BS EN 61260-1:2014

BSI Standards Publication

Electroacoustics — Octave-band and fractional-octave-band filters

Part 1: Specifications

National foreword

This British Standard is the UK implementation of EN 61260-1:2014. It is identical to IEC 61260-1:2014. Together with BS EN 61260-2 and BS EN 61260-3 it supersedes BS EN 61260:1996, which will be withdrawn upon publication of the rest of the series.

The UK participation in its preparation was entrusted to Technical Committee EPL/29, Electroacoustics.

A list of organizations represented on this committee can be obtained on request to its secretary.

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Electroacoustics - Octave-band and fractional-octave-band filters - Part 1: Specifications (IEC 61260-1:2014)

Electroacoustique - Filtres de bande d'octave et de bande d'une fraction d'octave - Partie 1: Spécifications (CEI 61260-1:2014)

Elektroakustik - Bandfilter für Oktaven und Bruchteile von Oktaven - Teil 1: Anforderungen (IEC 61260-1:2014)

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Foreword

The text of document 29/835/FDIS, future edition 1 of IEC 61260-1, prepared by IEC/TC 29 "Electroacoustics" was submitted to the IEC-CENELEC parallel vote and approved by CENELEC as EN 61260-1:2014.

The following dates are fixed:

• latest date by which the document has to be implemented at national level by publication of an identical national standard or by endorsement	(dop)	2014-12-21
• latest date by which the national standards conflicting with the document have to be withdrawn	(dow)	2017-03-21

This document supersedes EN 61260:1995.

EN 61260-1:2014 includes the following significant technical changes with respect to EN 61260:1995:

a) the single document in the first edition of EN 61260:1995 is in EN 61260 series separated into the three parts covering: specifications, pattern evaluation tests and periodic tests;

b) the EN 61260:1995 specified three performance categories: classes 0, 1 and 2. The EN 61260 series specifies requirements for class 1 and 2;

c) in the EN 61260:1995, the design goals for the specification can be based on base-2 or base 10 design. In EN 61260 series only base-10 is specified;

d) the reference environmental conditions have been changed from 20 °C / 65 % RH to 23 °C / 50 % RH;

e) EN 61260:1995 specified tolerance limits without considering the uncertainty of measurement for verification of the specifications. EN 61260 series specifies acceptance limits for the observed values and maximum-permitted uncertainty of measurements for laboratories testing conformance to specifications in the standard.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CENELEC [and/or CEN] shall not be held responsible for identifying any or all such patent rights.

Endorsement notice

The text of the International Standard IEC 61260-1:2014 was approved by CENELEC as a European Standard without any modification.

In the official version, for Bibliography, the following notes have to be added for the standards indicated:

CISPR 16-1-1:2010 NOTE Harmonised as EN 55016-1-1:2010.

Annex ZA
(normative)
Normative references to international publications with their corresponding European publications

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.

NOTE 1 When an International Publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

NOTE 2 Up-to-date information on the latest versions of the European Standards listed in this annex is available here: www.cenelec.eu

Publication	Year	Title	EN/HD	Year
IEC 61000-4-2	-	Electromagnetic compatibility (EMC) -- Part 4-2: Testing and measurement techniques - Electrostatic discharge immunity test	EN 61000-4-2	-
IEC 61000-4-3	2006	Electromagnetic compatibility (EMC) -- Part 4-3: Testing and measurement techniques - Radiated, radio-frequency, electromagnetic field immunity test	EN 61000-4-3	2006
IEC 61000-6-1	2005	Electromagnetic compatibility (EMC) -- Part 6-1: Generic standards - Immunity for residential, commercial and light-industrial environments	EN 61000-6-1	2007
IEC 61000-6-2	2005	Electromagnetic compatibility (EMC) -- Part 6-2: Generic standards - Immunity for industrial environments	EN 61000-6-2	2005
			+	2005
IEC 61000-6-3	2006	Electromagnetic compatibility (EMC) -- Part 6-3: Generic standards - Emission standard for residential, commercial and light-industrial environments	EN 61000-6-3	2007
IEC 61672-1	-	Electroacoustics - Sound level meters -- Part 1: Specifications	EN 61672-1	-
ISO/IEC Guide 98-3	-	Uncertainty of measurement -- Part 3: Guide to the expression of uncertainty in measurement (GUM:1995)	-	-
ISO/IEC Guide 98-4	2012	Uncertainty of measurement -- Part 4: Role of measurement uncertainty in conformity assessment	-	-
CISPR 22 (mod)	2008	Information technology equipment - Radio disturbance characteristics - Limits and methods of measurement	EN 55022	2010
			+AC	2011

CONTENTS

INTRODUCTION

IEC 61260:1995 and its Amendment 1:2001 are now separated into the following three parts of IEC 61260 series:

- Part 1: Specifications
- Part 2: Pattern evaluation tests (under consideration)
- Part 3: Periodic tests (under consideration)

For assessments of conformance to performance specifications, IEC 61260-1 uses different criteria than were used for the IEC 61260:1995 edition.

IEC 61260:1995 did not provide any requirements or recommendations to account for the uncertainty of measurement in assessments of conformance to specifications. This absence of requirements or recommendations to account for uncertainty of measurement created ambiguity in determinations of conformance to specifications for situations where a measured deviation from a design goal was close to a limit of the allowed deviation. If conformance was determined based on whether a measured deviation did or did not exceed the limits, the end-user of the octave-band and fractional-octave-band filters incurred the risk that the true deviation from a design goal exceeded the limits.

To remove this ambiguity, IEC Technical Committee 29, at its meeting in 1996, adopted a policy to account for measurement uncertainty in assessments of conformance in International Standards that it prepares.

This first edition of IEC 61260-1 uses an amended criterion for assessing conformance to a specification. Conformance is demonstrated when (a) measured deviations from design goals do not exceed the applicable *acceptance limits* and (b) the uncertainty of measurement does not exceed the corresponding maximum-permitted uncertainty. Acceptance limits are analogous to the tolerance limits allowances for design and manufacturing implied in the IEC 61260:1995.

Actual and maximum-permitted uncertainties of measurement are determined for a coverage probability of 95 %. Unless more-specific information is available, the evaluation of the contribution of a specific filter or filter set to a total measurement uncertainty can be based on the acceptance limits and maximum-permitted uncertainties specified in this standard.

ELECTROACOUSTICS – OCTAVE-BAND AND FRACTIONAL-OCTAVE-BAND FILTERS –

Part 1: Specifications

1 Scope

1.1 This part of the IEC 61260 series specifies performance requirements for analogue, sampled-data, and digital implementations of band-pass filters. The extent of the pass-band region of a filter's relative attenuation characteristic is a constant percentage of the exact mid-band frequency for all filters of a given bandwidth. An instrument conforming to the requirements of this standard may contain any number of contiguous band-pass filters covering any desired frequency range.

1.2 Performance requirements are provided for two filter classes: class 1 and class 2. In general, specifications for class 1 and class 2 filters have the same design goals and differ mainly in the acceptance limits and the range of operational temperature. Acceptance limits for class 2 are greater than, or equal to, those for class 1. Maximum-permitted expanded uncertainties of measurement are also specified.

1.3 Performance requirements are given for designs where the octave frequency ratio and the mid-band frequencies are powers of ten.

1.4 Band-pass filters conforming to the performance requirements of this standard may be part of various measurement systems or may be an integral component of a specific instrument such as a spectrum analyser.

1.5 This standard specifies the ranges of environmental conditions for operation of the filters. The required range depends on whether the instrument containing the filters is designed to be operated in a controlled environment or more generally in the field.

1.6 Band-pass filters conforming to the requirements of this standard are capable of providing frequency-band-filtered spectral information for a wide variety of signals, for example, time-varying, intermittent or steady; broadband or discrete frequency; and long or short durations.

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.

IEC 61000-4-2, *Electromagnetic compatibility (EMC) – Part 4-2: Testing and measurement techniques – Electrostatic discharge immunity test*

IEC 61000-4-3:2006, *Electromagnetic compatibility (EMC) – Part 4-3: Testing and measurement techniques – Radiated, radio-frequency, electromagnetic field immunity test*

IEC 61000-6-1:2005, *Electromagnetic compatibility (EMC) – Part 6-1: Generic standards – Immunity for residential, commercial and light-industrial environments*

IEC 61000-6-2:2005, *Electromagnetic compatibility (EMC) – Part 6-2: Generic standards – Immunity for industrial environments*

IEC 61000-6-3:2006, *Electromagnetic compatibility (EMC) – Part 6-3: Generic standards – Emission standard for residential, commercial and light-industrial environments*
Amendment 1:2010

IEC 61672-1, *Electroacoustics – Sound level meters – Part 1: Specifications*

CISPR 22:2008, *Information technology equipment – Radio disturbance characteristics – Limits and methods of measurement*

ISO/IEC Guide 98-3, *Uncertainty of measurement – Part 3: Guide to the expression of uncertainty in measurement (GUM: 1995)*

ISO/IEC Guide 98-4:2012, *Uncertainty of measurement – Part 4: Role of measurement uncertainty in conformity assessment*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in IEC 61000-4-2, IEC 61000-4-3, IEC 61000-6-1, IEC 61000-6-2, and IEC 61000-6-3, as well as the following apply.

3.1
band-pass filter
filter with a single transmission band (or pass-band with small relative attenuation) extending from a lower band-edge frequency greater than zero to a finite upper band-edge frequency

3.2
octave frequency ratio
frequency ratio nominally equal to an octave or a frequency ratio of 2:1

Note 1 to entry: 5.2.1 gives the expression of the octave frequency ratio for this standard.

3.3
bandwidth designator
reciprocal of a positive integer, including 1, to designate the fraction of an octave band

Note 1 to entry: The bandwidth designator is used to designate the nominal bandwidth of the filters in a set of filters, for example, for $1/b$ = 1/12, the filters are designated as one-twelfth-octave-band filters.

3.4
reference frequency
single frequency selected to normalize the attenuation response for all band-pass filters in a filter set

Note 1 to entry: The reference frequency is expressed in hertz (Hz).

3.5
exact mid-band frequency
frequency that has a specified relationship to the reference frequency such that the ratio of the exact mid-band frequencies of any two contiguous band-pass filters is the same for all filters in a filter set of a specified bandwidth

Note 1 to entry: Exact mid-band frequency is expressed in hertz (Hz).

3.6
nominal mid-band frequency
rounded mid-band frequency for the designation of band-pass filters

Note 1 to entry: Nominal mid-band frequency is expressed in hertz (Hz).

3.7
normalized frequency
for a band-pass filter, ratio of a frequency to the corresponding exact mid-band frequency

3.8
band-edge frequencies
frequencies at the lower and upper edges of the pass-band of a band-pass filter such that the exact mid-band frequency is the geometric mean of the lower and upper band-edge frequencies

Note 1 to entry: Band-edge frequencies are expressed in hertz (Hz).

3.9
normalized bandwidth of a filter
relative bandwidth for a given filter, the ratio of the upper band-edge frequency minus the corresponding lower band-edge frequency to the exact mid-band frequency

3.10
octave-band filter
band-pass filter for which the ratio of upper band-edge frequency to lower band-edge frequency is the octave frequency ratio

3.11
fractional-octave-band filter
band-pass filter for which the ratio of upper band-edge frequency to lower band-edge frequency is the octave frequency ratio raised to an exponent equal to the applicable bandwidth designator

Note 1 to entry: An octave-band filter is also a fractional-octave-band filter ($1/b$ = 1/1).

