Subject: Distortion mechanisms
Posted by Wayne Parham on Wed, 23 Feb 2005 21:41:50 GMT
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Earl Geddes and I were discussing various distortion mechanisms, both on and off forum. I wanted to bring the discussion out in public I think most will find it interesting and because I'd like to hear other's opinions too. Some of you have done a lot of thinking on these matters, and some have done some work and models and measurements.One thing that comes to mind is Geddes opinion that second and third harmonic distortion from loudspeakers is not as objectionable as higher harmonics. I think he's probably right. I think measurements of second harmonics are still pretty good information, since they are easy to make and they indicate asymmetry. That will also introduce other even harmonics and the ones higher up in frequency may be the ones that are really noticeable, even if at lower amplitudes.Something else that comes to mind is the matter of nonlinear distortions verses linear distortions. That is something Geddes brings up a lot, and was also mentioned recently by Dave Williams. My thinking is that efficient, powerful speakers used at home hifi levels are probably used pretty much in the linear regions, at least where electro-mechanical properties like suspension stiffness and voice coil resistance and motor strength are concerned.I think the mathematical models are useful. I don't think it is wise to assume perfectly pistonic behavior of the diaphragm, perfectly resistive impedance of the voice coil or perfectly linear excursion of the motor. It is good to realize that isn't the case, and to take it into account when making a design. But the models that make those assumptions are useful tools.I also think that it is worthwhile to design systems that are very tolerant of parameter shifts because they're going to happen. And I think that doing things to reduce the things that cause nonlinear distortion is always good too. But first, you must define them and know what they are to begin dealing with them.There are many other distortion mechanisms too. There is throat distortion, caused by the nonlinearity of the air in extreme compression/rarefaction cycles. There are the high order modes that Geedes often focuses on. There is doppler distortion from moving diaphragms. There is intermodulation distortion. There is compression. Then there are other nonlinearities that don't have specific names. There is the modification of waveforms in some capacitors such as electrolytics and ceramics. There is the effect produced by a coil or transformer in magnetic saturation. There are the changes of a conductor when hot. Or of a semiconductor, like the carbon in resistors or the silicon in transistors. There is the non-uniformity of magnetic flux at the edges of travel in a loudspeaker, and the asymmetry produced by flux modulation.What do you guys think? Lots of things to consider here.

Subject: Re: Distortion mechanisms
Posted by Mike.e on Thu, 24 Feb 2005 00:05:28 GMT
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I think that we need a methodical approach,attacking the main offendors first rather than attacking the easy problems which have little effect.Polar response and crossover/driver interactions especially[as stated in SB1980 - Linkwitz]where he advocated 4th order LR filters and acoustic axis issues.What we have at the moment is an interesting market. The 'hifi' market that you see in the stores,and the 10% of those who are simply not happy with those products,be they

engineers,enthusiasts,musicians or anything. The vast majority are happy with these cheap system until they hear better, so the real 'hifi'owners will always be a minority group. I feel that the real improvements will always come through the prosound area and that there will always be the people who are happy with their technically bad, but subjectively good {to them atleast}sounding systems.Once into this group theres so many ways to go,but to me theres 2 main branches each aiming at different goals.the low efficiency omnidirectional guys,and the directional high efficiency guys. These to me seem to be opposite and equal but just 2 extremes of the audio pie full of varying flavours! One cant be better than another,and aslong as people admit where they are measurement wise and arent operating in a physics free world I dont mind if they listen through 5" fullrangers or MTM d appolito 2ways..Cheers!Mike.e

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Subject: Re: Distortion mechanisms
Posted by Manualblock on Thu, 24 Feb 2005 01:10:37 GMT
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Say Wayne; Curious; how do you determine how well components tolerate parameter shifts? Unless you are able to pinpoint the moment when they occur? Or is that the wrong question?Also there was an article in AE where Jean Hiraga did listening tests that seemed to corroborate the supposition that very high order harmonic distortion is not as objectionable as some smaller order anomalies? Nice thread BTW. I was hoping you guys would break this out again; you and Earl; good stuff.

