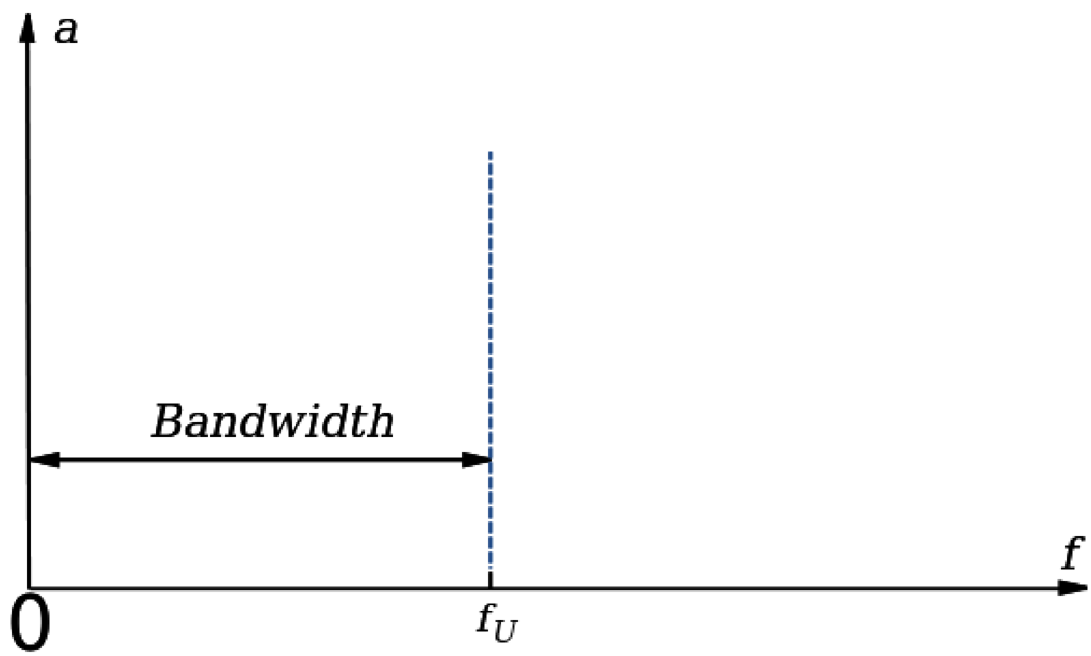
BANDWIDTH AND CENTER FREQUENCY

Bandwidth

Bandwidth is the difference between the upper and lower frequencies in a continuous set of frequencies. It is typically measured in hertz, and may sometimes refer to *passband bandwidth*, sometimes to *baseband bandwidth*, depending on context. **Passband bandwidth** is the difference between the upper and lower cutoff frequencies of, for example, a bandpass filter, a communication channel, or a signal spectrum. In the case of a low-pass filter or baseband signal, the bandwidth is equal to its upper cutoff frequency.

Bandwidth in hertz is a central concept in many fields, including electronics, information theory, digital communications, radio communications, signal processing, and spectroscopy and is one of the determinants of the capacity of a given communication channel.

A key characteristic of bandwidth is that any band of a given width can carry the same amount of information, regardless of where that band is located in the frequency spectrum. For example, a 3 kHz band can carry a telephone conversation whether that band is at baseband (as in a POTS telephone line) or modulated to some higher frequency.



Bandwidth is a key concept in many telephony applications. In radio communications, for example, bandwidth is the frequency range occupied by a modulated carrier wave, whereas in optics it is the width of an individual spectral line or the entire spectral range.

In many signal processing contexts, bandwidth is a valuable and limited resource. For example, an FM radio receiver's tuner spans a limited range of frequencies. A government agency (such as the Federal Communications Commission in the United States) may apportion the regionally available bandwidth to broadcast license holders so that their signals do not mutually interfere. Each transmitter owns a slice of bandwidth, a valuable (if intangible) commodity.

For different applications there are different precise definitions, which are necessarily different for signals than for systems. For example, one definition of bandwidth, for a system, could be the range of frequencies beyond which the frequency response is zero. This would correspond to the mathematical notion of the support of a function (i.e., the total "length" of values for which the function is nonzero). A less strict and more practically useful definition will refer to the frequencies beyond which frequency response is *small*. Small could mean less than 3 dB below the maximum value, or more rarely 10 dB below, or it could mean below a certain absolute value. As with any definition of the *width* of a function, many definitions are suitable for different purposes.

Bandwidth typically refers to baseband bandwidth in the context of, for example, the sampling theorem and Nyquist sampling rate, while it refers to passband bandwidth in the context of Nyquist symbol rate or Shannon-Hartley channel capacity for communication systems.

Antenna systems

In the field of antennas, two different methods of expressing relative bandwidth are used for narrowband and wideband antennas. For either, a set of criteria is established to define the extents of the bandwidth, such as input impedance, pattern, or polarization.