3.12
signal level
time-average signal level
at any frequency, ten times the logarithm to the base ten of the ratio of a specified time-mean-square signal to the square of a specified reference value

Note 1 to entry Time-averaged signal level is expressed in decibels (dB).

3.13
filter attenuation
at any frequency, for a band-pass filter, the input signal level minus the corresponding output signal level

Note 1 to entry: Filter attenuation is expressed in decibels (dB).

3.14
reference attenuation
for all band-pass filters in an instrument, nominal filter attenuation in the pass-band for determining relative attenuation

Note 1 to entry: Reference attenuation is expressed in decibels (dB).

3.15
relative attenuation
filter attenuation minus the reference attenuation

Note 1 to entry: Relative attenuation is expressed in decibels (dB).

3.16
normalized response
at any normalized frequency, the anti-logarithm to the base ten of minus one-tenth of the corresponding relative attenuation

3.17
normalized effective bandwidth
integral over normalized frequency of the normalized response of a band-pass filter to constant-amplitude sinusoidal input signals, the normalized response being weighted with the inverse of the normalized frequency

3.18
normalized reference effective bandwidth
normalized effective bandwidth for a band-pass filter having zero relative attenuation in the passband and infinite relative attenuation at other frequencies

3.19
effective bandwidth deviation
ten times the logarithm to the base ten of the ratio of the normalized effective bandwidth of a filter to the normalized reference effective bandwidth

Note 1 to entry: Effective bandwidth deviation is expressed in decibels (dB).

3.20
reference level range
one of the available level ranges specified for testing the electrical performance characteristics of the band-pass filters in a filter set

3.21
reference input signal level
specified reference level of the input signal on the reference level range

Note 1 to entry: The reference input signal level is expressed in decibels (dB).

3.22
level linearity deviation
on any level range at the exact mid-band frequency, if not otherwise specified, an indicated output signal level minus the anticipated output signal level

Note 1 to entry: Level linearity deviation is expressed in decibels (dB).

3.23
linear operating range
for a stated filter and a stated level range, the extent of steady sinusoidal input signal levels over which level linearity deviations do not exceed the applicable limits of this standard

Note 1 to entry: Linear operating range is expressed in decibels (dB).

3.24
level range control
device for adjusting the sensitivity of a band-pass filter in response to changes in the level of the input signal in order to maintain the overall operation of the filter within the linear operating range

3.25
measurement range
for any exact mid-band frequency, the range from the lower boundary of the input signal level for the linear operating range on the most-sensitive level range to the upper boundary of the input signal level for the linear operating range on the least-sensitive level range

Note 1 to entry: A measurement range is expressed in decibels (dB).

3.26
analogue filter
filter that operates continuously on an input signal to produce a filtered output

3.27
sampled-data filter
computational process that operates on samples of an input signal to produce a filtered output

3.28
digital filter
subset of sampled-data filters that operates on digitized samples of input data

3.29
time-invariant operation
operational mode or capability of a system of band-pass filters such that the response to a signal is independent of the time when the signal was applied

3.30
filter decay time
at a stated frequency, elapsed time required for the output signal level to decrease by 60 dB after sudden cessation of the signal from the input to the filter

Note 1 to entry: Filter decay time is expressed in seconds (s).

3.31
reference orientation
orientation of a band-pass filter with respect to the principal direction of an emitter or receiver of radio-frequency fields

3.32
group X band-pass filter
self-contained instrument that includes band-pass filtering facilities conforming to the requirements of this standard and which specifies internal battery power for the normal mode of operation and requiring no external connection to other apparatus to operate the instrument

3.33
group Y band-pass filter
self-contained instrument that includes band-pass filtering facilities conforming to the requirements of this standard and which specifies connection to a public supply of electrical power for the normal mode of operation and also requiring no external connection to other apparatus to operate the instrument

3.34
group Z band-pass filter
instrument that includes band-pass filtering facilities conforming to the requirements of this standard and requiring two or more items of equipment to be connected together by some means for the normal mode of operation, with operation either from batteries or from a public supply of electrical power

Note 1 to entry: If the items communicate by means of radio or optical methods, but are not connected by any conductive device, the items are not connected in this context.

3.35
coverage probability
probability that the set of true quantity values of a measurand is contained within a specified coverage interval

[SOURCE: ISO/IEC Guide 98-4:2012, 3.2.8]

3.36
acceptance limit
specified upper or lower bound of permissible measured quantity values

[SOURCE: ISO/IEC Guide 98-4:2012, 3.3.8]

4 Reference environmental conditions

Reference environmental conditions are as follows:

- temperature 23 °C
- static pressure 101,325 kPa
- relative humidity 50 %

5 Performance requirements

5.1 General

5.1.1 Electrical response characteristics specified in this standard for fractional-octave-band filters apply under the reference environmental conditions of Clause 4, if not otherwise stated.

5.1.2 Any filter design realization may be utilized provided the resulting filters conform to all applicable requirements of this standard.

5.1.3 Band-pass filters may be powered by batteries or from external power supply systems.

5.1.4 The configuration of the filter shall be as specified in the Instruction Manual for one of the normal modes of operation, including required accessories.

5.1.5 For filters enclosed in a sound level meter with detachable preamplifier, the signal input to the filter may be, as specified by the supplier, the input of the preamplifier through a suitable input device replacing the microphone, or the terminal where the signal from the preamplifier normally is connected.

5.1.6 Acceptance limits in this standard include allowances for design, manufacturing and aging.

5.1.7 In subsequent subclauses, acceptance limits are provided for allowable values of measured deviations from design goals. Annex A describes the relationship between tolerance interval, corresponding acceptance interval and the maximum-permitted uncertainty of measurement.

5.1.8 For pattern-evaluation tests and periodic tests, the laboratory shall determine that their actual expanded uncertainties, as the 95 % coverage intervals in accordance with ISO/IEC Guide 98-3 and ISO/IEC Guide 98-4, do not exceed the maximum-permitted expanded uncertainties specified in Annex B.

5.1.9 Conformance to the specifications is demonstrated when (a) the measured deviations from the design goals do not exceed the applicable acceptance limits and (b) the corresponding actual expanded uncertainties of measurements does not exceed the corresponding maximum-permitted uncertainty of measurement given in Annex B.

5.1.10 Annex C gives examples of evaluation of conformance to specifications of this standard.

5.2 Octave frequency ratio

5.2.1 For this standard, the octave frequency ratio, G, shall be given by the following expression

$$G = 10^{3/10} \tag{1}$$

5.2.2 The octave frequency ratio calculated from Formula (1) to six significant digits is 1,995 26. Filters designed according to this ratio are designated base-10 filters.

NOTE 1 Filters specified in this standard are by convention called octave-band and fractional-octave band filters.

NOTE 2 For technical reasons, some filters have been designed based on G = 2, exactly. Such filter designs are called base-2 filters. The probability that a base-2 filter conforms to the requirements of this standard decreases as the difference between the mid-band frequency and the reference frequency increases; see Annex D.

5.3 Reference frequency

For the purposes of this standard, the reference frequency, f_{r}, is 1 000 Hz, exactly.

5.4 Exact mid-band frequencies

5.4.1 When the denominator of the bandwidth designator is an odd number, the exact mid-band frequencies, f_{m}, of any filter in a set of filters shall be determined from the following expression

$$f_{\mathrm{m}} = f_{\mathrm{r}} G^{x/b} \tag{2}$$

where f_{r} is the reference frequency and $1/b$ is the bandwidth designator, for example 1/1 or 1/3 for octave-band or one-third-octave-band filters, respectively.

5.4.2 When the denominator of the bandwidth designator is an even number, exact mid-band frequencies of any filter in a set of filters shall be determined from the following expression

$$f_{\mathrm{m}} = f_{\mathrm{r}} G^{(2x+1)/(2b)} \tag{3}$$

where x in Formulas (2) and (3) is any integer, positive, negative or zero.

NOTE 1 The outputs of narrow-bandwidth fractional-octave-band filters that have exact mid-band frequencies determined from Formula (2) or Formula (3) can be combined to approximate the band level indicated by a filter of wider bandwidth with a corresponding exact mid-band frequency and corresponding band-edge frequencies.

NOTE 2 When the denominator of the bandwidth designator is an odd number, one of the filters in a complete filter set can have a mid-band frequency of 1 000 Hz. When the denominator of the bandwidth designator is an even number, the band-edge frequencies of an adjacent pair of filters in a complete filter set can be at 1 000 Hz and none of the filters will have a mid-band frequency of 1 000 Hz.

5.5 Nominal mid-band frequencies

Octave-band and fractional-octave-band filters shall be identified, or labelled, by their nominal mid-band frequencies. Annex E provides exact and nominal mid-band frequencies for octave-band and one-third-octave-band filters for the usual range of audio frequencies. Annex E also specifies a procedure for determining the nominal mid-band frequencies for fractional-octave-band filters with other bandwidth designators.

5.6 Band-edge frequencies

5.6.1 Lower and upper band-edge frequencies for a pass-band filter shall be determined from the following expressions:

$$f_1 = f_m \, G^{-1/(2b)} \tag{4}$$

and

$$f_2 = f_m \, G^{+1/(2b)} \tag{5}$$

where

f_1 is the lower band-edge frequency;

f_2 is the upper band-edge frequency;

G is the octave frequency ratio given by Formula (1), and

f_m is an exact mid-band frequency determined from Formula (2) or Formula (3).

NOTE An exact mid-band frequency is the geometric mean of the corresponding band-edge frequencies as given by $f_m = \sqrt{f_1 f_2}$.

5.6.2 A band-edge frequency ratio is given by $f_2/f_1 = G^{1/b}$, for example $10^{3/10}$ for octave-band filters and $10^{1/10}$ for one-third-octave-band filters.

5.6.3 The normalized bandwidth of a filter is given by $(f_2 - f_1)/f_m = G^{+1/(2b)} - G^{-1/(2b)}$.

5.7 Time-averaged signal levels

5.7.1 A time-averaged signal level, L, shall be determined according to the following expression:

$$L = 10 \lg \frac{(1/T)\int_0^T V^2(t)\,\mathrm{d}t}{V_0^2} \ \mathrm{dB} \tag{6}$$

where

$V(t)$ is the instantaneous signal as a function of time t,

T is the elapsed time for integration and averaging, and

V_0 is an appropriate reference value such as 1 μV if the signal is a voltage.

5.7.2 The reference value shall be the same for the level of input signals and output signals.

5.8 Filter attenuation

5.8.1 For any normalized frequency, $\Omega = f/f_m$, filter attenuation, $A(\Omega)$, shall be determined from the following expression:

$$A(\Omega) = L_{in}(\Omega) - L_{out}(\Omega) \tag{7}$$

where

$L_{in}(\Omega)$ is the time-averaged level of the input signal and

L_{out} (Ω)is the corresponding time-averaged level of the output signal.

5.8.2 For measurement of filter attenuation, the resolution of the indications of the levels of the input and output signals shall be 0,1 dB or smaller.

5.9 Reference attenuation

5.9.1 The instruction manual shall specify the reference attenuation in the pass-band. The reference attenuation shall be nominally the same for all filters of all available filter bandwidths in a set of filters.

5.9.2 Verification of the specified reference attenuation may require that the filters be adjusted according to a procedure described in the instruction manual.

