

Bandwidth Filters

Instruments used to analyze noise have either constant bandwidth or proportional bandwidth devices.

The constant bandwidth is essentially a tunable narrow band filter with constant bandwidth, $w = f_u - f_\ell$, where f_u and f_ℓ are the upper and lower half-power frequencies. The center frequency of the filter, defined in general as

$$f_c = \sqrt{f_u f_\ell} \quad (1)$$

is usually variable so that the filter can be swept over the desired frequency range. Bandwidths range from a few tens of a hertz to less than a few hundredths of a hertz.

The proportional bandwidth instrument consists of a series of relatively broadband filters with upper and lower half-power frequencies satisfying the relationship $f_u/f_\ell = \text{constant}$. Each bandwidth, being proportional to the center frequency, increases with increasing frequencies with contiguous bands. Common instruments of this type are the *octave-band* filter with $f_u/f_\ell = 2$, the *1/3-octave-band* filter with $f_u/f_\ell = 2^{1/3}$, and the *1/10-octave-band* filter with $f_u/f_\ell = 2^{1/10}$.

As an example, the *1-octave-band* filter width in terms of the center frequency.

$$w = (\sqrt{2} - \frac{1}{\sqrt{2}})f_c, \quad (2)$$

which gives

$$w = 0.707f_c, \quad (3)$$

and the *1/3-octave-band* filter width in terms of the center frequency.

$$w = (\sqrt{2^{1/3}} - \frac{1}{\sqrt{2^{1/3}}})f_c, \quad (4)$$

which gives

$$w = 0.232f_c. \quad (5)$$

The standard octave band center frequencies are 16, 31.5, 63, 125, 250, 500, 1,000, 2,000, 4,000, 8,000, 16,000, 31,500 Hz.

Note that $f_u/f_\ell = 2^{1/3} = 1.2599$ and $2^{10/3} = 10.0793$ is nearly 10. Thus ten 1/3-octaves are nearly a decade. Since round numbers are convenient, center frequencies of the standard 1/3-octave bands are chosen so that (n+10)th center frequency is 10 times the n th frequency. Thus if 1000 Hz is the center frequency of a standard 1/3-octave band 1, 10, 100, 1000, 10,000 Hz etc., are also standard 1/3-octave band center frequencies.