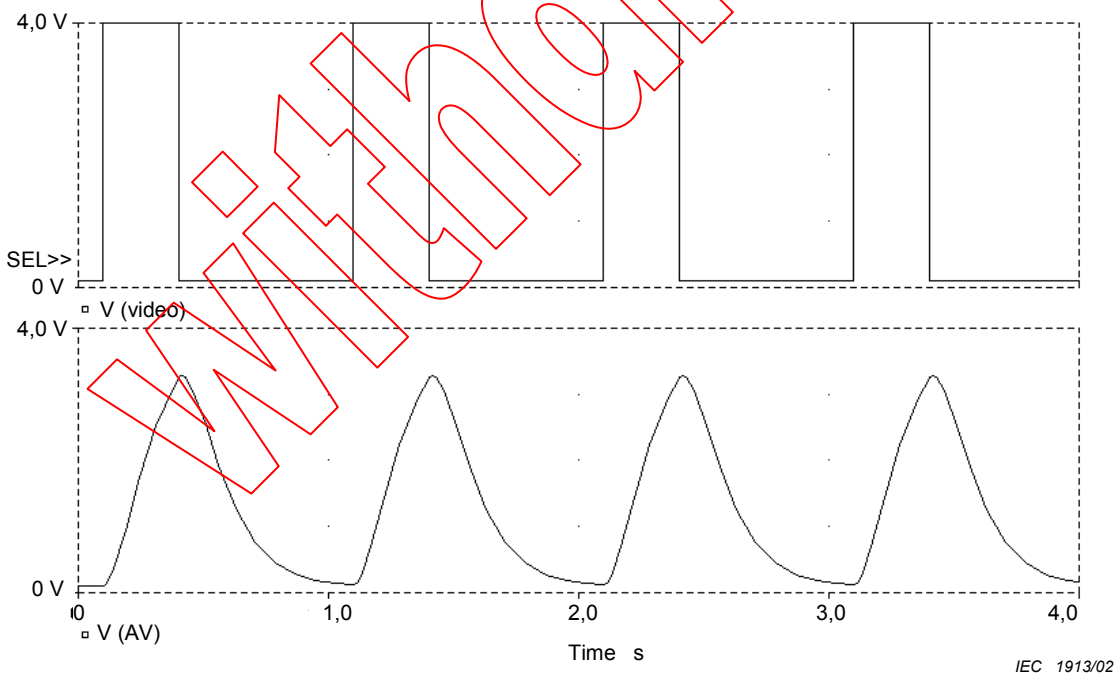
Figure 5 – Block diagram of an average detector.

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

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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 2a) and 2b), 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 2c). For receivers having other bandwidths, Figure 2 describes 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 4.

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 signalling equipment as defined in EN 50065-1 [12][1]), 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 that meet the requirements of this clause can be used for compliance measurements.

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.

[1] Figures in square brackets refer to the Bibliography.

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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 ± 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

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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 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 (±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 $278 \times (B_3)^{-1/2}$ µVs 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(µV)] rms. For the measuring receivers for Bands B, C, D and E, the corresponding values are $44 \times (B_3)^{-1/2}$ µVs and 1 000 Hz. The source impedances of the pulse generator and the signal generator shall both be the same. A tolerance of ±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.

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

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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 ± 2,0)	–20 ± 2,0
10 k	-	-	–10 ± 1,0	–10 ± 1,0
1 000	-	0 (ref.)	0 (ref.)	0 (ref.)
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 (ref.)	+16 ± 1,6		
10	+4 ± 0,4	+20 ± 2,0		
5	+9 ± 0,7	+25 ± 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 ±1,0 dB is allowed for this requirement.

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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 ± 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 Figure 2, for Bands A, B, C and D. For the Band E receiver, the selectivity curve is given in Figure 4.

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.

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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, Amendment 1, 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 ±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.

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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 ±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 7.

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 8 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.