5.10 Relative attenuation

5.10.1 Relative attenuation, $\Delta A(\Omega)$at normalized frequency $\Omega = f/f_m$, shall be determined from the following expression:

$$\Delta A(\Omega) = A(\Omega) - A_{ref} \tag{8}$$

where

A_{ref} is the reference attenuation.

5.10.2 For class 1 or class 2 octave-band filters, in the pass-band from Ω_1 to Ω_2, the relative attenuation of any filter shall be within the acceptance limits in Table 1 for the minimum and maximum relative attenuations at the specified octave-band normalized frequencies. In the stop-bands for $\Omega < \Omega_1$ and $\Omega > \Omega_2$, the relative attenuation shall be not less than the minimum acceptance limits in Table 1.

Table 1 – Acceptance limits on relative attenuation for octave-band filters

Normalized frequency $\Omega = f/f_m$		**Minimum and maximum acceptance limits on relative attenuation** in dB	
		Class 1	**Class 2**
Ω_l	$\leq G^{-4}$	+70; +∞	+60; +∞
Ω_l	G^{-3}	+60; +∞	+54; +∞
Ω_l	G^{-2}	+40,5; +∞	+39,5; +∞
Ω_l	G^{-1}	+16,6; +∞	+15,6; +∞
$\Omega_{1-\varepsilon}$ *	$G^{-1/2} - \varepsilon$	+1,2; +∞	+0,8; +∞
$\Omega_{1+\varepsilon}$ *	$G^{-1/2} + \varepsilon$	-0,4; +5,3	-0,6; +5,8
Ω_l	$G^{-3/8}$	-0,4; +1,4	-0,6; +1,7
Ω_l	$G^{-1/4}$	-0,4; +0,7	-0,6; +0,9
Ω_l	$G^{-1/8}$	-0,4; +0,5	-0,6; +0,7
Ω_l , Ω_h	$G^0 = 1$	-0,4; +0,4	-0,6; +0,6
Ω_h	$G^{+1/8}$	-0,4; +0,5	-0,6; +0,7
Ω_h	$G^{+1/4}$	-0,4; +0,7	-0,6; +0,9
Ω_h	$G^{+3/8}$	-0,4; +1,4	-0,6; +1,7
$\Omega_{2-\varepsilon}$ *	$G^{+1/2} - \varepsilon$	-0,4; +5,3	-0,6; +5,8
$\Omega_{2+\varepsilon}$ *	$G^{+1/2} + \varepsilon$	+1,2; +∞	+0,8; +∞
Ω_h	G^{+1}	+16,6; +∞	+15,6; +∞

Normalized frequency $\Omega = f/f_m$		Minimum and maximum acceptance limits on relative attenuation in dB	
		Class 1	**Class 2**
Ω_h	G^{+2}	+40,5; +∞	+39,5; +∞
Ω_h	G^{+3}	+60; +∞	+54; +∞
Ω_h	$\geq G^{+4}$	+70; +∞	+60; +∞
* ε is any small number approaching zero in the regions around the lower and upper normalized band-edge frequencies.			

5.10.3 For a fractional-octave-band filter with bandwidth designator $1/b$, the high-frequency fractional-octave-band normalized frequency $\Omega_{h(1/b)}$, corresponding to a finite octave-band relative attenuation acceptance limit for the performance class, shall be calculated for $\Omega_{h(1/b)} \geq 1$ from:

$$\Omega_{h(1/b)} = 1 + \frac{G^{1/(2b)} - 1}{G^{1/2} - 1}(\Omega_{h(1/1)} - 1) \tag{9}$$

5.10.4 For $\Omega < 1$, the corresponding low-frequency fractional-octave-band normalized frequency $\Omega_{l(1/b)}$ shall be calculated from:

$$\Omega_{l(1/b)} = 1/\Omega_{h(1/b)} \tag{10}$$

for the same acceptance limit on relative attenuation.

5.10.5 Annex F provides an example calculation of the normalized frequencies at the breakpoints of Table 1 for the acceptance limits on minimum and maximum relative attenuation for one-third-octave-band filters.

5.10.6 Between any pair of adjacent normalized breakpoint frequencies Ω_a and Ω_b from Table 1 for octave-band filters, or between comparable normalized fractional-octave-band breakpoint frequencies calculated according to Formulas (9) or (10) for fractional-octave-band filters, the acceptance limit for relative attenuation ΔA_x at normalized frequency Ω_x shall be determined by linear interpolation according to the following expression:

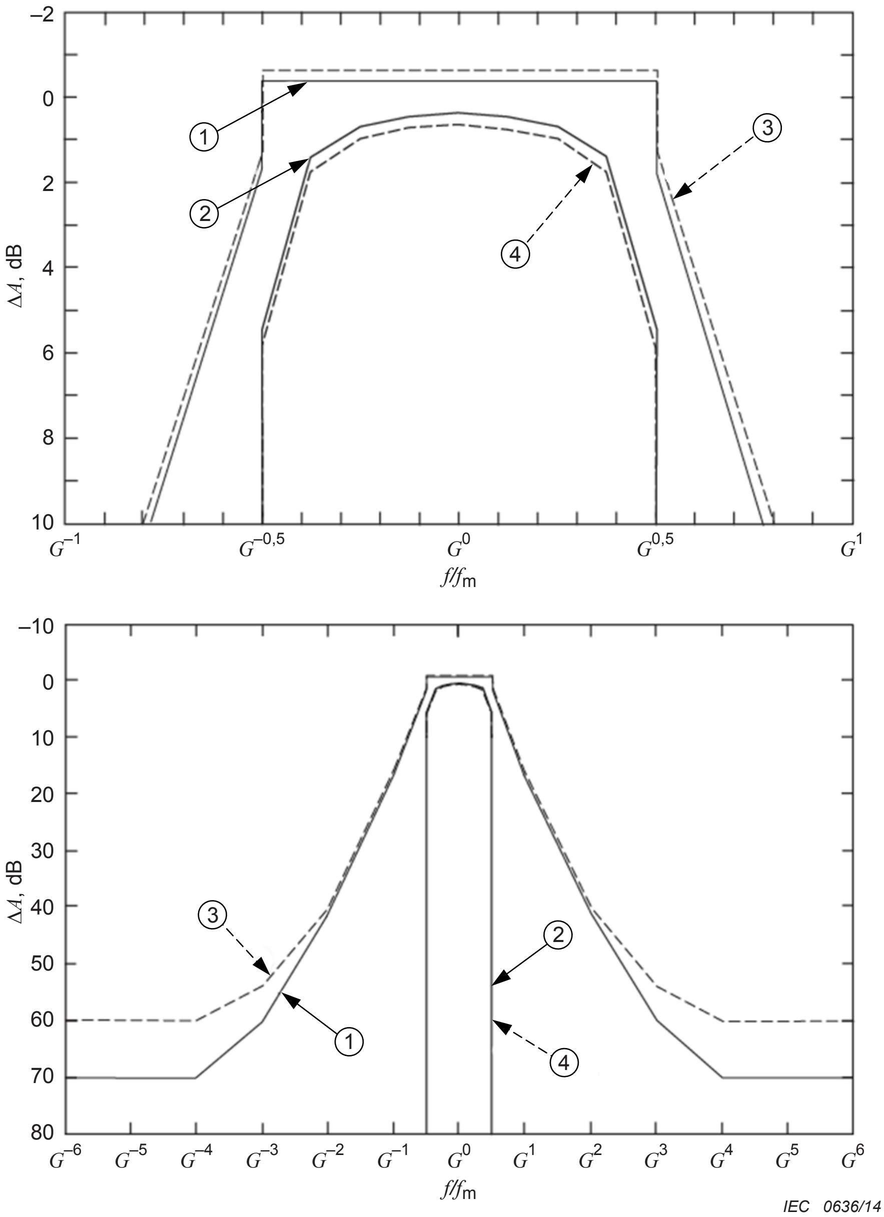
$$\Delta A_x = \Delta A_a + (\Delta A_b - \Delta A_a)\frac{\lg(\Omega_x/\Omega_a)}{\lg(\Omega_b/\Omega_a)} \tag{11}$$

where

ΔA_a is a relative attenuation acceptance limit at normalized frequency Ω_a, and

ΔA_b is a relative attenuation acceptance limit at normalized frequency Ω_b.

5.10.7 Figure 1 illustrates the acceptance limits on minimum and maximum relative attenuation for octave-band filters. The figure also shows the discontinuous changes in minimum and maximum relative attenuation at the band-edge frequencies and the linear variation of relative attenuation limits between the breakpoint normalized frequencies of Table 1.



Key

x-axis: Normalized frequency f/f_m – logarithmic scale.

y-axis: Relative attenuation ΔA in decibels.

(1) Minimum limits on attenuation for class 1 filters

(2) Maximum limits on attenuation for class 1 filters

(3) Minimum limits on attenuation for class 2 filters

(4) Maximum limits on attenuation for class 2 filters

Figure 1 – Minimum and maximum limits on relative attenuation as a function of f/f_m for class 1 and class 2 octave-band filters

5.11 Normalized effective bandwidth

5.11.1 The normalized response of a band-pass filter to a sinusoidal input signal shall be given by

$$10^{-0,1\Delta A(\Omega)} \tag{12}$$

where $\Delta A(\Omega)$ is the relative attenuation in decibels at normalized frequency Ω, Formula (8).

5.11.2 In accordance with the definition 3.17, for constant-amplitude sinusoidal input signals, normalized effective bandwidth of a band-pass filter, B_e, shall be determined from

$$B_e = \int_0^{\infty} (1/\Omega) 10^{-0,1\Delta A(\Omega)} d\Omega \tag{13}$$

where

$(1/\Omega)$ is the frequency weighting term.

In practice, the infinite range of normalized frequency in Formula (13) is replaced by a finite range extending from a starting frequency to an ending frequency. Formula (13) is then modified as:

$$B_e = \int_{\Omega \text{start}}^{\Omega \text{end}} (1/\Omega) 10^{-0,1\Delta A(\Omega)} d\Omega \tag{14}$$

where Ω_{start} and Ω_{end} are chosen to ensure that all significant contributions to the integral are included. Appropriate starting and ending frequencies depend on filter bandwidth and the design of the filters.

NOTE 1 If the input signal is a series of discrete sinusoidal signals that yields a series of filter-response measurements, the continuous integral is replaced by a summation and the integral is evaluated numerically.

NOTE 2 If the input signal is a constant-amplitude sinusoidal signal for which the frequency varies exponentially with time, the integral expression in Formula (13) is replaced by an integral over time. Annex G provides information related to the use of exponentially swept sinusoidal input signals.

The relation between sweep frequency, relative attenuation and the time is illustrated in Figure G.1.

5.11.3 In accordance with the definition 3.18 and Formula (13), the normalized reference effective bandwidth shall be given by

$$\begin{aligned} B_r &= \int_{\Omega_1}^{\Omega_2} (1/\Omega) d\Omega \\ &= \ln(\Omega_2 / \Omega_1) = \ln(f_2 / f_1) \\ &= (1/b)\ln(G) \end{aligned} \tag{15}$$

where the ratio of band-edge frequencies $\Omega_1 = f_1/f_m$ and $\Omega_2 = f_2/f_m$ is from Formulas (4) and (5) and ln represents natural or Napierian logarithms.

