Glossary of Terms

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z #

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- A -

AB test
A direct comparison between two pieces of equipment, or two design alternatives. Everything in the system is unchanged except the item under test, which is switched between the two alternatives. Also see ABX test.

Absorption coefficient
The sound absorption coefficient defines the fraction of sound energy absorbed by, for example, one reflection from a wall. Energy is proportional to the square of sound pressure, so for an absorption coefficient of 0.2, 20% percent of the energy is absorbed, reducing the sound pressure by 10.6%.

ABX test
ABX company has created hardware which allows an individual to test if they can distinguish any difference between two pieces of equipment, or other variables. The hardware randomly switches between the two alternatives, and neither the person running the test, nor the listener (they can both be the same person) know which alternative is active. This is a classic "double blind" test design to eliminate bias. Arny Kruger has posted free downloadable software to run tests yourself between two .wav files.

Acoustics
The effect of a room on music. Rooms are typically described as "dead" when they have a lot of sound absorbing stuff like drapes and heavy furniture in the room, which reduce the number of audible reflections (echoes). A room with bare concrete walls has tons of audible reflections and is extremely "live".

Acoustic Suspension
A type of loudspeaker enclosure design, made popular by the Acoustic Research AR3 among others. The cone of a driver is suspended by a "surround" (see the driver cutaway drawing) which acts like a spring, to restore the cone to its central position. The air in a sealed enclosure also acts like a spring, and is used as such in this design. The result is a lower resonant frequency, and lower bass, than would otherwise be obtainable. These designs also typically use an enclosure filling material that makes the enclosure act larger than it really is. See the section on

Thiele-Small analysis for greater detail.

Active
Containing tubes or transistors that require an external source of power, and typically provide amplification

Aliasing
An effect that occurs when an analog signal is digitally sampled. See the graphical example of 44,100 Hz sampling [by coincidence, 44.1 kb]. Samples (black circles) of a 10,000 Hz tone are identical to samples of a 34,100 tone. In general, samples of a tone of frequency f are identical (except for a phase shift) to samples of a tone of frequency Fs - f, where Fs is the sampling rate. Thus if f equals, say Fs/2 + f0, the digital recording will produce a false tone of Fs/2 - f0. Anti-aliasing filters are used to eliminate tones above Fs/2 to avoid this effect. See the Signal Processing Section for more detail.

Amp
Short for amplifier, and also the abbreviation of Ampere, the unit for electrical current. Electrical current is sent through the speaker input terminals to make the speaker produce sound. A good 120 watt amplifier can momentarily send a peak current of 80 amps through a speaker, which will really rattle your windows; maximum sustained average current at 120 watts, which is also very loud, is around 4 amps.

Amplifier
Same as power amplifier. Converts a low-power signal from a pre-amplifier into a high-power signal (tens to hundreds of watts) needed to drive a loudspeaker.

Anechoic chamber
A room where the walls, ceiling, and floor have been covered with acoustic absorbing material to (nearly) totally eliminate reflections. Useful for engineering development of loudspeakers since it isolates the performance of the speaker. But the response in a real room will be very different.

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Bass-reflex
See vented enclosure.

Biamplified
Using two stereo power amplifiers. For a typical system with two tweeters, midranges and woofers, one amplifier drives two woofers, and the second amplifier drives the midranges and tweeters. This is discussed further in the section on sound system design

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c
The speed of sound, 344.4 meters per second at 1 atmosphere pressure, 20^0 C; 347.3 m/s @ 25^0 C; very little change with pressure.

Capacitor
A component in crossover networks. Available at electronic supply stores. Capacitance is denominated in Farads. A cousin of a resistor, but presents a high resistance to low frequencies, and low resistance to high frequencies. Perversely, more capacitance means less resistance.

Cascade
To connect the output of one network to the input of a second network.

Circuit
A conglomeration of electronic components. More or less interchangeable with "network", but networks are usually small, tidy and passive, and circuits tend to be big, messy and active.

Class A
A type of amplifier design that generally produces less distortion than class AB, or B amplifiers, but with lower efficiency lower power output.

CLIO
A PC based audio measurement system made by Audiomatica. Includes a calibrated microphone and software. This system can measure impedance, component values of inductors and capacitors. Most important, the time-domain and frequency response, both amplitude and phase, of drivers and systems can be measured. It also measures room reverberation time, SPL sound levels, and sundry other stuff. This was an absolutely essential tool in developing my system, and I highly recommend it to anyone serious about building sound systems

Coloration
An alteration of the character of music due to imperfect frequency response. Can make music sound shrill, dull, boomy, etc.