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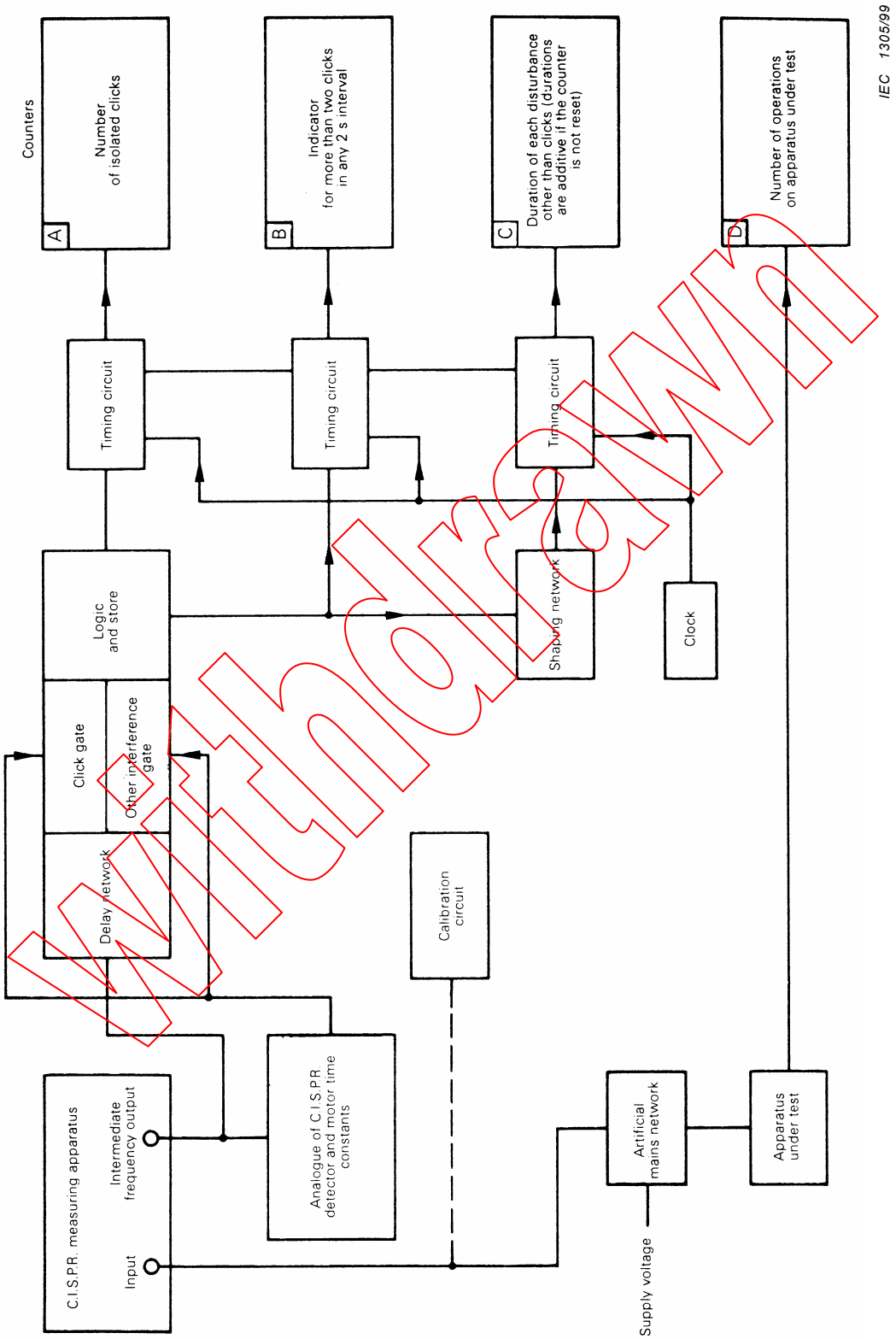