NOTE The normalized reference effective bandwidth for octave-band filters is 0,690 776 to six digits. For one-third-octave-band filters, the normalized reference effective bandwidth is 0,230 259 to six digits.

5.11.4 The normalized reference effective bandwidth is the same for all filters of a given bandwidth in a filter set.

5.12 Effective bandwidth deviation

5.12.1 For a band-pass filter, the effective bandwidth deviation, ΔB, shall be determined from

$$\Delta B = 10 \lg (B_e/B_r) \text{ dB} \tag{16}$$

5.12.2 For each band-pass filter in an instrument, the acceptance limits for the effective bandwidth deviation are ± 0,4 dB for class 1 instruments and ± 0,6 dB for class 2 instruments.

5.13 Linear operating range

5.13.1 For all filter bandwidths, and for each available level range, the linear operating range at the exact mid-band frequency of a filter shall be at least 60 dB for class 1 filters and at least 50 dB for class 2 filters. For each level range, the instruction manual shall state the upper and lower boundaries of the linear operating ranges.

5.13.2 At the reference input signal level on the reference level range, the level linearity deviation is zero.

5.13.3 For input signal levels from the upper boundary of the linear operating range to 40 dB less than the upper boundary, the acceptance limits for the level linearity deviation are ± 0,5 dB for class 1 filters or ± 0,6 dB for class 2 filters. These acceptance limits on level linearity deviation apply on all level ranges that are available.

5.13.4 For input signal levels from 40 dB less than the upper boundary to the lower boundary of the linear operating range, the acceptance limits for the level linearity deviation shall not exceed ± 0,7 dB for class 1 filters or ± 0,9 dB for class 2 filters. These acceptance limits on level linearity deviation apply on all level ranges that are available.

NOTE Deviations that can be introduced by the level range control, if provided, are included in the acceptance limits for level linearity deviations.

5.13.5 Level ranges, if more than one is provided, shall overlap such that the linear operating ranges overlap by at least 40 dB for class 1 filters and by at least 30 dB for class 2 filters.

5.13.6 For instruments with more than one level range, a reduced linear operating range is allowed on the most-sensitive range, provided the most-sensitive range is not the reference level range and also provided that the reduction in the linear operating range is stated in the instruction manual.

5.13.7 For filters in a set of filters, each filter may have a different linear operating range provided they have a common reference level range and reference input signal level.

NOTE Typically, filters have a common upper boundary for the linear operating range but different lower boundaries because of the influence of electrical noise and the resolution available from the digitization process.

5.13.8 For filters where a display of the output signal is an integral component, or when the filter output is transferred to an external display or to another measurement system, and the range of the display is greater than the linear operating range, the instruction manual shall state the acceptance limits on level linearity that are maintained outside the linear operating range.

5.14 Time-invariant operation

5.14.1 The time-averaged signal level, L_{out}, at the output of the instrument should be the same for all filters when a constant-amplitude sinusoidal signal is applied to the input and the frequency of the signal is varied at an exponential rate over the frequency range of all filters of any given bandwidth.

5.14.2 For a constant-amplitude exponential-swept-frequency sinusoidal input signal, the theoretical time-average output signal level, L_c, which would be indicated at the output, shall be determined from

$$L_c = L_{in} - A_{ref} + 10\lg\left[\frac{T_{sweep}}{T_{avg}}\frac{\lg(f_2/f_1)}{\lg(f_{end}/f_{start})}\right] \text{ dB} \qquad (17)$$

where

L_{in}	is the signal level of the constant-amplitude input signal;
A_{ref}	is the reference attenuation according to 3.14 and 5.9;
T_{sweep}	is the elapsed time required to perform an exponential frequency sweep from the starting frequency f_{start}, to the ending frequency f_{end}, that is, $T_{sweep} = T_{end} - T_{start}$;
f_1 and f_2	are the band-edge frequencies according to Formulas (4) and (5), and
T_{avg}	is the averaging time selected for measurement of the output signal level L_{out}.

NOTE 1 In Formula (17), $\lg(f_2/f_1)$ equals $3/(10b)$.

NOTE 2 Formula (17) is an approximation that assumes that the relative attenuation is equal to the reference attenuation in the pass-band and is infinite outside the pass-band. The sweep is assumed to be started at a frequency sufficiently less than the lowest of the lower band-edge frequencies of the filters in a set of filters and stopped at a frequency sufficiently above the highest of the upper band-edge frequencies in the set. The integration time is assumed to be sufficiently long to also include time-delayed components of the output signal.

NOTE 3 Formula (17) corresponds to Formula (G.8) in Annex G and gives identical numeric results.

5.14.3 For each filter in a filter set, when the frequency is changed at a rate corresponding to one decade in 2 s to 5 s, the acceptance limits for the deviation of a measured time-averaged output signal level, L_{out}, from the corresponding constant theoretical time-averaged output signal level, L_c as determined according to Formula (17), are ± 0,4 dB for class 1 instruments and ± 0,6 dB for class 2 instruments.

NOTE When the frequency increases by one decade in 2 s to 5 s, the rate, r, as given by Formula (G.2) will be in the range 0,460 5 s^{-1} to 1,151 s^{-1},calculated to four significant digits.

5.14.4 The instruction manual shall state the bandwidth designators and corresponding ranges of nominal mid-band frequencies for which the requirements of 5.14.3 apply for time-invariant operation.

NOTE For sampled-data filters operating in real time, time-invariant operation requires that, on average, the computations associated with each sampling interval are completed in a time period less than or equal to the sampling interval such that all input data are processed within the sampling interval and all samples of an input signal contribute with equal weight to the resulting filtered output signal level.

5.15 Anti-alias filters

The manufacturer shall include anti-alias filters, analogue and digital as appropriate, in a sampled-data or digital-filter system. Anti-alias filters shall minimize interference between an input signal and the sampling process that would cause the relative attenuation response to exceed the minimum or the maximum acceptance limits on relative attenuation from Table 1.

5.16 Summation of output signals

For a sinusoidal input signal at any frequency between two consecutive octave or fractional-octave mid-band frequencies, the acceptance limits for the difference between (a) the level of the input signal minus the reference attenuation and (b) the level of the sum of the time-mean-square output signals from adjacent filters of specified filter bandwidth are +0,8 dB and –1,8 dB for class 1 instruments and +1,8 dB and –3,8 dB for class 2 instruments.

5.17 Overload indicator

5.17.1 A band-pass filter shall be provided with an overload indicator. The instruction manual shall describe the operation and interpretation of overload indications.

5.17.2 An overload indication shall be displayed for sinusoidal input signals above the upper boundary of the linear operating range before the acceptance limits for level linearity deviation and relative attenuation are exceeded. This requirement applies to all level ranges and for any frequency in the range from the lower band-edge frequency for the filter with the lowest mid-band frequency to the upper band-edge frequency of the filter with the highest mid-band frequency in a set of filters.

5.17.3 The overload indication shall be presented as long as the overload condition exists and for at least 1 s.

5.17.4 For band-pass filters with a device that displays time-averaged output signal levels, time-integrated band levels, maximum levels, or displays of stored results, the overload indication shall indicate if an overload condition occurred during any part of the measurement duration. The indication shall remain displayed as long as the measurement result is displayed.

5.18 Filter decay time

5.18.1 Reverberation time in enclosed spaces is often measured with octave-band or fractional-octave-band filters. For instruments that measure reverberation time, the instruction manual shall state the maximum filter decay time for each filter.

5.18.2 Where the decay rate of a filter is not constant, the decay in the range between 5 dB and 35 dB less than the initial level shall be extrapolated and used for determination of filter decay time from the time at the onset of the decay to 60 dB less than the initial level.

5.18.3 For each available filter bandwidth, the decay time of a filter shall be determined from the mean of the decay times for frequencies within the pass-band of a filter.

NOTE Knowledge of filter decay times is sufficient to determine the shortest reverberation times that can be measured reliably, but is not sufficient for determining the shortest of the early or initial decay of a sound in an enclosure.

5.18.4 For any filter, the indicated filter decay time, shall not exceed the maximum filter decay time as given in the instruction manual.

NOTE Annex H provides information related to the measurement of filter decay time.

5.19 Maximum input signal

The instruction manual shall state the maximum root-mean-square voltage of the sinusoidal input signal on each level range for which every filter in the instrument conforms to the requirements of this standard.

5.20 Output terminals and terminating impedances

5.20.1 If applicable, the instruction manual shall state the input and output terminating impedances necessary to ensure proper operation of the instrument.

5.20.2 If analogue output terminals are provided, a short-circuit of these terminals to signal ground shall not later lead to non-conformance to the performance requirements of this standard.

5.21 Power supply check

5.21.1 For instruments containing band-pass filters that require a battery power supply, the manufacturer shall provide a suitable means to check that the power supply is adequate, at the time of checking, to operate the instrument according to all requirements of this standard.

5.21.2 When the battery voltage is changed from the minimum voltage where adequate battery voltage is displayed to the specified maximum battery voltage, the level of the output signal shall not change more than 0,2 dB.

5.22 Sensitivity to various environments

5.22.1 General

The requirements in 5.22 apply to band-pass filters that are stand-alone instruments as well as band-pass filters that are integral components of other instruments.

5.22.2 Ambient air temperature and relative humidity

5.22.2.1 The instruction manual shall state the range of relative humidity and corresponding air temperature over which the instrument can operate. The influence of variations in air temperature on the measured relative attenuation is specified over the range of air temperatures from –10 °C to +50 °C for class 1 band-pass filters and for temperatures from 0 °C to +40 °C for class 2 filters.

5.22.2.2 The influence of variations in atmospheric humidity on the measured relative attenuation is specified over the range of relative humidity from 25 % to 90 % with the limitation that the combination of temperature and humidity shall not yield a dewpoint greater than +39 °C or less than –15 °C.

5.22.2.3 For any filter available in the set of filters, at the exact mid-band frequency, the acceptance limits for deviation of the relative attenuation from the relative attenuation under reference environmental conditions are ± 0,5 dB for class 1 filters and ± 0,7 dB for class 2 filters. This specification applies over the applicable ranges of air temperatures and relative humidity.

5.22.2.4 If the filters are an integral part of another instrument the acceptance limits of 5.22.2.3 apply to the temperature and humidity range stated for that instrument.

5.22.2.5 For band-pass-filters that are designated in the instruction manual as intended only for operation in an environmentally controlled enclosure, the acceptance limits of 5.22.2.3 apply to the restricted temperature range from +5 °C to +35 °C.

5.23 Electrostatic-discharge and electromagnetic-compatibility requirements

5.23.1 General

5.23.1.1 The 5.23 specifies requirements for band-pass filters with respect to their immunity to electrostatic discharges and to power-frequency and radio-frequency electromagnetic fields, and to the maximum-permitted radio-frequency electromagnetic emissions.

5.23.1.2 If the filters are an integral part of another instrument, for example, a sound level meter as specified in IEC 61672-1, the filter shall conform to the acceptance limits and performance requirements as specified in 5.23 for levels of test signals as specified for that instrument.

5.23.1.3 The technical requirements in 5.23 apply for group X, group Y and group Z filter configurations.

5.23.1.4 The electromagnetic and electrostatic immunity requirements are equally applicable for band-pass filters used in residential, commercial, and light-industrial environments, or at industrial sites.