Subject: Re: Distortion mechanisms
Posted by Earl Geddes on Thu, 24 Feb 2005 01:17:40 GMT
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I think that I must disagree with the comment about omin directional versus directional - that they are just two different approachs. This is not correct. In an anechoic chamvber, yes, they are both the same with the listener receiving only the direct sound. Bt in a normal room with reverberation they are dramaticaly different. The omni has no reflection free time lag after the direct sound while the directional speaker does - if pproperly aimed. This is not a small effect either, it is almost dominat to imaging and coloration.So, no, I don't agree with your comment.

Subject: Re: Distortion mechanisms
Posted by Wayne Parham on Thu, 24 Feb 2005 01:33:02 GMT
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What I was referring to when I wrote that statement is specifically how voice coil heaing shifts the

electro-mechanical parameters of the speaker. Over excursion also changes electro-mechanical parameters, as the coil and gap relationship changes. The suspension may act differently near xmax too. In Klippel models, there are terms for the nonlinear parameters but T/S models just deal with small-signal values.Certain alignments are very sensitive to electro-mechanical parameters. It's like they're close to the edge, often providing maximum extension but also needing tight tolerance to prevent underdamped response. Other alignments are much more tolerant of shifts and could not become underdamped except from extreme changes which are completely out of range.

Subject: Re: Distortion mechanisms
Posted by akhilesh on Thu, 24 Feb 2005 18:42:59 GMT
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HI Wayne,I agree, higher order distortions are more irritating, since htey are further from the fundamental. http://www.pmillett.addr.com/file%20downloadss/1has a great slide show. Here is a good primer on distortion in general, with a cool applet.
http://www.mindspring.com/~j.blackstone/dist101.htm-akhilesh

Subject: Re: Distortion mechanisms
Posted by Wayne Parham on Thu, 24 Feb 2005 19:16:41 GMT
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Great links, thanks!The one at http://www.mindspring.com/~j.blackstone/dist101.htm is really cool, because it lets you actually hear tones with various amounts of harmonics. You can start with a single tone sine wave, then add in components of whatever harmonics you like to hear the resulting sound.The other link didn't work for me. So I backtracked to find the host at Pete Millet's Audio Page, http://www.pmillett.addr.com. That looks like an interesting site as well.

Subject: Clarification
Posted by Mike.e on Thu, 24 Feb 2005 20:08:57 GMT
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Hi EarlMy intention was to say that the two approaches are opposite and produce rather different results in room. Is this your opinion also?Whether one is more correct than the other... Perhaps my NZ english prevents me from understanding quite what you mean in this sentance below RegardsMike.eomni has no reflection free time lag after the direct sound while the directional speaker does - if pproperly aimed

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Subject: Re: Clarification
Posted by Earl Geddes on Thu, 24 Feb 2005 20:52:44 GMT
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This is a very complex phenomina, but absolutely the key to why directional sources sound better in rooms than non-directional ones.Picture an omni source - it hits all the walls, near far what ever, on the first wave. Now picture the directional source, picture it very narow, like a beam of light. It hits only one wall on the first pass, another on the second, maybe two, its at least three or four reflection before the reverb field begins to build. The omni happens immediately.This takes a lot of thought, but think it through and you'll see what I mean.So I am saying that one type is definately better than the other.

Subject: Re: Clarification
Posted by Earl Geddes on Thu, 24 Feb 2005 21:07:28 GMT
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I should also add the subjective nature that makes this delay necesary.The ear integrates over a period of time. The time is variable with frequency but it has a typical value of 10 - 20 ms. The more reflections that arrive in this time period the more difficulty the ear has determining an unambiguous sound localization. Thus this first few ms. is critical to imaging and coloration of a loudspeaker. Sure the room can help, but in small rooms the lodspeaker and room must both be done correctly to get the best imaging and sound quality. Neither one alone can do it.

