

Australian/New Zealand Standard[®]

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

[IEC title: Electroacoustics — Octave-band and fractional-octave-band filters]

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PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee AV/2, Acoustics, Instrumentation and Measurement Techniques, to supersede AS Z41—1969, *Octave, half octave and one-third octave band pass filters intended for the analysis of sound and vibrations* and NZS 1499:1965, *Specification for octave and one-third octave band-pass filters*.

The objective of this Standard is to provide performance requirements and methods for testing the performance of band pass filters that comprise a filter set or spectrum analyser for use in the measurement of sound.

This Standard is identical with and has been reproduced from IEC 1260:1995, *Electroacoustics—Octave-band and fractional-octave-band filters*.

The term ‘informative’ has been used in this Standard to define the application of the appendix to which it applies. An ‘informative’ appendix is only for information and guidance.

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References to international Standards should be replaced by equivalent Australian or Australian/New Zealand Standards, as follows:

<i>Reference to International Standard or other publication</i>	<i>Australian/New Zealand Standard</i>
IEC	AS
50 International Electrotechnical Vocabulary (IEV)	
50(801) Chapter 801: Acoustics and electro-acoustics	—
651 Sound level meters	1259 Acoustics—Sound level meters
651/Amdt 1 Amendment 1	1259.1 Non-integrating
801.2 Electromagnetic compatibility for industrial-process measurement and control equipment Part 2: Electrostatic discharge requirements	—
801.3 Electromagnetic compatibility for industrial-process measurement and control equipment Part 3: Radiated electromagnetic field requirements	—

IEC		AS	
804	Integrating-averaging sound level meters	1259	Acoustics—Sound level meters
		1259.2	Integrating—Averaging
804/Amdt 1	Amendment 1		
804/Amdt 2	Amendment 2		
ISO			
266	Acoustics—Preferred frequencies for measurements	2533	Acoustics—Preferred frequencies for measurements
OIML	Vocabulary of legal metrology— Fundamental terms	—	

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CONTENTS

	<i>Page</i>
Clause	
1 Scope	1
2 Normative references	1
3 Definitions	2
4 Performance requirements	6
5 Test methods	12
6 Instrument marking	18
7 Instruction manual	18
Tables	
1 Limits on relative attenuation for octave-band filters	8
A.1 Midband frequencies for octave-band and one-third-octave-band filters in the audio range	21
B.1 Limits on relative attenuation for one-third-octave-band filters	23
Figure 1 — Illustration of minimum and maximum limits on relative attenuation for class 1 octave-band filters	9
Annexes	
A Midband frequencies	20
B Normalized frequencies at breakpoints of limits on minimum and maximum relative attenuation for one-third-octave-band filters	22
C Recommendations for verification of the electrical performance characteristics of bandpass filters	24

AUSTRALIAN/NEW ZEALAND STANDARD

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

1 Scope

1.1 This International Standard provides performance requirements and methods for testing the performance of analogue, sampled-data, and digital implementations of band-pass filters that comprise a filter set or spectrum analyser. The extent of the passband region of a filter's relative attenuation characteristic is a constant percentage of the midband frequency for all filters of a given bandwidth. An instrument complying with the requirements of this International Standard may contain any number of bandpass filters covering any desired frequency range.

1.2 Performance requirements are provided for three filter classes designated class 0, class 1, and class 2. Allowed tolerances increase as the class number increases.

1.3 Bandpass filters complying with the performance requirements of this standard may be part of various measurement systems or may be an integral component of a specific instrument and shall operate in real time. Performance requirements apply to any method that is selected by the manufacturer to implement the design of the filters.

1.4 Instruments complying with 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, and steady; broadband and discrete frequency; and long and short durations. For applications involving transient signals, different realizations of filters meeting the requirements of this standard may give different results.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this International Standard. At the time of publication, the editions indicated were valid. All normative documents are subject to revision, and parties to agreements based on this International Standard are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. Members of the IEC and ISO maintain registers of currently valid International Standards.

IEC 50(801): 1994, *International Electrotechnical Vocabulary (IEV) — Chapter 801: Acoustics and electro-acoustics*

IEC 651:1979, *Sound level meters*
Amendment 1:1993

IEC 801-2: 1991, *Electromagnetic compatibility for industrial-process measurement and control equipment — Part 2: Electrostatic discharge requirements*

IEC 801-3: 1984, *Electromagnetic compatibility for industrial-process measurement and control equipment — Part 3: Radiated electromagnetic field requirements*

IEC 804:1985, *Integrating-averaging sound level meters*
 Amendment 1, 1989
 Amendment 2, 1993

ISO 266:1975, *Acoustics — Preferred frequencies for measurements*

OIML: 1978, *Vocabulary of legal metrology — Fundamental terms*

3 Definitions

For the purpose of this International Standard, the following definitions apply.

NOTE — For definitions of additional terms in this standard, reference should be made to IEC 50(801) and the OIML vocabulary of legal metrology.

3.1 bandpass filter: Filter with a single transmission band (or passband with small relative attenuation) extending from a lower bandedge frequency greater than zero to a finite upper bandedge frequency.

3.2 octave ratio: Nominal frequency ratio of 2:1; general symbol G .

NOTES

1 This standard permits two options, designated base-ten and base-two, for determining an octave-band, or fractional-octave-band, frequency ratio.

2 For base-ten systems, $G_{10} = 10^{3/10}$ (1)

3 For base-two systems. $G_2 = 2$ (2)

4 The base-ten system is preferred.

3.3 bandwidth designator: Reciprocal of a positive integer, including 1, to designate the fraction of an octave band; symbol $1/b$.