5.23.2 Electrostatic discharges

5.23.2.1 Band-pass filters in groups X, Y or Z shall withstand electrostatic discharges of specified magnitudes. The requirements are those specified in 1.5 of Table 1 in IEC 61000-6-1:2005 and are summarized as follows:

Contact discharges up to 4 kV and air discharges up to 8 kV with both positive and negative polarities. The polarity of the electrostatic voltage is with respect to earth ground.

5.23.2.2 IEC 61000-6-1 specifies performance criterion B during and after electrostatic discharge tests, given as:

"The apparatus shall continue to operate as intended after the test. No degradation of performance or loss of function is allowed below a performance level specified by the manufacturer, when the apparatus is used as intended. The performance level may be replaced by a permissible loss of performance. During the test, degradation of performance is however allowed. No change of actual operating state or stored data is allowed. If the minimum performance level or the permissible performance loss is not specified by the manufacturer then either of these may be derived from the product description and documentation and what the user may reasonably expect from the apparatus if used as intended."

5.23.2.3 The term “apparatus” means any band-pass filter or set of band-pass filters conforming to the requirements of this standard.

5.23.2.4 Tests for electrostatic discharge should be conducted using methods described in IEC 61000-4-2. After the test, it shall be confirmed that the filter is still functioning and operational. Previously stored data (if any) shall remain unchanged.

5.23.3 Immunity to power-frequency and radio-frequency fields

5.23.3.1 Band-pass filters in groups X, Y and Z shall exhibit at least a minimum degree of immunity over a range of power- and radio-frequencies and field strengths. The requirements in this standard are based on 1.1 and 1.2 of Table 1 in IEC 61000-6-2:2005 with amendments. These amendments extend the range of radio-frequency fields to cover from 27 MHz to 1 000 MHz and from 1 400 MHz to 2 700 MHz, and increase the field strength for the power frequency field to 80 A/m.

5.23.3.2 The specifications for the testing of immunity requirements are summarized as follows:

- frequency range from 27 MHz to 1 000 MHz: Root-mean-square electric field strength up to and including 10 V/m (unmodulated) with 80 % sinusoidal amplitude modulation at 1 kHz or at the mid-band frequency of the filter in the set of filters with the mid-band frequency closest to 1 kHz;
- frequency range from 1 400 MHz to 2 000 MHz: Root-mean-square electric field strength up to and including 3 V/m (unmodulated) with 80 % sinusoidal amplitude modulation at

1 kHz or at the mid-band frequency of the filter in the set of filters with the mid-band frequency closest to 1 kHz;

- frequency range from 2 000 MHz to 2 700 MHz: Root-mean-square electric field strength up to and including 1 V/m (unmodulated) with 80 % sinusoidal amplitude modulation at 1 kHz or at the mid-band frequency of the filter in the set of filters with the mid-band frequency closest to 1 kHz;
- uniform alternating magnetic root-mean-square field strength of 80 A/m at 50 Hz or 60 Hz, as appropriate.

5.23.3.3 Tests for immunity to radio-frequency fields may be performed at discrete frequencies in accordance with Clause 8 of IEC 61000-4-3:2006, but increments of up to 4 % for frequencies less than 500 MHz and up to 2 % for all other frequencies may be substituted for the 1 % specified therein. Dwell time at each frequency shall be appropriate for the band-pass filter under test. Testing at a limited number of discrete frequencies does not eliminate the need to conform to the requirements of 5.23.3.9 and 5.23.3.10 at all frequencies within the specified ranges.

5.23.3.4 If the instrument under test is fitted with any connection device that allows interface or interconnection cables to be attached to it, then all tests for immunity to power- and radio-frequency fields shall be performed with cables connected to all available connection devices. All cables shall be left unterminated and shall be arranged as described in Clause 8 of CISPR 22:2008 unless the supplier of the band-pass filter also supplies the device connected to the band-pass filter by this cable, in which case all items shall be tested together.

5.23.3.5 For band-pass filters in groups Y or Z that are connected to a public power supply, the instruments shall also conform to additional requirements given in Table 4 of IEC 61000-6-2:2005.

5.23.3.6 For band-pass filters in group Z, and where any interconnecting cable between any two parts of the system exceeds 3 m in length, the instruments shall also conform to the requirements of Table 2 in IEC 61000-6-2:2005.

5.23.3.7 For band-pass filters that have an external d.c. supply connection, the instrument shall also conform to additional requirements given in Table 3 of IEC 61000-6-2:2005.

5.23.3.8 Tests of immunity to radio-frequency fields shall be performed as described in Clause 8 of IEC 61000-4-3:2006.

5.23.3.9 When the power or radio-frequency field as specified in 5.23.3.1 and 5.23.3.2 is applied, the indication of the output from a band-pass filter shall be measured at the output connection in a manner that causes no interference with either the applied electromagnetic field or the normal operation of the band-pass filter, or of the immunity of the instrument to radio-frequency radiation. The output indication equivalent to maximum output for the setting of the filter shall be determined, and the effects of the power or radio-frequency fields shall not exceed a given reading relative to this maximum output. For a class 1 band-pass filter, the indication of the level of the output signal shall be at least 65 dB less than the level of the maximum output signal and at least 55 dB for a class 2 band-pass filter. If a means does not exist to measure an indication at these output signal levels, the lowest reading obtainable shall not be altered by more than 0,3 dB when the power or radio-frequency fields are applied.

5.23.3.10 When testing the additional requirements given in 5.23.3.5 and 5.23.3.6, the immunity of a band-pass filter shall not exceed a given reading relative to the level of the maximum output signal determined in 5.23.3.9. For a class 1 band-pass filter, the indication of the level of the output signal shall be at least 65 dB less than the level of the maximum output signal and at least 55 dB for a class 2 band-pass filter. If a means does not exist to measure an indication at these output signal levels, the lowest reading obtainable shall not be altered by more than 0,3 dB when these tests are performed. No power or radio-frequency field shall be applied during the testing for conformance to these additional requirements.

5.23.3.11 The instruction manual shall state the mode of operation and the connecting devices (if any) that produce the minimum immunity to power and radio-frequency fields.

5.23.4 Emission limits

5.23.4.1 The upper limits on radio-frequency emissions from any apparatus are specified for compatibility with many different standards. The limits given in Table 1 of IEC 61000-6-3:2006, Amendment 1:2010 form the basic requirements for band-pass filters in groups X, Y or Z. These requirements are summarized in Table 2.

5.23.4.2 Band-pass filters in groups Y or Z powered from a public power supply system shall also conform to the limits for disturbance to the public supply system specified in CISPR 22 for class B equipment. For band-pass filters, these requirements are summarized in Table 3.

5.23.4.3 The instruction manual shall describe the mode of operation of, and the connecting devices (if any) to, the instrument that produces the greatest electromagnetic emissions.

Table 2 – Limits for radiated disturbance of class B Information Technology Equipment (ITE) at a distance of 10 m

Frequency range in MHz	**Quasi-peak limits** in dB
30 to 230	30
230 to 1 000	37

NOTE 1 The smaller quasi-peak limit applies at the transition frequency of 230 MHz.

NOTE 2 Additional provisions can be necessary for cases where interference occurs.

NOTE 3 These limits have been copied for information only without alteration from CISPR 22.

NOTE 4 The characteristics of a quasi-peak receiver are specified in CISPR 16-1-1:2010. The reference value for levels of quasi-peak signals in Table 2 is 1 μV/m.

Table 3 – Limits for conducted disturbance to the voltage of a public supply of electric power

Frequency range in MHz	**Limits on voltage level of disturbance (r_e 1μV)** in dB	
	Quasi-peak level	**Average level**
0,15 to 0,50	66 to 56	56 to 46
0,50 to 5	56	46
5 to 30	60	50

NOTE 1 See Annex H of CISPR 16-1-1:2010 for the characteristics of quasi-peak measuring receivers.

NOTE 2 Lower limits for voltage levels apply at the transition frequencies.

NOTE 3 Limits on the levels of voltage disturbances decrease linearly with 20 times the base-10 logarithm of the frequency in the range from 0,15 MHz to 0,50 MHz.

6 Instrument marking

6.1 A set of band-pass filters that complies with all requirements of this standard shall be marked "YYY-band filters, class X, IEC 61260-1:ZZZZ" where YYY is the bandwidth, for example, one-third-octave, X is 1 or 2, as appropriate, and ZZZZ is the year of issue of the pertinent edition of IEC 61260-1. The filter set shall also be marked with the name of the supplier, the model designation, and serial number, if practical.

6.2 The marking shall be placed on the filter set or on the instrument where the filter set constitutes an integral part. If the instrument does not provide sufficient space for the marking, the marking may be placed in the instruction manual as long as reference to a particular issue of the instruction manual is provided.

7 Instruction manual

7.1 General

An instruction manual shall be supplied with each set of band-pass filters and shall include at least the information listed below:

a) a statement according to which all filters of all nominal filter bandwidths available in each analysis channel of a set of band-pass filters (if more than one channel is available) conform to all performance requirements of this standard for the stated performance class;

b) for each analysis channel available, a list of nominal mid-band frequencies for all filters of each available filter bandwidth, in accordance with the guidelines in Annex E; and

c) the reference attenuation.

7.2 Operation

For operation of the filter or filter set, the Instruction Manual shall at least include the information listed below:

a) for each nominal mid-band frequency of each available filter bandwidth, the linear operating range of each level range;

b) the linear operating range and the level linearity acceptance limits, for displays of output signal levels outside the linear operating range of each level range, if applicable;

c) the maximum root-mean-square value of a sinusoidal input signal at any frequency in the range of the instrument and for each level range;

d) for each level range, recommendations on operation of the instrument to ensure that measurements are made within the linear operating range;

e) for each nominal filter bandwidth available, the range of nominal mid-band frequencies for time-invariant operation and other information pertinent to spectral analyses of transient and time-varying signals;

f) a description of the operation and interpretation of the overload indicator;

g) the range of ambient air temperatures and relative humidities over which the band-pass filters can operate without exceeding the requirements for the applicable performance class;

h) if battery powered, the recommended means to check that electrical power supplied by batteries is sufficient to operate the instrument so as to not exceed all applicable requirements at the time of checking;

i) if the filters are intended to be operated in conjunction with a sound level meter or equivalent instrument, the identification of the specific instrument;

j) if the band-pass filters are an integral part of an instrument for the measurement of reverberation time, the maximum filter decay time for each filter; and

k) for band-pass filters contained in an instrument that had been switched off for a sufficiently long time at the prevailing ambient air temperature to reach thermal equilibrium, the maximum time needed after switching on the instrument before the instrument may be used to measure filtered output signal levels that conform to the requirements of this standard for all applicable ambient air temperatures.

7.3 Testing

For conformance testing of the filter or filter set, the instruction manual shall at least include the information listed below:

a) the reference level range;
b) the reference input signal level and corresponding reference value;
c) any adjustment procedures that are required to verify the reference attenuation;
d) if required, the real and reactive components of the terminating impedances that should be placed at the input and output of the instrument;
e) the effect of any short circuit that is applied to the analogue output of a band-pass filter;
f) the configuration of the instrument for the normal mode of operation;
g) any specified degradation in performance or loss of functionality following the application of electrostatic discharges;
h) the configuration for the reference orientation for tests of immunity to power-frequency and radio-frequency fields;
i) the mode of operation and connecting devices that produce minimum immunity to power frequency and radio-frequency fields;
j) the setting and configuration for greatest radio-frequency emissions;
k) any additional information required to conduct tests to verify that the filters in a set of band-pass filters conform to the performance requirements of this standard.

