



Octave and fractional-octave band filters



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OCTAVE AND FRACTIONAL-OCTAVE BAND FILTERS

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OCTAVE AND FRACTIONAL-OCTAVE BAND FILTERS

1. NOTATION

f_a, f_b	intermediate band limits	Hz
f_c	centre (midband) frequency	Hz
f_{c1}, f_{c2}, f_{c3}	centre frequencies of third octave filters	Hz
f_l, f_u	lower and upper band limits for octaves (Sketch 3.1)	Hz
f_r	reference frequency	Hz
f_1, f_2	lower and upper band limits of $(1/q)^{\text{th}}$ octave bands	Hz
N, M	natural numbers	
n	series of integer numbers	
q	reciprocal of bandwidth designator	

Abbreviations

BSI	British Standards Institution
ISO	International Standards Organization

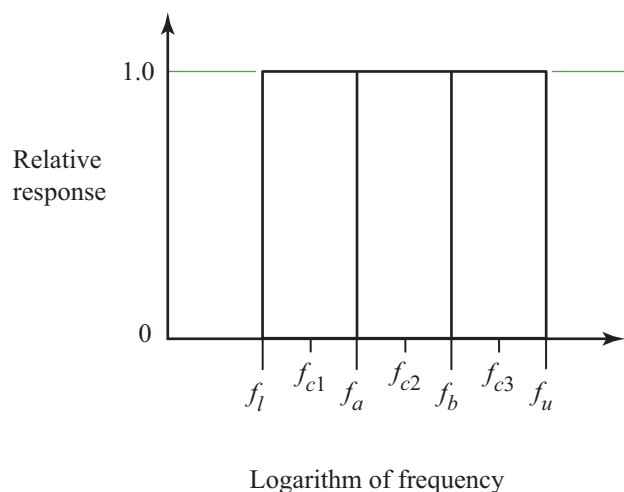
2. GENERAL

Filters which are used for the analysis of signals within a certain frequency bandwidth are called bandpass filters. They are usually classified as constant bandwidth or constant percentage. A series of filters may be used to cover a large frequency range. With constant bandwidth filters the same bandwidth, for example 10 Hz, is used throughout the frequency range. In the case of constant bandwidth filters the bandwidth increases as the frequency increases. Constant percentage filters are often defined in terms of their centre frequencies which are related to the bandwidths by a fixed ratio. Constant bandwidth filters are useful for the detection of unrelated pure tones. Constant percentage filters may be preferred for the analysis of signals, such as, for example, sound from rotating machinery which may exhibit a blade passing frequency and higher harmonics.

3. OCTAVE FILTERS AND THEIR FRACTIONAL VARIANTS

The octave band filter is the best known of the constant percentage filters. Fractional-octave band filters, such as the one-third, one-sixth and one-twelfth filters, are also used. An octave is a unit of frequency interval in the base-two logarithmic scale. The frequency interval between two frequencies, f_2 and f_1 , is represented by the ratio of the frequencies or by the logarithm of the frequencies. The value of the frequency interval expressed in octave units is $\log_2(f_2/f_1)$. Hence, the value of one for the frequency interval refers to the ratio of frequencies, $f_2/f_1 = 2$. A decade is a unit of frequency interval in the base-ten logarithmic scale and refers to the ratio of frequencies, $f_2/f_1 = 10$. Hence, the value of the frequency interval between frequencies f_2 and f_1 in decade units is $\log_{10}(f_2/f_1)$. An octave filter has an upper band limit which is twice the lower band limit. The centre (or mid) frequency is the geometric mean of the lower and upper band limits. There are three one-third octave filter bands required to cover the bandwidth of the octave filter. The ratio of the upper band limit to the lower band limit is always a constant, 2 in the case of octave filters, $2^{1/3}$ for one-third octave filters, or $2^{1/q}$ for a $(1/q)^{\text{th}}$ octave filter. The reciprocal of q is called the bandwidth designator, since it designates the fraction of the octave band.

The arrangement for three contiguous one-third octave filters is shown in Sketch 3.1, where the relative response of the filter is shown. The centre frequencies of the one-third octave filters are f_{c1} , f_{c2} and f_{c3} , whilst f_a and f_b are intermediate band limits.



Sketch 3.1 Scheme for ideal octave and one-third octave filters

In Sketch 3.1 the abscissa is the logarithm of frequency. One advantage of using the logarithm of frequency is that the bandwidths appear equal and the centre frequencies are distributed at equal intervals. The lower octave band limit is f_l and the upper octave band limit is f_u , where $f_u = 2f_l$.

3.1 Centre Frequencies

Octave, one-third octave and, in general, $(1/q)^{\text{th}}$ octave band filters are designated by their centre or midband frequencies. Values of centre frequencies can be exact, approximate or nominal (preferred).