Percent bandwidth, usually used for narrowband antennas, is used defined as $\%B = 100 \times \frac{f_H - f_L}{f_c} = 200 \times \frac{f_H - f_L}{f_H + f_L}$. The theoretical limit to percent bandwidth is 200%, which occurs for $f_L = 0$.

Fractional bandwidth or Ratio bandwidth, usually used for wideband antennas, is defined as $B = f_H / f_L$,and is typically presented in the form of $B:1$. Fractional bandwidth is used for wideband antennas because of the compression of the percent bandwidth that occurs mathematically with percent bandwidths above 100%, which corresponds to a fractional bandwidth of 3:1.

If $\%B = 200 \times \frac{f_H - f_L}{f_H + f_L} = p$

then $B = \frac{200 + p}{200 - p}$.

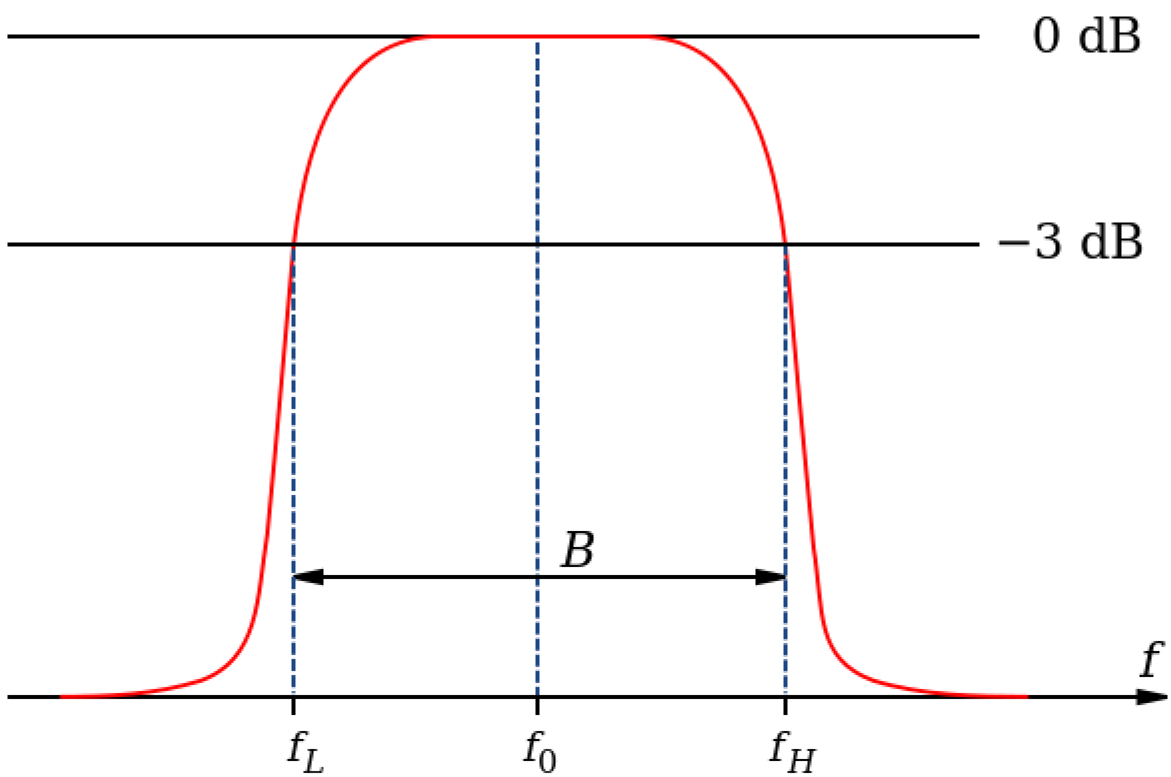
[Source: https://en.wikipedia.org/wiki/Bandwidth_(signal_processing)]

Center frequency

In electrical engineering and telecommunications, the **center frequency** of a filter or channel is a measure of a central frequency between the upper and lower cutoff frequencies. It is usually defined as either the arithmetic mean or the geometric mean of the lower cutoff frequency and the upper cutoff frequency of a band-pass system or a band-stop system.

Typically, the geometric mean is used in systems based on certain transformations of lowpass filter designs, where the frequency response is constructed to be symmetric on a logarithmic frequency scale. The geometric center frequency corresponds to a mapping of the DC response of the prototype lowpass filter, which is a resonant frequency sometimes equal to the peak frequency of such systems, for example as in a Butterworth filter.

The arithmetic definition is used in more general situations, such as in describing passband telecommunication systems, where filters are not necessarily symmetric but are treated on a linear frequency scale for applications such as frequency-division multiplexing.



[Source: https://en.wikipedia.org/wiki/Center_frequency]