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Subject: The 11th Lie (LONG!!)

Posted by [Dave Williams](#) on Mon, 21 Feb 2005 18:32:11 GMT

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Hi all, First posting here, so be nice 8^). I'll preface by saying that I'm far from the consummate audiophile. I haven't listened to many systems, never designed or built speakers, etc, although it is just something I'm interested in pursuing more once funds allow. Anyhow, that aside, the engineer in me really feels the need to comment on the Ten Biggest Lies article. First of all, I can't fault the author for skepticism about many claims routinely made in audio literature. There are loads of bogus claims made all the time, as there are in any industry, and I hold as much disdain as anyone for claims I see which set off my BS detector. But I think there is a major flaw in his article. Nearly all of his conclusions are based, implicitly or explicitly, on superposition, and therefore on the assumption of linearity of every analog component in the sound reproduction chain up to and including human perception of sound. Which brings me to lie number 11 (just call me Nigel Tufnel): 11. The world is linear. It isn't. We often MODEL it as linear, but there's a famous saying among people who model things for a living. "All models are wrong; some are useful." The 'some are useful' thing boils down to the degree of non-linearity. Some things are VERY close to linear, but many things really aren't all that linear, especially as one approaches the boundaries of their operating envelopes. For most devices, a good designer trying to use linearity in his/her modeling will be able to spec devices in such a way that nonlinearity is very weak in the operating range, but for some things this just isn't practical. To cite a specific example, speaker suspensions are stiffening springs; so at a minimum there is a cubic component to the stiffness. I haven't measured one, but I bet the non-linearity is measurable within the operating range. That's one reason why speakers exhibit significant harmonic distortion. Now everyone knows these systems aren't really linear, but many people don't fully understand the implications of that fact when they attempt to draw conclusions based upon simple concepts like superposition. So why would we model a system as linear if it really isn't all that linear? Two reasons:- It's intuitive- It allows us to invoke superposition. But superposition isn't "right" unless the system is linear. Hence the "All models are wrong" mantra I stated earlier. Just as an example, consider the cubic non-linearity noted earlier, where the suspension of the speaker has a stiffness like:  $F = k \cdot x + a \cdot x^3$  where  $k$  is what we normally think of as the stiffness (linear) and  $a$  is hopefully small. Now, suppose we feed it a signal of two sinusoids of different frequencies,  $w_1$  and  $w_2$ . The linear MODEL,  $F = k \cdot x$  will yield response only at  $w_1$  and  $w_2$  (superposition). However, with a healthy amount of algebra, you can show that for the cubic SYSTEM, the response contains information at the following frequencies:  $w_1, w_2, 3w_1, 3w_2, w_1 + w_2, w_1 - w_2, w_1 + 2w_2, w_1 - 2w_2, 2w_1 + w_2, 2w_1 - w_2$ . Now, there are various coefficients that crop up which I haven't kept track of which can be quite small especially if " $a$ " is small, so maybe the energy doesn't matter. But it's there. And if you're unlucky, it might be significant. You can see now why it might be the case that DAC artifacts above 20kHz that don't get totally filtered out (because we can't make a perfect filter) may still be important. Which brings me (in long-winded fashion) to my problem with this article. The author is falling into the VERY-EASE-TO-FALL-INTO trap of equating his model of the system with the system itself. It just isn't so. To make blanket statements about the real-world performance of a system based only on the linear performance of the model, without consideration and analysis of the non-linearities is just as irresponsible as his much-derided "audiophile" who dismisses ABX testing when it fails to show a difference between a Krell and a Pioneer. I'm not telling anyone they should swallow marketing claims hook, line, and sinker; go out and mortgage their house for a 6' length of cable; or believe someone when they tell them that they haven't heard holographic

imaging until they've put their CD player on top of a matched triad of pickled cat testicles. The author is right in his skepticism about over-priced audio gimmicks, but is totally misguided in his blanket invocation of superposition. As I say, I haven't measured the non-linearity of any any audio components, or the ear, or the acoustic behavior of air. They may or many not be significant in cables, or in capacitors, or in the response of the cochlea, but they're there. Linearity assumptions are very useful in that they get us a long way toward simulating and designing complex systems in simple fashion, and used appropriately they can allow the screening of BS claims. But one must always remember that the linear system is only a model, and does not capture all the phenomena that can occur in the real system. Rant over, you will now be returned to your regularly scheduled programming. BTW, cheers Wayne, for a great forum and an atmosphere that encourages rational discussion about audio in general and your products in particular rather than just the usual hype and drivel. Dave Williams

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