Figure 7 – Example of a disturbance analyzer

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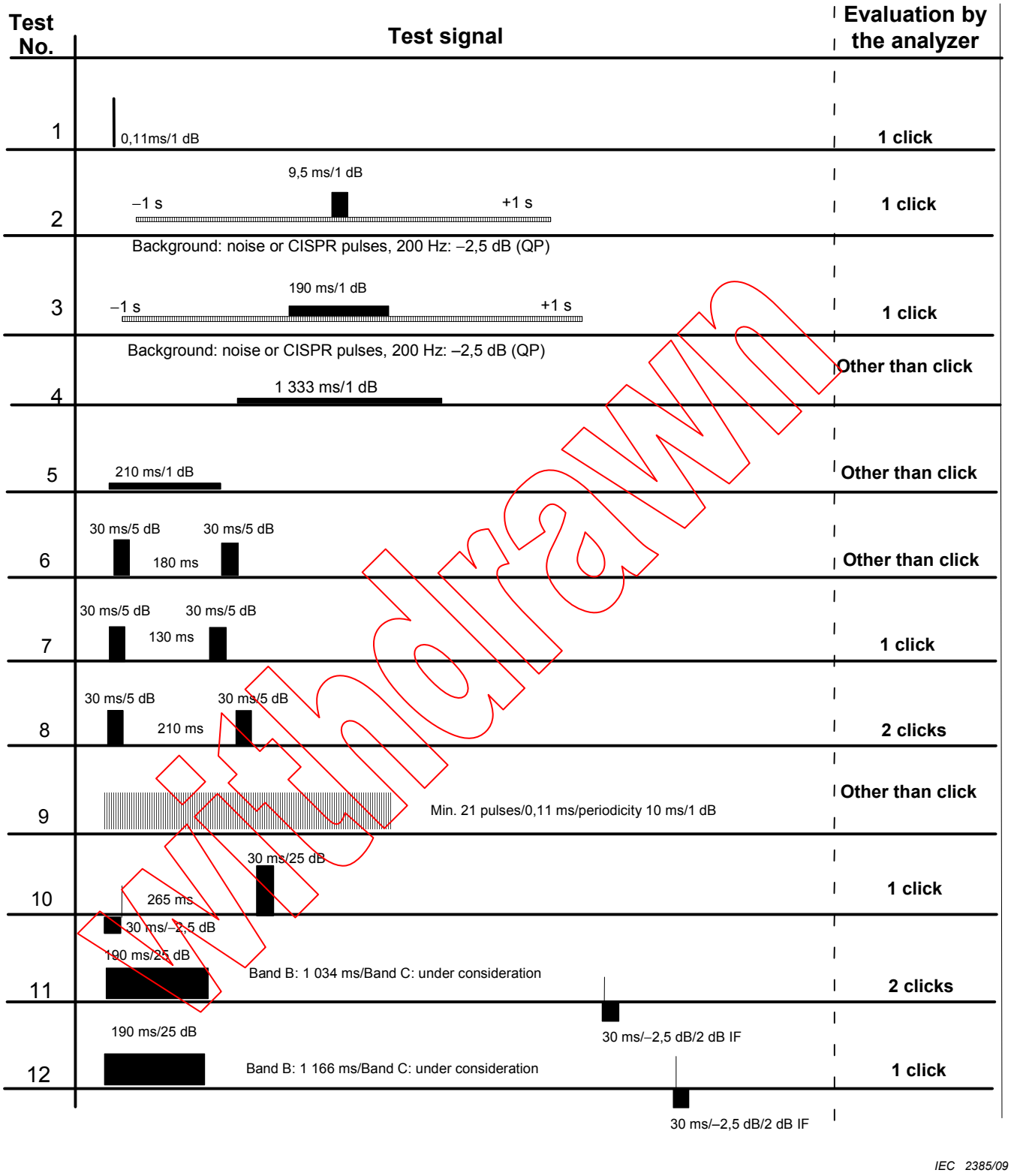

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Figure 8 – A graphical presentation of test signals used in the test of the analyzer for the performance check against the definition of a click according to Table 14

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Table 17 – Disturbance analyzer performance test – Test signals used for the check against the definition of a click

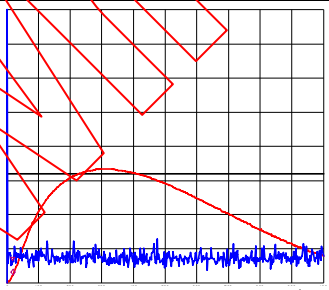
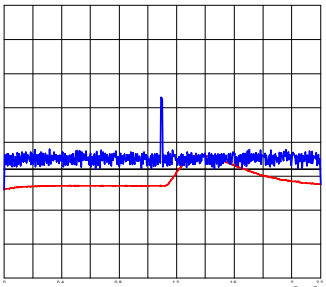
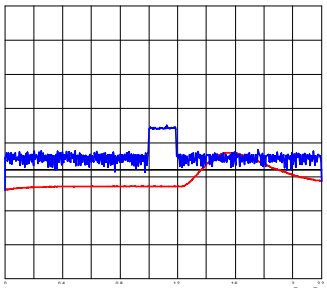
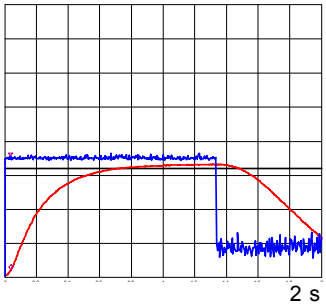
Test No.	Test signal parameters						
	1		2		3	4	5
	QP amplitude of impulses adjusted individually relative to QP reference indication of the measurement receiver dB		Duration of impulses [f] adjusted in the intermediate frequency output of the measurement receiver ms		Separation of impulses or periodicity (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	 1 s
2 [a]	1		9,5			1 click	 2,2 s
3 [a]	1		190			1 click	 2,2 s
4	1		1 333 [b]			Other than click	 2 s

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Table 17 (*continued*)

