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Sound IS the Experience !™

A LITTLE MORE CLARITY PLEASE

PARTS 1 and 2

BY

JOHN F. ALLEN

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A LITTLE MORE CLARITY PLEASE

PART ONE

by
JOHN F ALLEN

In reading some of the articles about sound appearing in these and other pages, including my own, it occurs to me that technical terms are freely used which are not always clearly defined. For instance, in one of my own articles, I talked about distortion but did not define it or always note the kind of distortion I was talking about. This then is the first of two articles in which I will attempt to clarify and discuss a few, though not all, of the more common audio terms, especially the ones I tend to use.

DECIBEL or dB:

"Deci" means 1/10. "Bel" (named after Alexander) is often misunderstood as a unit of sound, or power, or something. Actually a decibel is a logarithm of a ratio, multiplied by a constant, or number, usually 10 or 20. It may be written as dB = 10log(power level one/power level two). Which means 10 times the logarithm of the product of dividing power level two into level one. How does this work? Suppose you have a 100 watt amplifier operating at 50 watts. How much more power in terms of decibels do you have before the amplifier runs out of power? First you divide 100 by 50 and get 2. The logarithm of 2 is .3. Multiply that by 10 and you get 3 dB. Note that to go from 100 watts to 200 watts or 2000 to 4000 is each still an change of only 3 dB. In other words, every time you double or half your power, the level change is 3 dB.

If the ratio you are comparing is that of two voltages, then you use the formula: dB = 20log(voltage one/voltage two). The log of 2/1 would still be .3, but the change in decibels would be 20 times .3, or 6 dB. The point is that a decibel is not a unit of anything such as a pound or a mile. It is simply a mathematical convenience.

FREQUENCY:

Sound is basically a pressure wave in the air at a frequency we can hear. Waves ripple through the air much the same way they do in a pond. They go up and down. One complete wave is called a cycle or vibration. Frequency is measured by counting the number of complete waves or cycles per second. We can generally hear frequencies from about 27 cycles per second to about 15,000 to 20,000 cycles. Several years ago the easily comprehended term "cycles per second" was renamed Hertz.

FREQUENCY RANGE or BANDWIDTH:

The frequency range of a device, also called its bandwidth, is the range of frequencies it will operate in. Most monophonic cinema sound systems have an upper bandwidth limit of 6,000 to 8,000 Hertz, some are even less. 35 MM stereo optical systems can go up to about 12,000 Hertz or so, and 70 MM magnetic systems to about 16,000 Hertz.

FREQUENCY RESPONSE:

The term “frequency response” is, unfortunately, sometimes used synonymously with frequency range. They are not the same, however. A device may have a frequency range of 20 to 20,000 Hertz. Were the device to have a flat frequency response as well, its output would remain constant at all frequencies from 20 to 20,000 Hertz. Most audio components are not exactly flat. Their output varies up or down a little at different frequencies. The amount of this deviation is usually small and might be written as “frequency response: 20 to 20,000 Hertz, +1/2 dB.”

IMPEDANCE:

This often misunderstood term is most easily described as “that which impedes.” Were you to plug two wires into a wall socket and keep them apart, the potential current would be impeded by the high impedance of the air between them. Current would not flow from one wire to the other. Touch the wires together and nothing would impede the current, except the impedance of the wires themselves, which is very low. Now the flow would be enormous, enough to melt the insulation off the wires if the fuse didn’t blow.

Impedance in electrical circuits is stated in “ohms.” An ohm is a unit of resistance. Audio writer Don Davis defines impedance as the total opposition including resistance and reactance of an alternating current (AC) circuit. (I’ll save reactance for another day).

GAIN and LOSS:

Gain is the amount a signal is increased by a device. Loss is the amount of signal reduction encountered by transmission through a device or material. Gain and loss are usually expressed in decibels. Many power amplifiers have a voltage gain of 26 dB. This is a 20 times gain, or a one volt input will mean 20 volts out. In decibels this is 20log(20/1) or 26 dB.

