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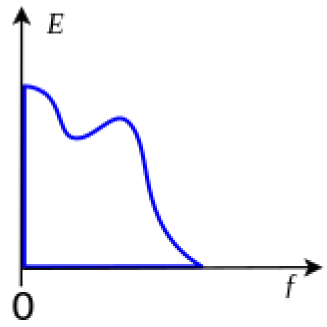
Baseband

Baseband is a signal that has a near-zero frequency range (or, a narrow frequency "bandwidth") from close to zero hertz up to a higher cut-off frequency.[i] An example of a baseband signal would be the audio signal output of a microphone, or a single musical note or synthesized tone.



Spectrum of a **baseband signal**, energy *E* per unit frequency as a function of frequency *f*. The total energy is the area under the curve.

Morse code transmissions have utilized trivial baseband signals since the invention of continuous wave radio transmitters in the early 20th century. Similarly, in modern digital telecommunications and signal processing, only baseband signals are transmitted.[2]

In conventional analog radio broadcasting, however, the baseband audio signal is used, after processing, to modulate a separate RF carrier signal at a much higher frequency.

Baseband can be synonymous with **lowpass** or **non-modulated**, and is differentiated from passband, carrier-modulated, intermediate frequency, or radio frequency (RF).

Contents

Various uses

Baseband signal

A *baseband signal* or *lowpass signal* is a signal that can include frequencies that are very near zero, by comparison with its highest frequency (for example, a sound waveform can be considered as a baseband signal, whereas a radio signal or any other modulated signal is not).[3]

A *baseband bandwidth* is equal to the highest frequency of a signal or system, or an upper bound on such frequencies,[4] for example the upper cut-off frequency of a low-pass filter. By contrast, passband bandwidth is the difference between a highest frequency and a nonzero lowest frequency.

Baseband channel

A *baseband channel* or *lowpass channel* (or *system*, or *network*) is a communication channel that can transfer frequencies that are very near zero.[5] Examples are serial cables and local area networks (LANs), as opposed to passband channels such as radio frequency channels and passband filtered wires of the analog telephone network. Frequency division multiplexing (FDM) allows an analog telephone wire to carry a baseband telephone call, concurrently as one or several carrier-modulated telephone calls.

Digital baseband transmission

Digital baseband transmission, also known as line coding,[6] aims at transferring a digital bit stream over baseband channel, typically an unfiltered wire, contrary to passband transmission, also known as *carrier-modulated* transmission.[7] Passband transmission makes communication possible over a bandpass filtered channel, such as the telephone network local-loop or a band-limited wireless channel.

Baseband transmission in Ethernet

The word "BASE" in Ethernet physical layer standards, for example 10BASE5, 100BASE-TX and 1000BASE-SX, implies baseband digital transmission (i.e. that a line code and an unfiltered wire are used).[8][9]

Baseband processor

A baseband processor also known as BP or BBP is used to process the down-converted digital signal to retrieve essential data for the wireless digital system. The baseband processing block in GNSS receivers is usually responsible for providing observable data: code pseudo-ranges and carrier phase measurements, as well as navigation data.

Equivalent baseband signal

An *equivalent baseband signal* or *equivalent lowpass signal* is—in analog and digital modulation methods for (passband) signals with constant or varying carrier frequency (for example ASK, PSK QAM, and FSK)—a complex valued representation of the modulated physical signal (the so-called passband signal or RF signal). The equivalent baseband signal is $Z(t) = I(t) + jQ(t)$ where $I(t)$ is the inphase signal, $Q(t)$ the quadrature phase signal, and j the imaginary unit. In a digital modulation method, the $I(t)$ and $Q(t)$ signals of each modulation symbol are evident from the constellation diagram. The frequency spectrum of this signal includes negative as well as positive frequencies. The physical passband signal corresponds to

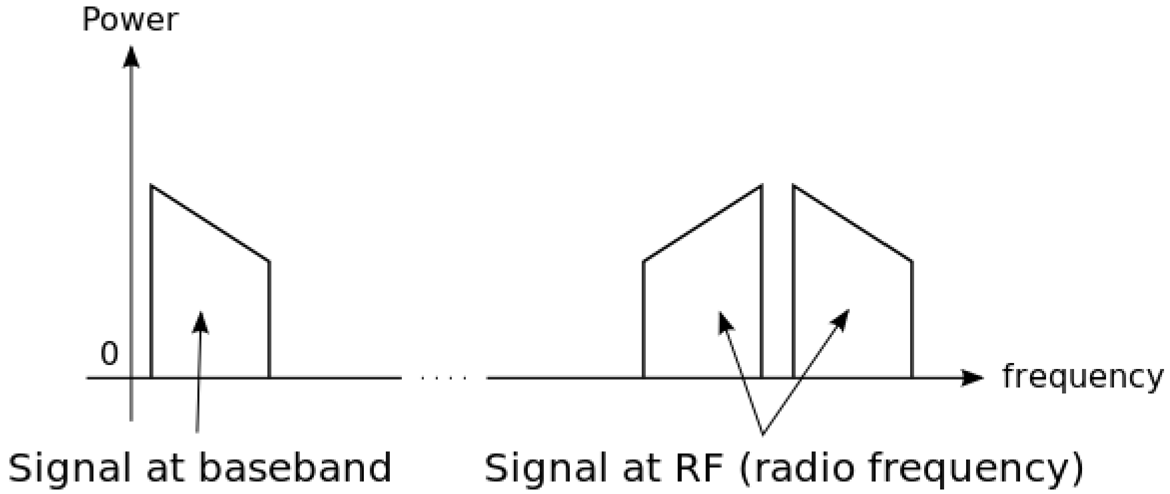
$$I(t)\cos(\omega t) - Q(t)\sin(\omega t) = \mathrm{Re}\{Z(t)e^{j\omega t}\}$$

where ω is the carrier angular frequency in rad/s.[10]

Modulation

A signal at baseband is often used to modulate a higher frequency carrier signal in order that it may be transmitted via radio. Modulation results in shifting the signal up to much higher frequencies (radio frequencies, or RF) than it originally spanned. A key consequence of the usual double-sideband amplitude modulation (AM) is that the range of frequencies the signal spans (its spectral bandwidth) is doubled. Thus, the RF bandwidth of a signal (measured from the lowest frequency as opposed to 0 Hz) is twice its baseband bandwidth. Steps may be taken to reduce this effect, such as single-sideband modulation. Some transmission schemes such as frequency modulation use even more bandwidth.

The figure shows what happens with AM modulation:



Comparison of the equivalent baseband version of a signal and its AM-modulated (double-sideband) RF version, showing the typical doubling of the occupied bandwidth.

See also

- Complex envelope
- Broadband
- In-phase and quadrature components
- Narrowband
- Wideband

Notes

i. or, more formally, a baseband has a spectral magnitude that is nonzero only for frequencies in the vicinity of the origin (termed f=0) and negligible elsewhere.[1]

References

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