Comb filtering
A filter that reduces the frequency response at a fundamental tone and all of its odd harmonics. If a signal is combined with its duplicate, except that the duplicate is delayed by a path-length difference d (a time-delay of d divided by the speed of sound) the two signals will cancel at all frequencies where d is an odd multiple of half of the wavelength. For example, if d=12 inches, cancellation will occur at wavelengths of 24, 8, 4.8, etc. inches, corresponding to frequencies of 565, 1695, 2825, etc. Hz. If these frequencies are plotted as vertical lines on a linear frequency scale, it will look something like the teeth of a comb. There is a doubling of the sound pressure at the frequencies between these teeth. The overall result is a

roller-coaster frequency response.

Cone
The cone-shaped part of a loudspeaker driver that moves the air. Made of paper, polypropylene, or recently out of high-tech materials such as Kevlar. See a cut-away drawing of a driver (8.2 kb).

Convolution
A mathematical process. To convolve a 128-point HRTF with a sound wave, both functions must be sampled at the same rate, e.g. 44,100 samples per second. The 128 HRTF samples then cover a time period of 2.9 milliseconds. The HRTF samples are first flipped in time. They are then aligned with the first 128 sound wave samples. Paired samples are multiplied together, and the 128 products are added together to create one new HRTF-processed time sample. The HRTF is then shifted one notch to align with sound samples 2-129, and another multiply and add is performed. This shift, multiply, and add is repeated until you run out of sound samples. Since a 5-second sound segment has 220,500 samples, we are talking about 28 million multiplications!

Critical Band
The ear behaves as if it contains a bank of filters, each filter passing frequencies within the critical band. Above 1 kHz the critical bandwidth is close to 1/6 octave. Below 100 Hz it is approximately 30 Hz. Two tones separated by more than a critical bandwidth are received by the cochlea more-or-less independently. Within a critical band a louder tone can make a softer tone inaudible, which is called "masking"

Crossover
An electronic network for dividing sound into high and low frequencies for reproduction by woofers, tweeters, etc. A crossover for a two-way system would consist of a high-pass filter that sends the high frequencies to the tweeter, and a low-pass filter that sends the low frequencies to the woofer. For a three-way system a band-pass filter is added to send the middle frequencies to the midrange speaker. The response beyond the crossover frequency is reduced by an amount that depends on the order of the crossover filters. A 1^{st} order filter reduces the response 6 dB per octave, a 2^{nd} order 12 dB per octave, a 3^{rd} order 18 dB per octave, and a 4^{th} order 24 dB per octave. Crossover design is discussed in the section on sound system design.

Crossover frequency
The nominal dividing line between frequencies sent to two different speaker drivers.

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Damping factor
A characteristic of amplifiers; 8 Ohms (the nominal impedance of common loudspeakers) divided by the output impedance. A large damping factor is allegedly good because it gives an amp tighter control over the loudspeaker. This is not true, and a damping factor of 1000 is really not better than a factor of 200, as shown in the section on Thiele-Small analysis.

dB
A logarithmic scale. A 3 dB increase means twice as much power; a 6 dB increase means 4 times as much. A 60 dB increase is one-million times as much, and a 120 dB increase is one-million times one-million as much power.

Degrees of freedom
The number of independent variables that must be specified to determine the state of a system. For example, to specify the position of a molecule, the x, y, and z coordinates are required, so it has 3 degrees of freedom. A collection of N molecules has 3N degrees of freedom. However in some cases, such as a diatomic molecule, certain degrees of freedom are restricted, reducing the number. See the short discussion elsewhere

Diffraction
When a sound wave from a loudspeaker reaches an edge of the speaker cabinet, it creates a new source of sound that appears to emanate from the edge. This is called edge diffraction. Diffraction will occur any time a wave encounters an obstacle, or abrupt change in a surface. An animated cartoon (107 kb) shows a blue wave emanating from a dome tweeter that diffracts first from the rim of the tweeter as a green wave, and then from the cabinet edge as a red wave. Rounding the corners of a speaker cabinet will reduce, but not eliminate, diffraction. See the section on loudspeaker construction, for more discussion on this topic.