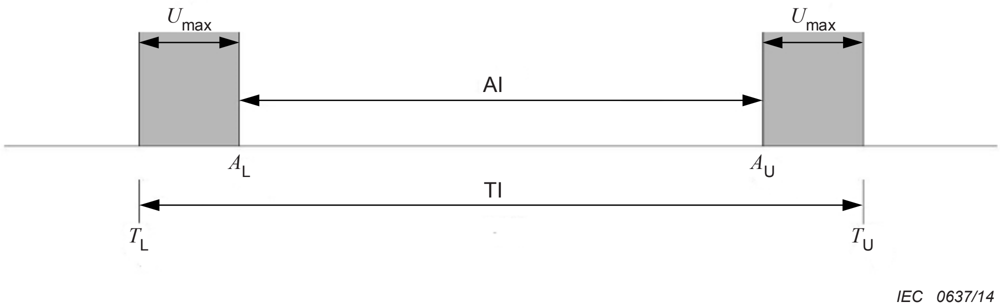
Annex A
(informative)

Relationship between tolerance interval, corresponding acceptance interval and the maximum-permitted uncertainty of measurement

This standard, in common with others written by IEC Technical Committee 29, uses adaptations of the guidelines from ISO/IEC Guide 98-4 as the basis for demonstration of conformance of an instrument to the specifications given in this standard.

ISO/IEC Guide 98-4 describes guarded acceptance in terms of tolerance intervals, acceptance intervals and uncertainties of measurement.

To promote clarity for users and testing laboratories, IEC/TC 29 has adopted a policy whereby tolerance limits around design goals are not explicitly stated, but can be determined if required from the specified acceptance limits for allowed deviations from a design goal and the corresponding specified maximum-permitted uncertainty of measurement, by using the illustration in Figure A.1.



Key

AI acceptance interval

TI tolerance interval

U_{max} guard band for the maximum-permitted uncertainty of measurement for a 95 % coverage interval

A_L lower acceptance limit

A_U upper acceptance limit

T_L lower tolerance limit

T_U upper tolerance limit

Figure A.1 – Relationship between tolerance interval, corresponding acceptance interval and the maximum-permitted uncertainty of measurement

The limits of an acceptance interval are associated with the acceptance interval and not with the guard band for the maximum-permitted uncertainty of measurement. Hence a measured deviation equal to a limit of an acceptance interval demonstrates conformance to a specification, providing also that the uncertainty of the measurement from the laboratory performing a test does not exceed the specified maximum-permitted uncertainty.

Annex B
(normative)

Maximum-permitted expanded uncertainties of measurement

Table B.1 gives the maximum-permitted uncertainties, for a coverage probability of 95 % in accordance with the guidelines given in ISO/IEC Guide 98-3, applicable to pattern-evaluation tests and periodic tests to demonstrate conformance of a filter or filter set to the specifications of this standard.

Table B.1 – Maximum-permitted expanded uncertainties of measurement

Requirement	Clause, subclause, or table	Maximum-permitted expanded uncertainty of measurement
Frequency of input signal	5.10, Table 1	0,01 %
Input signal level	5.10, Table 1	0,10 dB
Output signal level	5.10, Table 1	0,15 dB for $(L_u - L) \leq 40$ dB* 0,25 dB for $(L_u - L) > 40$ dB*
Relative attenuation	5.10.2, Table 1	0,20 dB for $\Delta A \leq 2$ dB 0,30 dB for 2 dB < $\Delta A \leq 40$ dB 0,50 dB for $\Delta A > 40$ dB
Effective bandwidth deviation, ΔB	5.12.2	0,20 dB
Level linearity deviation	5.13.3 5.13.4	0,20 dB for $(L_u - L) \leq 40$ dB* 0,35 dB for $(L_u - L) > 40$ dB*
Time invariant operation	5.14.3	0,20 dB
Summation of output signals	5.16	0,20 dB
Filter decay time	5.18.4	10 % of indicated decay time
Influence of air temperature and humidity	5.22.2	0,15 dB

* L_u is the level of the input or output signal as appropriate, corresponding to the upper boundary of the linear operating range on the applied level range. L is the level of an input or output signal for testing. The largest uncertainty based on the input and output levels apply.

Annex C
(informative)

Examples of conformance assessment to specifications of this standard

C.1 General

C.1.1 The purpose of this annex is to clarify the use of measurement results and uncertainties of measurement in assessments to the specifications of IEC 61260-1 in either pattern-evaluation tests (IEC 61260-2)[1] or periodic tests (IEC 61260-3)[2] of octave-band and fractional-octave-band filters.

C.1.2 This annex demonstrates assessment using some general illustrative examples.

C.2 Conformance criteria

C.2.1 According to the requirements in this standard, conformance to a specification is established when measured deviations from design goals do not exceed the corresponding acceptance limits AND the uncertainty of measurement does not exceed the corresponding maximum-permitted uncertainty of measurement for a coverage probability of 95%.

C.2.2 With these two criteria, there are four possible outcomes:

1) Measured deviations do not exceed acceptance limits AND actual uncertainty does not exceed maximum-permitted uncertainty

   CONFORMANCE TO THE SPECIFICATION

2) Measured deviations do not exceed acceptance limits AND actual uncertainty exceeds maximum-permitted uncertainty

   NON-CONFORMANCE BECAUSE THE ACTUAL UNCERTAINTY EXCEEDS THE MAXIMUM-PERMITTED UNCERTAINTY

3) Measured deviations exceed acceptance limits AND actual uncertainty does not exceed maximum-permitted uncertainty

   NON-CONFORMANCE BECAUSE MEASURED DEVIATIONS EXCEED THE ACCEPTANCE LIMITS

4) Measured deviations exceed acceptance limits AND actual uncertainty exceeds maximum-permitted uncertainty

   NON-CONFORMANCE BECAUSE NEITHER CRITERION IS SATISFIED

NOTE In practice, a laboratory can sometimes pre-determine the uncertainty of a measurement. If the pre-determined uncertainty exceeds the maximum-permitted uncertainty the laboratory would not attempt to perform the test.

---

[1] Under consideration.

[2] Under consideration.

C.3 Example test results

C.3.1 Table C.1 gives examples of test results to explain the method of determining conformance or non-conformance to the specifications of this standard. This method applies for any tests in this standard where acceptance limits and maximum-permitted uncertainties are specified.

Table C.1 – Examples of conformance assessment

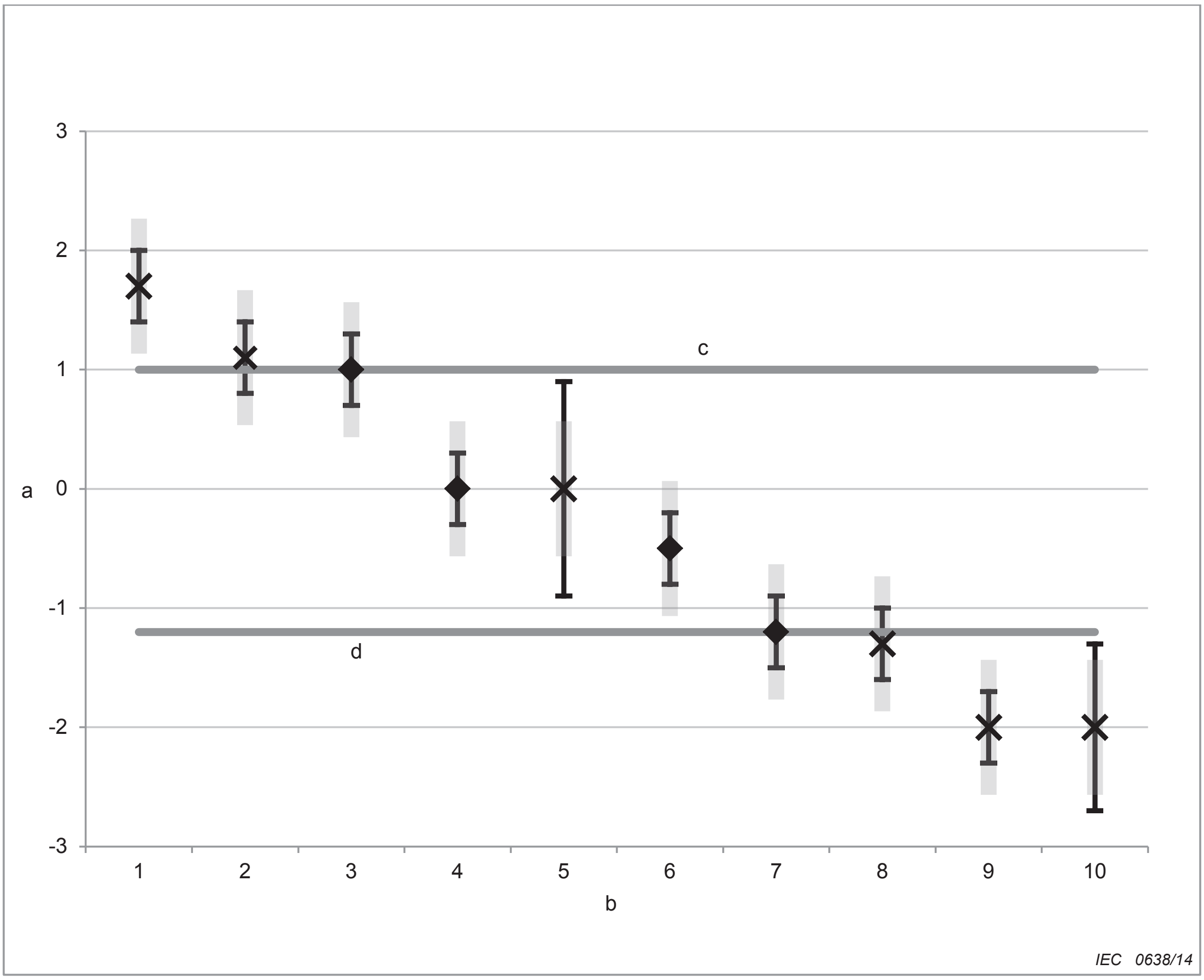
Example number	**Measured deviation from design goal** in dB	**Acceptance limits** in dB	**Actual uncertainty** in dB	**Maximum-permitted uncertainty** in dB	**Conforms to specifications** Yes or No	**Reasons for conformance or non-conformance**
1	+1,7	+1,0; -1,2	0,3	0,5	No	Deviation exceeds acceptance limits
2	+1,1	+1,0; -1,2	0,3	0,5	No	Deviation exceeds acceptance limits
3	+1,0	+1,0; -1,2	0,3	0,5	Yes	Deviation within acceptance limits AND uncertainty within maximum-permitted
4	0,0	+1,0; -1,2	0,3	0,5	Yes	Deviation within acceptance limits AND uncertainty within maximum-permitted
5	0,0	+1,0; -1,2	0,9	0,5	No	Deviation within acceptance limits BUT uncertainty exceeds maximum-permitted
6	-0,5	+1,0; -1,2	0,3	0,5	Yes	Deviation within acceptance limits AND uncertainty within maximum-permitted
7	-1,2	+1,0; -1,2	0,3	0,5	Yes	Deviation within acceptance limits AND uncertainty within maximum-permitted
8	-1,3	+1,0; -1,2	0,3	0,5	No	Deviation exceeds acceptance limits
9	-2,0	+1,0; -1,2	0,3	0,5	No	Deviation exceeds acceptance limits
10	-2,0	+1,0; -1,2	0,7	0,5	No	Deviation exceeds acceptance limits AND uncertainty exceeds maximum-permitted

C.3.2 Figure C.1 shows the ten examples of conformance assessments from Table C.1 in graphical form.