Subject: my rant
Posted by pgolde on Fri, 25 Feb 2005 19:56:21 GMT
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I am a student of these forums and of audio. Much of what DR. Geddes and Wayne debate is not only over my head, but I lack the proper tools for measurement and the time to invest to prove either of their theories, once I do get a good understanding of both.I think there is more R&D money in pro audio and more lately, high end home theater. I think designs like Dr. Geddes waveguide and TD's Unity Horn are proof of progress being made to reproduce sound as accurately as possible. Compression drivers, and cone drivers are using pretty much the same technology that has existed for decades. New designs are being proven still for new ways to get the most out of these inefficient devices, but most people dont give a rats ass. Every time I try to show a someone the basshorn I built, or even discuss it, the first thing out of their mouth usually goes something like this "oh, thats like the BOSE". Though playing music through them always puts a smile on their face. I do enjoy learning as much as I can, wish I had more to contribute than questions or observations. I do also appreciate others sharing their trials for us to learn from and build on. But there is a point that is reached with DIY that gets very expensive to do better. Dr. Geddes has years of scientific research to pull from, and is nice enough to share some of his

findings and observations with us who are willing to read and listen. But unless I have my own scientific data to back up what I believe to be good sound, it is difficult for me, or a guy like me prove. So on to the next project, a horn based on Leach math, using a BMS coax.Thanks

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Subject: So you are saying
Posted by akhilesh on Fri, 25 Feb 2005 20:11:07 GMT
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directivity systems are better for imaging? Seems intuitively correct! Wold you say that horns are more directional or less directional than say dome drivers, than, say cone drivers?thanx-akhilesh

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Subject: Re: So you are saying
Posted by Earl Geddes on Fri, 25 Feb 2005 20:39:48 GMT
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That question has no answer.Since waveguides have a directivity that is constant with frequency and domes and cones and pistons directivity narrows with frequency there is a frequency region where the pistons are wider and a frequency region where they are narrower.

Subject: Re: Clarification
Posted by Mike.e on Sun, 27 Feb 2005 05:45:35 GMT
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These are the issues ive started looking at recently,and for these reasons Im wanting to build a horn loaded system,with HF horn,15" midbass and perhaps a matching 300hz-2khz midrange rectangular mouth horn,cone driven.Question: Why have some many,for so long aimed for this omnidirectional source ?Another reason I want less room interaction,is because the electronica music I tend to listen to,I enjoy it so much more on headphones and I think this is why.RegardsMike.e

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Subject: Re: Clarification
Posted by Earl Geddes on Sun, 27 Feb 2005 17:00:48 GMT
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Its hard to understand why people hold on to obsolete views for so long. Things like "sweet spot" and omni directional patterns are dead and gone.When rooms are very dead then omni works as well as anything else and most acousticians make small rooms very dead to smooth out the bass. In this case the omni is an adequite solution. And lets face it it is a whole lot easier and cheaper to make an omni source.But the small room problem is low frequency only. That is, it is true that one wants a lot of absorption at LF in small rooms, but that does not mean that one wants a lot of HF absorption. In fact the exact opposite is true. So building the correct room acoustics is a bit problematic, but it certainly can be done (see my books). When the room has a lot of LF absorption and little HF absorption, the omni-directional source is a disaster. This is where the directional source is not only desirable but required. In fact in any room which has little sound absorption, the directional source will always sound better.So you see, that the desire to have an omni-directional response is misguided.

Subject: Re: Clarification
Posted by Mike.e on Mon, 28 Feb 2005 02:29:59 GMT
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Thanks earl,yes I agree. I see the people on 'hifi' forums buying the latest 1" + 4" + 8" and damp the hell out of their rooms to get some sort of imaging...The directive route seems so much more logical.RegardsMike.e

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Subject: Re: So you are saying
Posted by akhilesh on Mon, 28 Feb 2005 14:14:34 GMT
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Earl,Thanks, I think you did answer my question!If the directovty of domes & cones goes down as frequency increases (i am assuming that;s the case), then would it make sense to use cones for bass & midrange, but horns (are those wave guides?) for the higher frequencies?Also, I was curious, how do your findings on directivty being preferable mesh with Floyd Toole's work in the 1980's, that omnidirectional sources are preferred. OR do I have the literature wrong?-akhilesh

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Subject: Re: So you are saying
Posted by Earl Geddes on Mon, 28 Feb 2005 14:49:34 GMT
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I think that you said that backwards. The directivity of cones and pistons goes UP as frequency increases. But, yes, you are corect that pistons do make good sources at low to mid frequencies which is exactly how I use use. I let the directivity of a large piston narrow until it reaches the

same coverage as the waveguide and then I cross it over to the waveguide. This gives me a smooth polar response transition from very low to very high frequencies.I am not aware of any work that Floyd did saying the omni-speakers are prefered. That would not agree with JBL's trend to make their loudspeakers directional. In their extreme high end system they basically do the same thing that I do. Only thiers cost ten times as much!