Diffuse-field Equalization
A manner of equalizing data, such as head-related transfer functions, such that the power spectrum average over all directions is uniform. This eliminates measurement effects which are a function of frequency, but not a function of the direction of the incoming sound.

Dome
Same function as a cone, but shaped as it is named. Used for many tweeters and some midranges. Made of fabric, aluminum, titanium, or other high-tech material.

Doppler distortion
Harmonic and intermodulation distortion caused by the motion of a loudspeaker cone. See the analysis for a piston in a tube.

Doppler shift
A change in pitch caused by a relative motion between the sound source and an observer. The pitch is higher when the source and observer are getting closer, and lower when they are moving apart. A mathematical analysis is given in the physics section.

Driver
"Driver" always refers to a single naked speaker (e.g. a woofer or a tweeter) rather than an ensemble of drivers, enclosure, and crossover network, which is a loudspeaker. The primary parts of a driver are (1) the cone, which moves the air, and (2) the voice coil and magnet, which moves the cone. See a cut-away drawing of a driver (8.2 kb). Sometimes "loudspeaker" is used to mean "driver."

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e
A magical mathematical number equal to 2.71828..... It is an irrational number, so unlike rationals, the decimals run on forever, never forming a repeating pattern. One form of Euler's equation, $e^{i\pi}+1=0$, relates 5 special numbers. This equation has been converted to music by Tom Dukich

Electrostatic Speaker
A loudspeaker that uses a large, flat (sometimes curved), thin membrane instead of a cone. The membrane is situated between two screens that are charged with a high electrical voltage to move the membrane. Ideally the entire membrane moves back and forth as a unit. The large area and low moving mass are advantages. The limited membrane travel seriously limits the low frequency response. Also presents a difficult load impedance to an amplifier.

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Filter
An electronic circuit designed to selectively pass certain sound frequencies. Also see crossover.

Feedback
Positive feedback in an amplification loop causes the output signal to grow uncontrollably, and results in the annoying squeal when a microphone gets too close to a loudspeaker. Negative feedback is a technique intentionally employed in typical amplifier designs to reduce distortion. Hence, positive feedback is a negative quality , and negative feedback is a positive quality (some folks dispute the latter). If engineers didn't make things hard to understand we wouldn't get paid so much.

Fletcher-Munson Curves
Curves originally obtained by two Bell Lab scientists relating subjective sound

levels to objective levels of pressure/power. See discussion in the section on music and ears. Or view the curves themselves [102 kb].

Fourier transform
A graph of sound pressure vs. time is an illustration of a time-domain function. Sound can also be described as a frequency-domain function, as the superposition of a group of sinusoidal waves spanning the audio frequency spectrum. Mathematically both functions contain exactly the same information and each function perfectly defines the sound. A Fourier transform, and inverse transform, convert functions back and forth between the time and frequency domains. This is a error-free transformation, but the width of the frequency range and frequency resolution (fine-grain detail) is limited by the time resolution and duration. The longer the duration, the finer the detail, and the finer the time detail, the wider the frequency range. A fast Fourier transform is a technique for performing these mathematical operations very quickly with a computer. See the Signal Processing Section for more detail.

Frequency
The rate at which sound pressure varies. Denoted by f and denominated in Hertz=cycles per second; abbreviated Hz, (or kHz, meaning thousands of Hz). A 1000 Hz (1 kHz) tone pushes your eardrum back and forth 1000 times each second. The lowest bass note on an organ keyboard is a rumbling 16.4 Hz; the highest is a squeak of 18,794 Hz, which is inaudible to most males over the age of 40. These sample tones are audible with good loudspeakers or headphones, but are not audible with many computer speakers: a 100 Hz tone (12 kb wav file);and a 10kHz tone (44 kb wav file). Frequency can also be defined mathematically as the derivative of phase with respect to time, in which case it is usually denoted by ω and denominated in radians per second. $\omega=2\pi f$.

Frequency band
A specific range of frequencies. For example a typical subwoofer band is 20 Hz to 100 Hz.

Frequency response
The response of a system to a fixed input voltage, at different input frequencies. Same as frequency domain response.

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Group delay
Mathematically group delay is the derivative of the phase, in radians, with respect to frequency. Filters cause such a delay. Group delay can also mean an average of this delay over some frequency band.

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Harmonic
A tone whose frequency is an integer times the frequency of the fundamental (lowest) tone. Every note played on a musical instrument consists of a fundamental tone plus many harmonics.