C.3.3 In Figure C.1, the lower and upper acceptance limits are indicated by the heavy horizontal lines. The measured deviations from the design goal are shown by the solid markers. A diamond-shaped marker indicates conformance to the specification and a cross-shaped marker indicates non-conformance.

C.3.4 In Figure C.1, the actual uncertainty of measurement is indicated by the vertical error bars and the maximum-permitted uncertainty is indicated by the vertical shaded area.

C.3.5 The practice illustrated in Table C.1 and Figure C.1 for assessing conformance applies equally for pattern-evaluation testing as well as periodic testing.



Key

a Deviation from design goal, in dB

b Example number from Table C.1

c Upper acceptance limit

d Lower acceptance limit

A diamond-shaped marker indicates conformance to the specification and a cross-shaped marker indicates non-conformance. The actual uncertainty of measurement is indicated by the vertical error bars and the maximum-permitted uncertainty is indicated by the vertical shaded area.

Figure C.1 – Examples of conformance assessment

Annex D
(informative)

Base 2 filters

D.1 For technical reasons, some band-pass filters have been designed according to the modified requirements obtained by setting G = 2 in all relevant formulas in this standard.

D.2 The effect on filter design and response of the choice of G = 2 instead of $G = 10^{3/10}$ will be small for filters with mid-band frequencies close to the reference frequency.

D.3 For mid-band frequencies less than the reference frequency, the exact mid-band frequency for a base 2 design will be less than the corresponding exact mid-band frequency for a base-10 design. For a filter with nominal mid-band frequency of 1 Hz, the frequency difference is 2,3 %.

D.4 For mid-band frequencies greater than the reference frequency, the exact mid-band frequency for a base 2 design will be greater than for the corresponding exact mid-band frequency for a base-10 design.

NOTE Bar graph presentations on spectrum analysers applying base 2 designs often utilize the base 10 frequency indications.

D.5 The probability that a base 2 filter conforms to the requirements of this standard decreases as the difference between the mid-band frequency and the reference frequency increases.

D.6 Base 2 filters are not recommended for new designs.

Annex E
(normative)

Nominal mid-band frequencies

E.1 Mid-band frequencies for octave-band and one-third-octave-band filters

Table E.1 gives the exact and nominal mid-band frequencies for octave-band and one-third-octave-band filters in the audio range. Exact mid-band frequencies were calculated to five significant digits by use of Formula (2) with octave-frequency ratio G given by Formula (1). The table may be extended to any decade in frequency by choosing index x or by appropriate placement of the decimal sign.

E.2 Mid-band frequencies for one-half-octave-band filters

For one-half octave-band filters with bandwidth designator $1/b$ = 1/2, exact mid-band frequencies shall be calculated by using Formula (3). Nominal mid-band frequencies shall be obtained by rounding to the first three significant digits.

E.3 Mid-band frequencies for other bandwidths

E.3.1 For bandwidth designators from 1/4 to 1/24 inclusive, exact mid-band frequencies shall be calculated from Formula (2) or Formula (3), as appropriate.

E.3.2 When the most-significant digit (that is, the left-most) of an exact mid-band frequency is between 1 and 4 inclusive, the nominal mid-band frequency shall be rounded to the first three significant digits.

E.3.3 When the most-significant digit of an exact mid-band frequency is between 5 and 9 inclusive, the nominal mid-band frequency shall be rounded to the first two significant digits.

E.3.4 As an example, for $1/b$ = 1/24 and x = –111, the exact mid-band frequency by applying Formula (3) is 41,567 Hz to five digits. The corresponding nominal mid-band frequency is 41,6 Hz. For x = +75, the exact mid-band frequency is 8 785,2 Hz to five digits and the corresponding nominal mid-band frequency is 8 800 Hz.

E.3.5 When the denominator of a bandwidth designator is greater than 24, the number of significant digits shall be increased to provide unique nominal mid-band frequencies in any 10:1 frequency ratio.

Table E.1 – Mid-band frequencies for octave-band and one-third-octave-band filters in the audio range

Index x	Exact f_m in Hz	Exact f_m calculated in Hz	Nominal mid-band frequency in Hz	Octave	One-third-octave
-16	$10^{1,4}$	25,119	25		X
-15	$10^{1,5}$	31,623	31,5	X	X
-14	$10^{1,6}$	39,811	40		X
-13	$10^{1,7}$	50,119	50		X
-12	$10^{1,8}$	63,096	63	X	X
-11	$10^{1,9}$	79,433	80		X
-10	10^{2}	100,00	100		X
-9	$10^{2,1}$	125,89	125	X	X
-8	$10^{2,2}$	158,49	160		X
-7	$10^{2,3}$	199,53	200		X
-6	$10^{2,4}$	251,19	250	X	X
-5	$10^{2,5}$	316,23	315		X
-4	$10^{2,6}$	398,11	400		X
-3	$10^{2,7}$	501,19	500	X	X
-2	$10^{2,8}$	630,96	630		X
-1	$10^{2,9}$	794,33	800		X
0	10^{3}	1 000,0	1 000	X	X
1	$10^{3,1}$	1 258,9	1 250		X
2	$10^{3,2}$	1 584,9	1 600		X
3	$10^{3,3}$	1 995,3	2 000	X	X
4	$10^{3,4}$	2 511,9	2 500		X
5	$10^{3,5}$	3 162,3	3 150		X
6	$10^{3,6}$	3 981,1	4 000	X	X
7	$10^{3,7}$	5 011,9	5 000		X
8	$10^{3,8}$	6 309,6	6 300		X
9	$10^{3,9}$	7 943,3	8 000	X	X
10	10^{4}	10 000	10 000		X
11	$10^{4,1}$	12 589	12 500		X
12	$10^{4,2}$	15 849	16 000	X	X
13	$10^{4,3}$	19 953	20 000		X

NOTE Exact mid-band frequencies were calculated to five significant digits using Formula (2).

Annex F
(informative)

Normalized frequencies at breakpoints of acceptance limits on minimum and maximum relative attenuation for one-third-octave-band filters

F.1 This annex provides an example calculation of the normalized frequencies for the acceptance limits on minimum and maximum relative attenuation for one-third-octave-band filters. The acceptance limits on minimum and maximum attenuation for one-third-octave-band filters are also tabulated consistent with the limits in Table 1 for octave-band filters.

F.2 For the example, let $\Omega_{\mathrm{h}(1/1)} = G^{1/8}$. From Formula (9), for $1/b$ = 1/3, the fractional-octave-band high-frequency breakpoint is found from the following relationship

$$\Omega_{\mathrm{h}(1/3)} = 1 + \frac{G^{1/6} - 1}{G^{1/2} - 1}\left(G^{1/8} - 1\right) \qquad \text{(F.1)}$$

F.3 For $G = 10^{3/10}$, Formula (F.1) reduces to

$$\Omega_{\mathrm{h}(1/3)} = 1 + \frac{10^{1/20} - 1}{10^{3/20} - 1}\left(10^{3/80} - 1\right) \qquad \text{(F.2)}$$

or approximately 1,026 67.

F.4 From Formula (10), the corresponding low-frequency breakpoint is

$$\Omega_{\mathrm{i}(1/3)} = 1/\Omega_{\mathrm{h}(1/3)} \qquad \text{(F.3)}$$

or approximately 0,974 02.

F.5 For the octave-band breakpoint frequencies in Table 1, continued application of Formulas (9) and (10) yielded the normalized frequencies in Table F.1 for one-third-octave-band filters.

Table F.1 – Acceptance limits on relative attenuation for one-third-octave-band filters

Normalized frequency $\Omega = f/f_m$		Minimum; maximum acceptance limits on relative attenuation in dB	
		Class 1	Class 2
$\Omega_{l(1/3)}$	< 0,185 46	+70; +∞	+60; +∞
$\Omega_{l(1/3)}$	0,327 48	+60; +∞	+54; +∞
$\Omega_{l(1/3)}$	0,531 43	+40,5; +∞	+39,5; +∞
$\Omega_{l(1/3)}$	0,772 57	+16,6; +∞	+15,6; +∞
$\Omega_{1(1/3)} - \varepsilon$*	0,891 25 – ε	+1,2; +∞	+0,8; +∞
$\Omega_{1(1/3)} + \varepsilon$*	0,891 25 + ε	-0,4; +5,3	-0,6; +5,8
$\Omega_{l(1/3)}$	0,919 58	-0,4; +1,4	-0,6; +1,7
$\Omega_{l(1/3)}$	0,947 19	-0,4; +0,7	-0,6; +0,9
$\Omega_{l(1/3)}$	0,974 02	-0,4; +0,5	-0,6; +0,7
$\Omega_{l(1/3)}$, $\Omega_{h(1/3)}$	1,000 00	-0,4; +0,4	-0,6; +0,6
$\Omega_{h(1/3)}$	1,026 67	-0,4; +0,5	-0,6; +0,7
$\Omega_{h(1/3)}$	1,055 75	-0,4; +0,7	-0,6; +0,9
$\Omega_{h(1/3)}$	1,087 46	-0,4; +1,4	-0,6; +1,7
$\Omega_{2(1/3)} - \varepsilon$*	1,122 02 – ε	-0,4; +5,3	-0,6; +5,8
$\Omega_{2(1/3)} + \varepsilon$*	1,122 02 + ε	+1,2; +∞	+0,8; +∞
$\Omega_{h(1/3)}$	1,294 37	+16,6; +∞	+15,6; +∞
$\Omega_{h(1/3)}$	1,881 73	+40,5; +∞	+39,5; +∞
$\Omega_{h(1/3)}$	3,053 65	+60; +∞	+54; +∞
$\Omega_{h(1/3)}$	> 5,391 95	+70; +∞	+60; +∞

* ε is any small number approaching zero in the regions around the lower and upper normalized band-edge frequencies.

Annex G
(informative)

Filter response to exponentially swept sinusoidal signals

G.1 Exponential frequency sweep

G.1.1 In an exponential frequency sweep, the frequency of the constant-amplitude sinusoidal signal increases exponentially with time. The sweep is applied as the input signal to a filter. The sweep starts at time T_{start} with the starting frequency f_{start} and ends at time T_{end} when the frequency f_{end} is reached.

G.1.2 At any time, t, during the sweep, the frequency of the signal, $f(t)$, may be calculated from the expression

$$f(t) = f_{\text{start}} \exp\left[r\left(t - T_{\text{start}}\right)\right] \qquad \text{(G.1)}$$

where the sweep rate, r, assumed to be constant over the duration of the sweep, is given by

$$r = \frac{\ln(f_{\text{end}} / f_{\text{start}})}{T_{\text{end}} - T_{\text{start}}} \qquad \text{(G.2)}$$

and where ln indicates the natural (or Napierian) logarithm.

G.2 Response of set of band-pass filters to a sweep

G.2.1 The sweep is assumed to start at some frequency less than the lowest of the lower band-edge frequencies for a set of filters where the relative attenuation is at least 60 dB and ends at a frequency greater than the highest of the upper band-edge frequencies where the relative attenuation of the filter is at least 60 dB.