Subject: Re: So you are saying
Posted by akhilesh on Mon, 28 Feb 2005 16:51:03 GMT
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Earl,Yeah I said it backwards...sorry!I'll look up Floyd's work and get back. I thought he did some initial work at NRC that established that, along with flat freq & low distortion, people preferred omni sources over directed sources. But i'll check up on that.-akhileshPS. Do you match directivities by taking off axis measurements? At what point do you establish that directivities of the horn & cone are about equal? My guess is that it would be the d(change in SPL for a freq)/d(angle) that is equal or some such. Can you encapsulate your findings here? I wold be very interested. thanx

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Subject: Re: So you are saying
Posted by Mark Seaton on Mon, 28 Feb 2005 16:52:00 GMT
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Earl Geddes wrote:"I am not aware of any work that Floyd did saying the omni-speakers are prefered. That would not agree with JBL's trend to make their loudspeakers directional. In their extreme high end system they basically do the same thing that I do. Only thiers cost ten times as much!"Actually Earl, that should read "They are *charging* 10 times as much." Because they can! Of course those Berrilium diaphram compression drivers are certainly a bit more expensive than is warranted.Out of curiosity, Earl, have you measured or listened to the BMS 1" exit or their larger coax compression driver? Do you consider the slight increase in their high frequency extension to be of much value beyond marketing?Regards,-Mark Seaton

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Subject: I checked up Floyd Toole's work
Posted by akhilesh on Mon, 28 Feb 2005 17:12:13 GMT
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and you are right: they found that listeners favor constant directivity as well. -akhilesh
 Floyd's pape rsummarizing some of his work.

Subject: Hey, I just saw your website
Posted by akhilesh on Mon, 28 Feb 2005 17:24:09 GMT
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Earl,Very impressive work! I really hope you come for the Tulsa audio fest in a month or two, since I am very interested in hearing your speakers. -akhilesh(PS i myself am just a hobbyist who has been dabbling in this for about 2.5 years)

Subject: Re: So you are saying
Posted by Earl Geddes on Mon, 28 Feb 2005 17:29:48 GMT
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I have done some tests on the BMS drivers and don't find that they actually do have much more HF content. In the coaxial drivers the response at the crossover is a mess, and this is in a critical band for audibility. I have looked at just about every driver ot there and B&C is my choice. I am looking more seriuosly at Beyma, but BMS is not in the running.

Subject: Re: So you are saying
Posted by Earl Geddes on Mon, 28 Feb 2005 17:36:23 GMT
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First I ballpark the design by calculating what a 15" piston directivity would be and what a waveguide should be to match at 90°. Then I set up the system and measure the complete polar response of both drivers in the actual enclosure. Finally a crossover is designed and optimized with a computer program that I wrote to give the flatest response over all angles in the forward 90° arc, with a slight preference for 22.5° (the direct angle). Finally, of course, the crossovers and systems are tested at all polar angles (these results are shown on my web site). I have never seen a situation where the measurements and computer predictions were not the same, so this last step is a simple confirmation.

Subject: Re: I checked up Floyd Toole's work
Posted by Earl Geddes on Mon, 28 Feb 2005 17:42:34 GMT
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So then you have to ask yourself why there are so few constant directivity designs available. Maybe its because they are hrd to do?Please keep in mind that omni IS constant directivity. Its constant high directivity that is the key.If you have not heard a good narrow constant directivity

loudspeaker then do yourself a favor and hear them. You won't like anythiing else again. I would suggest mine.

Subject: DI matching
Posted by Wayne Parham on Mon, 28 Feb 2005 19:46:37 GMT
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This is called DI matching, and it is a good practice, in my opinion. You run the midwoofer up through the vocal range which does two things: It allows the voice fundamentals to be handled by a single driver and sets the crossover point in the overtone range, which is a natural sounding place to split, in my opinion. It also matches the directivity of the midwoofer to that of the horn tweeter. A 90x40 horn has DI of about 12, and that's what a 12" or 15" speaker has between 1kHz and 2kHz. It is collapsing past 10 approximately where wavlength equals diameter. See chapter 3 of Augspurger's JBL Sound System Design Manual for more information.