Harmonic distortion
Spurious harmonics produced by the sound system. Usually not quite as objectionable as intermodulation distortion because harmonics occur naturally in music. See the discussion in the section on music and ears.

Head-related transfer function
The sound wave that reaches the eardrum is quite different than the sound wave traveling through the air towards the ear. The incident sound is modified by reflections from the head, pinna, and within the ear canal. These effects are mathematically represented by the head-related transfer function (HRTF). An impulsive sound will reach the eardrum spread out over time, and this function of time is the HRTF. An example is shown here [44.6 kb].

The frequency-domain representation of the same HRTF is here [47.5]. It is different for sounds arriving from different angles. The magnitude dependence on angle is shown here [35.7 kb]. This is the HRTF for the right ear, located at 0-degrees elevation and 90-degrees azimuth. An angle of 0-degrees elevation and -90-degrees azimuth represents a source on the opposite (left ear) side of the head. 90-degrees elevation is directly overhead. The HRTF is a little different for every person, but one can expect the general characteristics to be similar. All examples shown here are drawn from the diffuse-field equalized data, posted on the web by Bill Gardner and Keith Martin (this link seems to occasionally disappear).

High-end Audio
Equipment that is always expensive and pretentious, and sometimes excellent. Also see Hi-Fi Fetishism.

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i (or j)
The basic "imaginary" number equal to the square root of minus one. Multiplying a quantity by i is equivalent to adding a 90^0 phase shift. Quantities involving i are called "complex" numbers, and if you don't already know about this stuff it is a bit complex.

Impedance

The technically correct term for the resistance produced by inductors, capacitors, and networks. For the technically minded, the real part of an impedance is equal to resistance, and the imaginary part is called reactance.

Impulse response
The response of a system to a "spike" input that abruptly rises from zero and then abruptly decays back to zero. The response of the system to any input can be predicted from the impulse response. The impulse response measured in a room also shows a series of echoes of the direct response, which are reflections from walls, etc. See the Signal Processing Section for more detail.

Incoherent addition
Sound from two loudspeakers can combine coherently or incoherently. This is generally different at different spots in the room, and the following refers to one specific spot. Coherent addition means all of the pressure peaks and lows of the sound wave from one speaker arrive at exactly the same time as the peaks and lows of the other. The pressures then add. Twice the pressure means 4 times the acoustic power, so the sound level increases 6 dB. Incoherent addition means the peaks and lows from one arrive at random times compared to the other. In this case the power adds and the sound level increases 3 dB. For frequencies below 100 Hz, where the sound tends to be monaural, and the distance between pressure peaks and lows is more than 5 feet, addition tends to be coherent. At higher frequencies addition tends to be incoherent.

Inductor
A component in crossover networks. Available at electronic supply stores, or can be made by winding wire in a doughnut shaped coil. Inductance is denominated in Henries. A cousin of a resistor, but presents a high resistance to high frequencies, and low resistance to low frequencies. More inductance means more resistance.

Infinite baffle
A speaker enclosure that is completely sealed except for openings occupied by the driver cones. The enclosure performance is similar to mounting the drivers on a panel of infinite extent, which explains the name. Also called a sealed enclosure, which is actually more accurate.

Inter-modulation distortion
Spurious tones created by the sound system. The frequency of a spurious tone equals the frequency of one tone in the music added to or subtracted from the frequency of a second tone in the music. Sounds awful. Also see discussion in the section on music and ears.

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- J -

j (or i)

The basic "imaginary" number equal to the square root of minus one. Multiplying a quantity by j is equivalent to adding a 90^0 phase shift. Quantities involving j are called "complex" numbers, and if you don't already know about this stuff, it is a bit complex.

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k
Abbreviation for 1000. 1kHz = 1000 Hz. Alternatively, frequently used as the algebraic symbol for the propagation constant.

Kinetic energy
Energy due to motion. Proportional to an objects mass and the square of its velocity. As a car accelerates, energy from burning gasoline is converted into kinetic energy. To slow a car down, the kinetic energy must be converted into heat by the brakes.

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Linear
If the input amplitude is increased by a factor of, say 1.2, then the output amplitude increases by a factor of 1.2, no more and no less. This is the ideal for all parts of a sound system, since no distortion is introduced.

Load
Whatever is connected to the output of an amplifier or electronic circuit.