3.4 reference frequency: Frequency of 1 000 Hz, exactly; symbol f_r .

3.5 exact midband frequency: In hertz, a frequency that has a specified relationship to the reference frequency such that the ratio of the exact midband frequencies of any two contiguous bandpass filters is the same for all filters in a filter set of a specified bandwidth; symbol f_m . When the denominator of the bandwidth designator is an odd number, exact midband frequencies of any filter in a set of filters are determined from:

$$f_m = (G^{x/b}) (f_r) \quad (3)$$

and when the denominator of the bandwidth designator is an even number, exact midband frequencies of any filter in a set of filters are determined from:

$$f_m = (G^{(2x+1)/(2b)}) (f_r) \quad (4)$$

where x is any integer, positive, negative, or zero.

NOTES

- 1 Exact midband frequencies determined from equation (3) or (4) permit the output of narrow-fractional-octave-band filters to be combined to yield the band level of a filter of wider-bandwidth with a corresponding exact midband frequency and corresponding bandedge frequencies.
- 2 With the base-ten system, midband frequencies included within any 10:1 frequency range are the same as within any other 10:1 frequency range except for the position of the decimal sign. With the base-two system, midband frequencies are unique and do not repeat.
- 3 As examples, for one-third-octave-band filters, the exact midband frequency for the band with a nominal midband frequency of 5 000 Hz is 5 011,872 Hz to three decimal places by the base-ten system and 5 039,684 Hz by the base-two system, or a difference of approximately 0,6 %. At a nominal midband frequency of 50 000 Hz, the exact midband frequency is 50 118,723 Hz by the base-ten system and 50 796,834 Hz by the base-two system, or an approximate difference of 1,4 %.
- 4 When the denominator of the bandwidth designator is an odd number, one of the filters in a complete filter set may have a midband frequency of 1 000 Hz. when the denominator of the bandwidth designator is an even number, the bandedge frequency of one adjacent pair of filters in a complete filter set may be at 1 000 Hz and therefore none of the filters will have a midband frequency of 1 000 Hz.
- 5 Exact midband frequencies for octave-band and one-third-octave-band filters are given in table A.1 for the usual range of audio frequencies.

3.6 nominal midband frequencies: In hertz, rounded midband frequencies for the designation of bandpass filters.

3.7 bandedge frequencies: In hertz, frequencies of the lower and upper edges of the passband of a bandpass filter such that the exact midband frequency is the geometric mean of the lower and upper bandedge frequencies; symbols f_1 and f_2 , respectively. Bandedge frequencies are determined from:

$$f_1 = (G^{-1/(2b)})(f_m) \quad (5)$$

and

$$f_2 = (G^{+1/(2b)})(f_m) \quad (6)$$

where

G represents an octave frequency ratio calculated according to equation (1) for base-ten systems or (2) for base-two systems;

f_m is an exact midband frequency determined from equation (3) or (4).

3.8 normalized frequency: For a bandpass filter, ratio of frequency to the exact midband frequency; symbol f/f_m .

3.9 filter bandwidth: In hertz, for a given filter, upper bandedge frequency f_2 minus the corresponding lower bandedge frequency f_1 calculated from equations (5) and (6).

3.10 octave-band filter: Bandpass filter for which the nominal ratio of upper bandedge frequency to lower bandedge frequency is two.

3.11 fractional-octave-band filter: Bandpass filter for which the ratio of upper band-edge frequency f_2 to lower band-edge frequency f_1 is an octave ratio raised to an exponent equal to the applicable bandwidth designator.

NOTE — In symbols, a bandedge frequency ratio is $f_2/f_1 = G^{1/b}$.

3.12 filter attenuation: In decibels, for a bandpass filter, at any frequency, the level of the time-mean-square input signal minus the level of the indicated time-mean-square output signal, with both signal levels relative to the same reference quantity; symbol A .

NOTE — In symbols, a time-mean-square input signal level L_{in} , in decibels, is represented by:

$$L_{in} = 10 \lg \left(\frac{1}{T} \int_0^T V_{in}^2(t) dt / V_o^2 \right) \text{ dB} \quad (7)$$

where

$V_{in}(t)$ is the instantaneous input signal as a function of time t ;

T is the elapsed time for integration;

V_o is an appropriate reference quantity such as 20 μV .

A corresponding expression applies for the level of the time-mean-square output signal.

3.13 reference attenuation: In decibels, for all bandpass filters in an instrument, nominal filter attenuation in the passband as specified by the manufacturer for determining relative attenuation; symbol A_{ref} .

3.14 relative attenuation: In decibels, for a bandpass filter, at any frequency, filter attenuation minus the reference attenuation; symbol ΔA .

NOTE — At any normalized frequency f/f_m , relative attenuation $\Delta A(f/f_m)$, in decibels, is determined from:

$$\Delta A(f/f_m) = A(f/f_m) - A_{ref} \quad (8)$$

where

$A(f/f_m)$ is the filter attenuation at normalized frequency f/f_m ;

A_{ref} is the reference attenuation.

Exact midband frequencies f_m are calculated from equation (3) or (4).

3.15 normalized effective bandwidth: For constant-amplitude sinusoidal electrical input signals, integral over normalized frequency of the ratio of the time-mean-square signal indicated by the readout device at the output of the filter set to the time-mean-square input signal; the ratio of time-mean-square signal is normalized by multiplying by a constant equal to $10^{0.1 A_{ref}}$ where A_{ref} is the reference attenuation, in decibels; symbol B_e .

NOTE — The analytical expression for normalized effective bandwidth is given in 4.5.2.