G.2.2 The time-averaged level of the output signal is measured for an averaging time T_{avg} which starts no later than the time when the sweep frequency is equal to the lowest of the lower band-edge frequencies where the relative attenuation of a filter is at least 60 dB, and ends at a time not less than when the sweep frequency is equal to the highest of the upper band-edge frequencies where the relative attenuation of the filter is again at least 60 dB.

NOTE The contribution to the time-averaged output level from frequencies where the relative attenuation is more than 60 dB is assumed to be insignificant.

G.2.3 For some appropriate input signal level L_{in}, the time-averaged output signal level is given by

$$L_{\text{out}} = 10\lg \frac{\int_{T_{\text{start}}}^{T_{\text{end}}} 10^{0,1\left\{L_{\text{in}} - A\left[f(t)/f_{\text{m}}\right]\right\}} \mathrm{d}t}{T_{\text{avg}}} \text{dB} \qquad \text{(G.3)}$$

or

$$L_{\text{out}} = L_{\text{in}} - A_{\text{ref}} + 10\lg \frac{\int_{T_{\text{start}}}^{T_{\text{end}}} 10^{-0,1\left\{\Delta A\left[f(t)/f_{\text{m}}\right]\right\}} \mathrm{d}t}{T_{\text{avg}}} \text{dB} \qquad \text{(G.4)}$$

where the frequency at any instant during the sweep is determined from Formulas (G.1) and (G.2).

G.2.4 The equation in the numerator shows similarities with the definition for effective bandwidth in Formula (13). A further analysis shows:

$$\begin{aligned}&\int_{T_{start}}^{T_{end}} 10^{-0,1\{\Delta A[f(t)/f_m]\}}\mathrm{d}t = \\ &\int_{\Omega_{start}}^{\Omega_{end}} \left(\frac{1}{r\times\Omega}\right)10^{-0,1\{\Delta A[\Omega]\}}\mathrm{d}\Omega \approx \\ &\int_{0}^{\infty} \left(\frac{1}{r\times\Omega}\right)10^{-0,1\Delta A(\Omega)}\mathrm{d}\Omega = \frac{B_e}{r}\end{aligned} \tag{G.5}$$

Since, for an exponential sweep as given in Formula (G.1):

$$\mathrm{d}t = \frac{1}{r\times\Omega}\mathrm{d}\Omega \tag{G.6}$$

It is assumed that Ω_{start} is so low that it can be approximated by zero and Ω_{end} so high that it can be approximated by infinity.

G.2.5 This gives:

$$L_{out} = L_{in} - A_{ref} + 10\lg\frac{B_e}{r\times T_{avg}}\,\mathrm{dB} \tag{G.7}$$

This may be combined with Formula (G.2):

$$L_{out} = L_{in} - A_{ref} + 10\lg\left[\frac{T_{end}-T_{start}}{T_{avg}}\,\frac{B_e}{\ln(f_{end}/f_{start})}\right]\mathrm{dB} \tag{G.8}$$

This shows that the effective bandwidth of a filter may be obtained from the time-averaged output level when the input signal is an exponential sweep.

G.2.6 For an ideal band-pass filter having zero relative attenuation in the pass-band and infinite relative attenuation at other frequencies, Formula (G.4) may be simplified as:

$$\begin{aligned}L_{out} &= L_{in} - A_{ref} + 10\lg\left[\frac{1}{T_{avg}}\int_{t_1}^{t_2}\mathrm{d}t\right]\mathrm{dB} \\ L_{out} &= L_{in} - A_{ref} + 10\lg\frac{t_2-t_1}{T_{avg}}\,\mathrm{dB}\end{aligned} \tag{G.9}$$

where t_1 and t_2 are the times when the sweep frequency equals the band-edge frequencies f_1 and f_2 , respectively. Times t_1 and t_2 are calculated from Formulas (G.1) and (G.2)

$$\begin{aligned}t_1 &= t_{start} + (1/r)\ln(f_1/f_{start}) \\ t_2 &= t_{start} + (1/r)\ln(f_2/f_{start})\end{aligned} \tag{G.10}$$

G.2.7 By combining the Formulas (G.2) and (G.6), Formula (G.5) may be simplified as:

$$L_{out} = L_{in} - A_{ref} + 10\lg\left[\frac{(1/r)\ln(f_2/f_1)}{T_{avg}}\right]\text{dB}$$

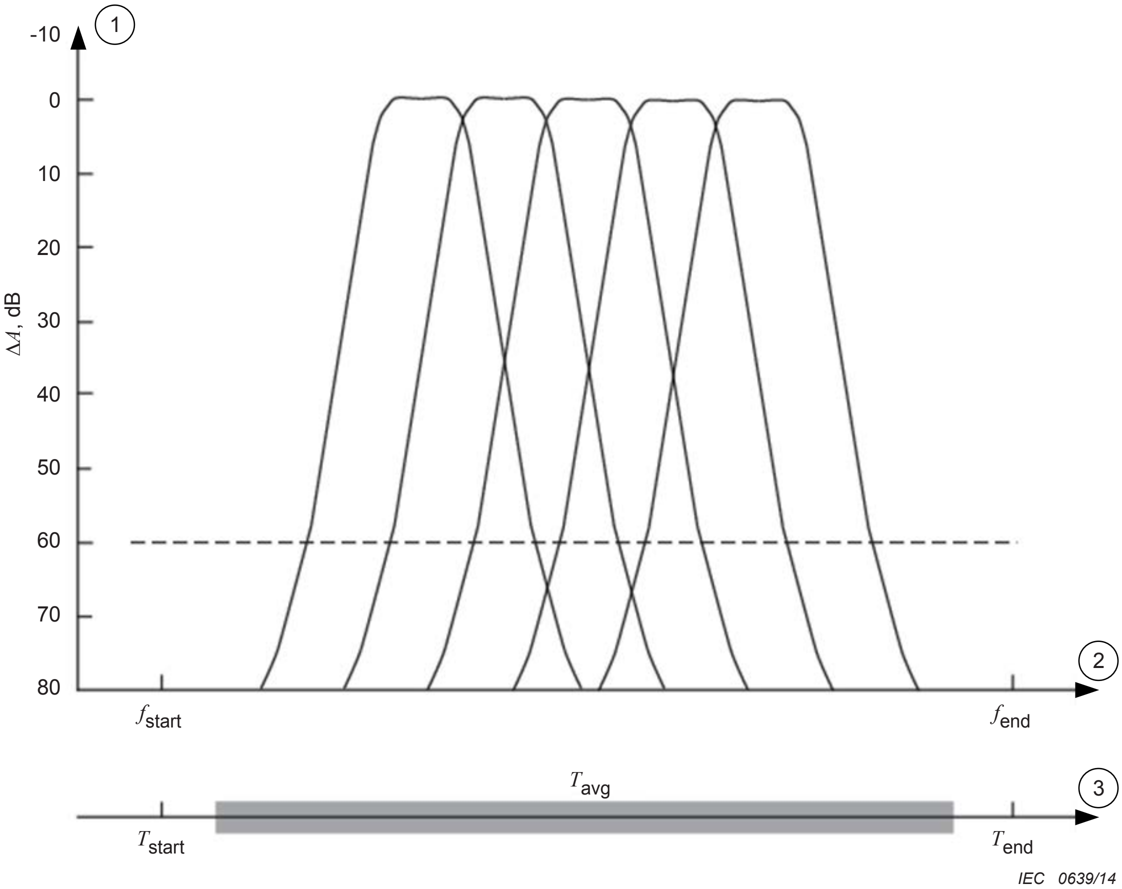
$$L_{out} = L_{in} - A_{ref} + 10\lg\left[\frac{T_{end} - T_{start}}{T_{avg}}\frac{\ln(f_2/f_1)}{\ln(f_{end}/f_{start})}\right]\text{dB} \qquad (G.11)$$

$$L_{out} = L_{in} - A_{ref} + 10\lg\left[\frac{T_{end} - T_{start}}{T_{avg}}\frac{B_r}{\ln(f_{end}/f_{start})}\right]\text{dB}$$

where B_r is the normalized reference effective bandwidth as specified in 5.11.3.

G.2.8 The Formulas (G.8) and (G.11) are identical if $B_e = B_r$ and the exponential sweep may be used for the measurement of the effective bandwidth deviation if the filter is time-invariant.

Sweep illustration



Key

1 Relative attenuation ΔA in dB

2 Logarithmic frequency scale

3 Linear time scale

NOTE The start of the averaging time, T_{avg} , can be before or after T_{start} and the end of the averaging time can be before or after T_{end}.

Figure G.1 – Relation between the logarithmic frequency scale and the linear time scale due to the exponential sweep

Annex H
(informative)

Measurement of filter decay time

H.1 General

H.1.1 When the reverberation time for a room is measured, the result is typically wanted for different frequency bands such as octave bands or one-third-octave bands. The room is typically excited by a broadband sound signal and the band-filtered response is measured. The reverberation time is determined from the decay of the output signal level indicated by each filter after the excitation signal is switched off.

H.1.2 For rooms with long reverberation times the result is little influenced by the filter design as long as the requirements in this International Standard are satisfied. However, for rooms with short reverberation times, the design of the filter can significantly affect the results obtained. The impulse response of the filter establishes a limit for the shortest reverberation time that can be measured. This limit is called the filter decay time.

H.1.3 The filter decay time is determined by measuring the virtual reverberation time when the filter is excited directly by the electrical excitation signal – without the influence of the room on the filter decay time.

H.2 Measurement of filter decay time

H.2.1 Instruments with the capability to measure reverberation time

H.2.1.1 If the filter or filter set is included in an instrument with the capability to measure reverberation time, this capability should be used for the measurement of the filter decay time. If the manufacturer of a filter or filter set, recommends the use of an additional instrument for the measurement of reverberation time, this additional instrument should be used for the measurement of filter decay time.

H.2.1.2 The reference level range should be selected. The input signal to the filter should be the recommended excitation signal for the instrument at a signal level that is at least 40 dB greater than the lower boundary of the linear operating range without overloading the filter. The measurement range for reverberation time should be set to the lowest available and with the recommended time resolution. The measurement should be repeated at least once. The mean value obtained should be considered to be the filter decay time.

H.2.2 Instruments without the capability to measure reverberation time

H.2.2.1 For filters not included in an instrument with the capability to measure reverberation time, the filter decay time should be measured with the following procedure:

H.2.2.2 The reference level range should be selected. The input signal to the filter should be stationary pink or white noise at a signal level that is at least 40 dB greater than the lower boundary of the linear operating range without overloading the filter. The time-averaged stationary output signal level, L_0, shall be determined. Switch off the input signal and record the output signal level, $L(t)$, as a function of time. The averaging time for the level measurement should be sufficiently short to not influence the result. The level decay rate, R, in decibels per second should be determined by linear regression on the output signal in dB (least squares fit) for output signal levels between 5 dB less than L_0 and 25 dB less than L_0. It is assumed that the decay rate is a negative value. The filter decay time, T_d, is determined as:

$$T_\mathrm{d} = \frac{-60\,\mathrm{dB}}{R} \qquad \text{(H.1)}$$

H.2.2.3 The measurement should be repeated at least once. The mean value obtained should be considered to be the filter decay time. It is recommended to average more decays (ensemble averaging) before the linear regression is made instead of averaging the filter decay time.

NOTE A formula for linear regression is given in Reference [2].[3]

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3 Numbers in square brackets refer to the Bibliography

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