Litz wire
Wire woven in a pattern to reduce the "skin effect." For ordinary stranded wire each strand tends to stay the same distance from the wire center. The magnetic field produced by the current in the wire effects the strands differently depending on this distance, causing the skin effect. In Litz wire the strands weave in and out, such that all strands experience almost the same magnetic field, and carry nearly equal current.

Lobing
A vertical array of two or more drivers will beam energy in a series of vertical lobes, over a portion of the frequency band. Probably more than you want to know about lobing can be found by following this link.

Loudspeaker
Converts electrical energy to sound energy. This can mean an entire system such as a woofer, midrange, tweeter, crossover network, and enclosure. It can also mean an individual speaker driver such as a woofer.

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Matlab
A software package for engineering analysis that does just about anything an engineer could desire. Lots of graphics capability, full kit of analysis tools. Produced by Mathworks (Cleve Molar, a founder of Mathworks, was a classmate of mine at Caltech - too bad I didn't have his entrepreneurial spirit).

Midrange
A speaker driver 2-5" in diameter for reproducing the middle range of sound frequencies.

Minimum phase filter
Not an easy thing to explain. A given amplitude response can in theory be produced by an infinite set of filters, each of which creates a different phase response. A phase response that is a non-linear function of frequency smears the response in time. The filter that produces the amplitude response with the least time-smearing is the minimum phase filter of the set.

Mode
Characterized by having a specific pattern (e.g. of sound pressure). Some sound features, like wavelength, can have any value. With modes there is no halfway; there are modes 1,2,3, etc., but no mode 1-1/2. Also see the discussion of resonant modes in a room.

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Network
A bunch of electrical components hooked together.

Non-linear
Anything other than linear. A non-linear relationship between the input and output of an amplifier, loudspeaker, or whatever creates harmonic and intermodulation distortion.

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Octave
A one octave increase in frequency means doubling the frequency. A note one octave higher than another sort of sounds the same, but at a higher pitch. Play a one octave step from 440 (A4 standard for orchestra tuning) to 880 Hz. (180 kb wav file; requires patience). 1/3 octave smoothing means averaging the frequency response over 1/3 octave intervals. This smoothes out (i.e. obscures) abrupt changes in frequency response.

Oscilloscope
A piece of electronic lab equipment with a screen similar to a television screen, which shows an instantaneous picture of the voltage of an electrical signal. When connected to the output of an audio amplifier the picture is an analog of the sound pressure coming out of the loudspeaker

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Passive
Not requiring an external source of power; containing resistors, capacitors, inductors, etc., but no tubes or transistors; provides no amplification.

Pentode
See tube.

Phase
A measure of how well two waves are aligned. "In phase" means the crests align perfectly and add together; "180^0 out of phase" means crests align with valleys and the waves cancel each other. It is easier to show graphically (18.8 kb) than to describe. A system has a flat (i.e. good) phase response if the relative phase of the input and output signals is the same for all frequencies (actually a linear variation is equally good). This is particularly important for good transient response.

Phon
The unit of subjective sound level. Defined such that the sound level in phones equals the level in SPL for a 1000 Hz tone. Generally used in tests where listeners are asked when a tone at a different frequency sounds as loud as a 1000 Hz tone, to define the subjective frequency response of the ear. See discussion in the text on music and ears.

Pi (π)
Another magical mathematical number, 3.14159..... It is an irrational number, so unlike rationals, the decimals run on forever, never forming a repeating pattern. Entire books have been devoted to Pi, which has roots far deeper than its relationship with circles.

Pink noise
Pink noise is random noise where the power is spread uniformly over a specific spectrum of frequencies, such as 20-20,000 Hz for audio. It sounds like a hiss, much like tuning between FM stations. For a theoretically infinite spectrum it is called white noise.

Pinna
The exterior part of the ear. The ridges are important in determining the direction sound comes from - see photo [19.4 kb]

Placebo effect
If you believe something will make an improvement, it will make an improvement (usually). A scientific fact so well documented that trials of new drugs are always blind-tested vs. a placebo (something with no "real" effect). The fact that a significant percentage of people taking the placebo are always cured is a rather remarkable proof of the power of the brain. It follows that one is often happier as a stupid believer than as a wiseacre cynic.

Port
See vented enclosure.