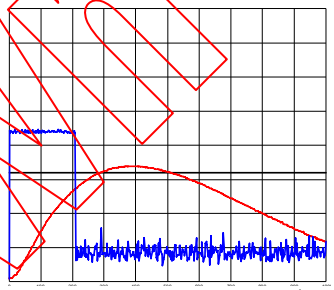
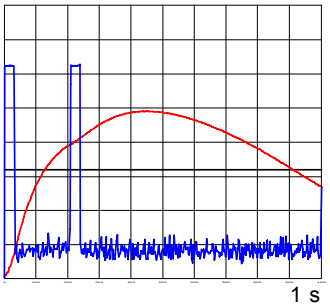
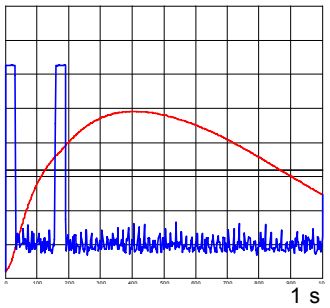
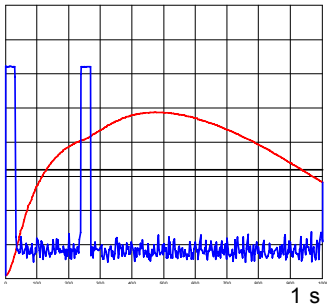
Test No.	Test signal parameters						
	1		2		3	4	5
	QP amplitude of impulses adjusted individually relative to QP reference indication of the measurement receiver dB		Duration of impulses [f] adjusted in the intermediate frequency output of the measurement receiver ms		Separation of impulses or periodicity (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			
5	1		210			Other than click (210 ms)	 1 s
6	5	5	30	30	180	Other than click (240 ms)	 1 s
7	5	5	30	30	130	1 click	 1 s
8	5	5	30	30	210	2 clicks	 1 s

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Table 17 (*continued*)

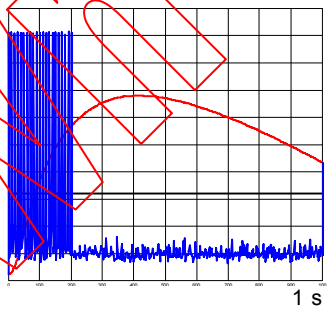
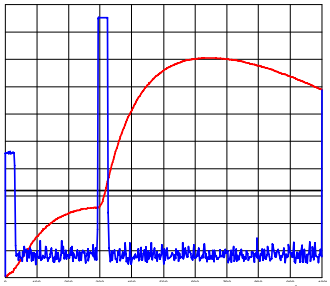
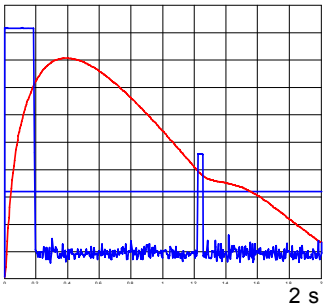
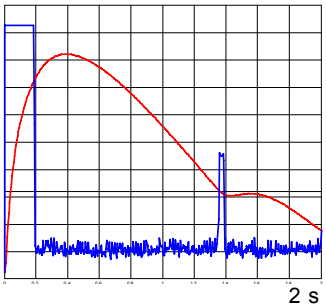
Test No.	Test signal parameters						
	1		2		3	4	5
	QP amplitude of impulses adjusted individually relative to QP reference indication of the measurement receiver dB		Duration of impulses [f] adjusted in the intermediate frequency output of the measurement receiver ms		Separation of impulses or periodicity (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			
9	1		0,11		Periodicity 10, minimum 21 pulses	Other than click	 1 s
10	–2,5	25	30	30	265	1 click	 1s
11	25	–2,5 [c]	190	30	1 034 [e]	2 clicks [d]	 2 s
12	25	–2,5 [c]	190	30	1 166 [e]	1 click	 2 s

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Table 17 (*continued*)

[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 be not 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.

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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:

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

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 $\upsilon\tau$ is, from the previous equation:

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

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

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

where $\omega = 2\pi f$.

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The bandwidths B_3 and B_6 will be:

$$B_3 = \frac{\left[\sqrt{2} \times \sqrt[4]{\left(\sqrt{2}-1\right)}\right]\omega_0}{\pi} = 0{,}361\omega_0 \tag{A.3a}$$

$$B_6 = \frac{\sqrt{2} \times \omega_0}{\pi} = 0{,}450\omega_0 \tag{A.3b}$$

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:

$$\Delta f = \left(\frac{1}{F_0^2}\right)\int_{-\infty}^{+\infty} F^2(f)df \tag{A.4}$$

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

$$\Delta f = \int_{-\infty}^{+\infty} F^2(f)df \tag{A.5}$$

Taking $F(f)$ from Equation (A.2) and putting G = 1, we have:

$$\Delta f = \int_0^{\infty} 2\left\{\frac{2\omega_0^2}{\left[(\omega_0 + j\omega)^2 + \omega_0^2\right]^4}\right\}df \tag{A.6}$$

this leads to:

$$\Delta f = 0{,}265\sqrt{2} \times \omega_0 = 0{,}375\omega_0 \tag{A.7}$$

thus:

$$B_3 = 0{,}963\ \Delta f \tag{A.8}$$

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.

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