WATT:

A watt is a unit of power. Like ordinary light bulbs, power amplifiers are usually rated in watts. An amplifier may be said to deliver 250 watts into an 8 ohm speaker and 500 watts into a 4 ohm speaker. How can this be? Power is voltage squared divided by resistance, or V^2/R=Power. An amplifier is, however, really a voltage source. In other

words if you run an amplifier at its maximum output and find the output voltage is 44.72 volts with an 8 ohm resistor (simulating an 8 ohm speaker) connected across the output terminals, the amplifier would be delivering 44.722/8 or 250 watts. If you replace the 8 ohm resistor with a 4 ohm resistor, the output voltage would still be 44.72 volts. If the amplifier were a perfect one, able to deliver all the current necessary, you would have 44.722/4 or 500 watts. This again is 3 dB more power from the same amplifier.

Next month: Transducers, boxes and all sorts of distortion.

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A LITTLE MORE CLARITY PLEASE

PART TWO

by
JOHN F. ALLEN

This is the second of two installments, the first appearing last month, discussing and clarifying some of the more common and commonly misunderstood audio terms. Here are a few more.

DISTORTION:

There are several kinds of distortion. Any writer, including, this one, owes it to the reader to specify which kind of distortion he or she is discussing as some kinds of distortion are far worse than others. Some say that any change in the sound as it travels from its original source, through the sound equipment to your ears is distortion. Loosely speaking, I suppose this is true. But since changes in frequency response can cause very audible effects, I think this definition is too broad.

The definition of distortion I like best is "frequencies present at the output of a device which are not present at its input." In other words, the component actually makes sound of its own. How horrible. Glancing at a specification sheet for an amplifier, you may see two kinds of distortion listed: Total Harmonic Distortion (THD) and Intermodulation Distortion (IM). Harmonic distortion refers to the undesired frequencies generated which are harmonically related to the frequencies being amplified. For example, a pure 40 hertz tone might be accompanied by unwanted 80, 120 and 160 hertz tones. All, of course, multiples of 40.

Intermodulation distortion refers to those undesired frequencies generated by the amplifier, which are not harmonically related to two frequencies being simultaneously amplified. Returning to the case above: Suppose a 350 hertz tone were added to the 40 hertz tone. The undesired inter-modulated frequencies could be 350 ±40, ±80 hertz, and so on.

Much of what we hear in music is full of harmonics. They add richness and warmth to the sound. This explains why harmonic distortion, though not desirable, is less offensive than intermodulation distortion. Since intermodulation distortion is not harmonically related to the sound, we are more sensitive to it. It tends to obscure clarity and is thus

quite diminishing.

With loudspeakers, in addition to harmonic distortion, there are two kinds of modulation distortion: Amplitude Modulation Distortion (AMD) and Frequency Modulation Distortion (FMD). Frequency modulation distortion does not occur in amplifiers but can be a real problem in loudspeakers.

While amplifier manufacturers brag about .001 percent harmonic distortion and .05 per cent intermodulation distortion, speaker manufacturers virtually never list distortion figures. This is because speakers can produce lots of distortion. A speaker running at 100 dB Sound Pressure Level (SPL), might have 1/2 percent total harmonic distortion and 1 per cent total modulation distortion (which is the sum of both the AMD and FMD). Another speaker operating at the same 100 dB SPL level, may have 1 percent harmonic distortion but 10 per cent modulation distortion.

Such high distortion would never be tolerated in amplifiers but can be found in many loudspeakers. Over the years, some speaker manufacturers have claimed that humans can't hear these levels of modulation distortion. I have wondered why then is low modulation distortion considered so important in amplifiers? Needless to say, I think we writers and others in this business should be very clear which kind of distortion we are discussing and ignoring.