Power Spectrum
A power spectrum plot shows the relative levels of power at different frequencies. The example power spectrum plot discussed in the section on music and the ear shows that the power around 4 kHz is about 20 dB below (1% of) the power at the lowest frequencies, and power drops another 20 dB for frequencies above 12 kHz.

Pre-amp
Preamplifier. Converts an electrical signal from a CD player or other music source into a stronger signal to drive a power amplifier. Also controls the source selection, volume, and treble and bass response.

Propagation constant
The mathematical term which defines wave propagation. It is equal to 2π divided by the wavelength.

Push-pull
A type of amplifier design. A tube or transistor that outputs positive voltage swings is matched with a second tube or transistor that outputs negative voltage swings. This results in a symmetrical response for positive and negative voltages.

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Q
The "quality factor" of a network or system. The lower the losses, the higher the Q. In electrical circuits losses occur due to resistance. In mechanical systems losses occur due to friction. An example of a high Q mechanical system is a bell, which rings for a long time after it is struck.

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Resistor
A basic component in electronic circuits that resists the flow of electrical current. Resistance is denominated in Ohms. Higher resistance results in less current. All electrical components (except superconductors) have some resistance, wanted or not. Most home speakers are nominally rated at 8 Ohms of resistance (4 Ohms for cars), but in reality the resistance is closer to 6 Ohms in most of the band, has a peak of 20-100 Ohms at resonance, and also rises at high frequencies due to voice coil inductance.

Resonance
A reinforcement of sound due to echoes adding in phase with the original source. In general, a motion or electrical or other response at a frequency where a system responds much more strongly than at other frequencies. The higher the system Q, the narrower the frequency band where the response is strong.

Reverberation
The echoes in a room that one hears after the original sound stops. The classic example is organ music in a cathedral. The usual measure of reverberation time, denoted RT_{60}, is equal to the time it takes the sound to decay 60 dB after the sound source stops, in seconds.

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Scalar
A physical quantity that involves magnitude, but not direction. Examples are speed, temperature, and pressure. Quantities that also involve direction, such as velocity, are called vectors.

Scientific notation

A convenient way of writing very large or very small numbers. $2x10^{27}$ means 2 followed by 27 zeros. (The 27 should be a superscript; some web browsers don't get it right). Basically the decimal point is moved 27 places to the right, filling in any spaces with zeros. So $1.6x10^{27}$ means 16 followed by 26 zeros. $2x10^{-27}$ means moving the decimal point 27 places to the left, or a decimal point followed by 26 zeros and then the number 2.

Sensitivity (of a loudspeaker)
Sensitivity is normally defined as the SPL level produced at a distance of 1 meter from the speaker, with 1 Watt of input power. However it is also common to specify an input of 2.83 volts instead of 1 watt of input power. This would be equivalent if the input impedance were 8 Ohms, but it is usually really closer to 6 Ohms.

Single-ended
A type of tube amplifier design where the output stage is biased such that a DC current exists when the input voltage is zero. A positive (negative) input voltage causes the output current to increase (decrease) relative to the DC bias level. The output transformer does not respond to the DC bias current, so the final output is only the AC part due to the input voltage. This type of design does not respond symmetrically to positive and negative input voltages.

Skin effect
At very high frequencies electrical current tends to flow in a thin layer on the surface of a conductor, a layer of thickness roughly equal to the "skin depth" δ. The skin depth for copper at 20 kHz is about 0.5 millimeters (0.018 inches). The 16 AWG gauge wire I use for speaker connections consists of 19 strands of .28 millimeter (.011 inch) diameter wire. The overall diameter of the bundle is 1.5 millimeters (.060 inches). Assuming that the strand bundle acts like a solid wire of the same diameter (a good assumption), the skin effect for this wire is shown by a plot of the current [40.1 kb] magnitude as a function of wire radius. The blue curves are the exact Bessel function solution for a cylindrical conductor. The red curves are the exponential solution $\exp(-x/\delta)$ for an infinitely thick rectangular slab. The Bessel solution is very close to the exponential solution for wires greater than 10 δ in diameter. However when the thickness is of the same order as δ, the Bessel function solution exhibits much less of an effect. The effective resistance of the wire is increased by 3.6% and 13.2% at 10kHz and 20 kHz respectively. Since the total resistance of a 10 meter length is about 0.1 Ohm, this increase of about .01 Ohms is insignificant compared to the typical voice coil resistance of 6 Ohms. The wire inductance is slightly reduced by the skin effect, but is tiny compared to the voice coil inductance in any case. The skin effect can be reduced by using Litz wire.