TRANSDUCERS:

Transducers are handy items that change one form of energy to another, such as a microphone when it transforms acoustic energy into electrical energy. In audio, microphones, tape heads, phono cartridges, solar cells and speakers are all transducers. Some transducers are better than others, but, in general, microphones and speakers are considered the least pure. In fact, many agree that loudspeakers are the weakest link in most sound systems. Microphones are a special subject all by themselves, but I will mention that recording engineers are well known for preferring different kinds of microphones for different instruments. What "sounds good" for a piano may not be as satisfying with strings or percussion. The best microphones and speakers are very good and very expensive. Though the best might never need replacement (like other fine instruments they seem to go on forever) people all to often scrimp. This is why almost every sound system you and I hear sounds unnatural, if not down right terrible.

Transducer design and building is as much an art as it is a science. Perhaps more. Many factors and tradeoffs must be weighed. A trip to a local Hi Fi store will point this out as a listener hears vastly different performance from the different speakers and very little

between amplifiers.

THEATRE SPEAKERS:

In movie theatre sound systems, there are basically two kinds of speakers used: Direct Radiators and Horn Systems. No matter which you examine, speakers are all basically air pumps. The direct radiator, as its name implies, radiates sound directly from the speaker cone into the air in the room. Only the actual piston area of the speaker cones act on the volume of air in the room. A horn is a completely different approach. It is an expanding column of air surrounded by ridged boundaries. In a horn system, the speaker cone radiates sound into the air in the horn which then acts on the air in the room with an effective piston area of the size of the horn's mouth. In other words, the horn functions as an acoustical transformer providing a superior coupling of the air at the speaker cone to the air in the room.

There are, in sheer numbers, probably more successful examples of direct radiator speakers on the market than there are successful horn speakers. This is not the fault of the horn approach. Rather it is the "fault" of the "artists" who made them. There are excellent examples of both types. Their selection should, therefore, be based on applicability and performance, not prejudice. When is a horn speaker not a horn speaker? As far as I know, only Klipsch and Cerwin Vega offer fully horn loaded stage speakers. The familiar Altec A-4, A-5 and A-7 systems, as well as the JBL 4676A-1 and 4676A-2 systems are not fully horn loaded as some say, but are actually short horn/bass reflex combinations.

BASS REFLEX:

In a bass reflex woofer design, energy from the rear of the speaker cone is routed out to the front of the speaker cabinet through a hole or port, where it combines with the sound radiated from the front of the speaker cone.

In fully horn loaded systems, the horns are several feet longer than the short horns found in the bass reflex combinations. The air behind the cones in a horn is sealed in a back air chamber of some specific volume. All to often, I find writers and others using the term "horn" when they are really discussing horn/bass reflex combinations when they are not at all the same. This is unfortunate, as the real horn systems can deliver significantly more performance than the combination types. The two should not be confused.

LOUDSPEAKER EFFICIENCY:

This refers to the ability of a loudspeaker to convert electrical power into acoustical power and is expressed as a percentage. Speakers are not very efficient. They vary from about 1

to 3 percent for direct radiators to as much as 10 to 20 percent for horn loaded systems. In other words, anywhere from 80 to 99 percent of your amplifier's power is always wasted heating the speaker's voice coils. Efficiency is often confused with sensitivity.

SPEAKER SENSITIVITY:

With 1 watt of power fed into a speaker, "sensitivity" is a measure of sound pressure level produced by the speaker. Note that efficiency is a measure of total radiated power and that sensitivity is a measure of sound pressure level. Why the confusion? Let's say you have a speaker with a radiating angle of 60° by 40°. It is 20 percent efficient and has a 1 watt / 1 meter sensitivity of 109 dB SPL. If you widen the radiating angle to the point where the speaker becomes an omnidirectional system, or 360° by 360°, the 1 watt / 1 meter level at any given point in space will drop considerably because the total power is now spread over a much larger area. The thing to keep in mind is that the total power output remains the same. The speaker is still 20 percent efficient even though it is now less sensitive. Efficiency and sensitivity are related but are not the same things.

The terms discussed in this and last month's article are often used in articles about sound. It is hoped that these brief, and therefore somewhat incomplete, notes will help those who enjoy the reading, but find some of the terminology unfamiliar.

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