Slew rate
A characteristic of amplifiers. The maximum rate of change of output voltage in response to a square-wave input, usually measured in volts per microsecond. The higher the better.

Solid-state
See transistor.

Speaker
Same as loudspeaker.

Spectrum
A range of frequencies; e.g. the standard audio spectrum extends from 20 Hz to 20 kHz.

SPL
Sound pressure level. A logarithmic dB scale is used, akin to the Richter scale for earthquakes. A 3-dB increase means doubling the power. Zero dB SPL is the threshold of hearing; a quiet room has a background SPL of about 40-dB; a loud rock concert can go to 120-dB; the threshold of pain is 135 dB. Peak sound pressure is 3 dB higher than root-mean-square (RMS) average pressure. SPL normally refers to RMS pressure. Also see sensitivity.

Subwoofer
Like a woofer but even bigger in diameter and lower in frequency.

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Thiele parameters
A set of parameters that define the behavior of a driver in an enclosure. Used for designing enclosures and analyzing the sound response. See the section on Thiele-Small analysis, and also the detailed definitions of the parameters.

Time domain response
The response of a system measured over an interval of time. One can mathematically transform the time domain response to obtain the frequency domain response (and vice-versa), using a Fourier transform.

Transistor
The basic component of most amplifiers. A glob of magic stuff (semiconducting solid-state material) that amplifies electrical current. From smaller than a pin head up to an Oreo cookie in size (transistor case included). Reviled by some high-end types as having a harsh inhuman sound.

Triode
See tube.

Tube
Short for vacuum tube; a small glass bottle with all the air removed, containing metal sheets and screens (three for a triode, five for a pentode) to control electron flow. The basic component of amplifiers built prior to the 60's. Many high-end audio types swear they sound better than transistors. High power output tubes are usually pentodes; some folks think triodes produce a cleaner sound. (My old

Dynakit Stereo 70 tube amp put out enough heat for the whole house).

Tweeter
A speaker driver on the order of 1" diameter for reproducing the highest sound frequencies.

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Vented enclosure
Same as Bass-reflex. A speaker enclosure with a enclosure "port", which is a hole or a cardboard tube connecting the inside of the box with the outside world. The port generates sound along with the speaker driver, and generally extends the bass response. See further discussion in the section on Thiele-Small analysis.

Vector
A physical quantity that involves direction as well as magnitude. Velocity is a vector; it's magnitude is speed, and the vector points in the direction of travel.

Voice coil
The coil of wire in a speaker driver that conducts the electrical current from the amplifier. This current creates a magnetic field that interacts with the permanent magnet of the speaker to move the speaker cone. See a cut-away drawing of a driver (8.2 kb).

Volt
Using an analogy of water flow, electrical voltage is analogous to pressure, and electrical current analogous to the volume of water flow. Voltage pushes current through a circuit. One volt will create a current of 1 amp through a 1-Ohm resistor. In general, current is directly proportional to voltage and inversely proportional to resistance. (Ohms law).

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ω
The commonly used symbol for frequency in radians per second. Equal to 2π times the frequency in Hz.

Watt
A unit of power. A 200 watt amplifier can make the walls shake pretty well.

Wavelength
The distance between two crests (or valleys) of sound wave pressure. Easy to see graphically (5.2 kb). Usually denoted by the symbol λ. Varies from 56 feet for a 20 Hz tone to 0.7 inches for a 20 kHz tone. In general the wavelength in inches is equal to 13,543 divided by the frequency in Hz.

Window
A Fourier transform of a segment of a pure 400 Hz tone will produce a spectrum with a sharp peak at 400 Hz. But since the segment is finite, if the tone amplitude is constant, the spectrum will have "sidelobes" that extend over a wide range of frequencies. The sidelobes can be sharply reduced by contouring the amplitude with a "window." An example of the spectrum with and without a window is shown here[50 kb]

Woofer
A speaker driver 8-12" in diameter for reproducing low sound frequencies.

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- Y -

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- Z -

Zobel network
Generally used to mean a network that compensates for the voice-coil impedance.

Without a Zobel the driver input impedance rises with frequency, which affects the crossover response. A Zoble flattens the input impedance. See impedance compensation in the crossover design section for further discussion and design information.

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