Subject: CD versus H/LD
Posted by akhilesh on Mon, 28 Feb 2005 20:32:02 GMT
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Earl, I hope you do come to Tulsa for the spring Audio fest, becuase I would love to hear your designs!I did some more thinking on this, and i agree: i was confusing constant dir (CD) (varies with frequency) and high versus low directivity (h/LD) (varies with degree) , as you said in your post. On re-reading Floyd's white paper, it seems he is saying one wants CD, but says nothing about LD versus HD. Clearly, HD (along with CD) will mean that the primary sound will dominate the musical energy, as opposed to first order and second order reflections. In other words the waterfall plot will slope much more with HD. Do you have any studies at GEDLEE that have established, in double blind tests, that HD is preferable to LD, CD being held constant? Intuitively I agree with you: HD will make the room sound "deader" than LD. Hope to see you in tulsa-akhileshPS: Do you offer your speakers for sale or on a trial basis?

Subject: Thanks Wayne & Earl
Posted by akhilesh on Mon, 28 Feb 2005 20:34:12 GMT
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Very enlightening. -akhilesh

Subject: Re: CD versus H/LD
Posted by Earl Geddes on Mon, 28 Feb 2005 20:54:48 GMT
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No - we only did studies of HD CD comparisons with different speakers.But here is the thing to consider with HD. With HD I can point the speakers such that the early reflections are minimizes and so that the first reflections come to the ear opposite the first arrival. This is very important since a first arrival and an early refelction at the same ear will cause coloration. This is point one.Now also consider the energy time arrival of an HD versus a LD. The LD reflections arrive almsot instantaneously there is not gap between the first arrial and the early reflections. Not so the HD. There is a significant gap between the first arrival and the early reflections. I cannot overstate how important this later aspect is to imaging. Without a gap in the arrival times of the direct sound and the early reflectiosn the ear cannot resolve spatial location cues and the imaging will be poor.The imaging on my speakers is as precise as headphones but without the "in the head" image problem. Pinpoint locailzation in a space beyond the actual location of the speakers. It really has to be heard to be believed.

Subject: Re: CD versus H/LD
Posted by akhilesh on Mon, 28 Feb 2005 21:49:44 GMT
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Earl,Thanks for your reply. I agree with you...intuitively it makes total sense: HD will lead to better imaging, and a cleaner sound. Since you have the setup & the skills, i was speculating that it would be interesting to measure, in a double blind test, if (educated) listeners (a la Floyd Toole's methodology) actually do prefer HD, and by how much (keeping CD & the rest of the room & system constant of course). Speculating further, we'll have to figure out how to develop 2 speaker systems, one with HD & one with LD, with CD constant. ALternately, one could use the same speaker system, but in one experimental tresatment emphasize room reflections so they are stronger and reach the listener sooner. Should be interesting & fun!Not to mention a good potential AES paper!-akhilesh

Subject: Re: CD versus H/LD
Posted by Earl Geddes on Mon, 28 Feb 2005 21:52:02 GMT
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Yes the speakers are for sale and they can be heard in either Ann Arbor (my home) or New Orleans. My pricing strategy does no allow for luxuries like loners. I want to keep the price as low as possible and not gouge the customer, but that means I can't offer the "nicities" that the gougers offer.

Subject: Re: CD versus H/LD
Posted by Earl Geddes on Mon, 28 Feb 2005 21:58:54 GMT
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Well actually it might be easier than you think, but I still doubt that it will ever be done. Almost no one actually does blind listening tests with a large number of subjects (prefered to trained subjects for variuos reasons) because they are so hard to do.I am in the process of doing two studies aimed at understanding some details of sound perception, but the question that you ask - LD versus HD seems so obviuos to me that I am not too interested in doing it. Once you heard a HD CD system properly setup I think that you too would also agree that such a test is not really needed.If the question that you are asking is what HD is optimal, 45°, 60°, 90° etc. then I can agree that would be an interesting test. But to ask if 90° is better than 360°, I think thats a no brainer.

Subject: Re: CD versus H/LD
Posted by akhilesh on Mon, 28 Feb 2005 22:23:39 GMT
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Hopefully we can meet at some time!-akhilesh

Subject: And what about tubes ?
Posted by Eric Mainardi on Wed, 02 Mar 2005 10:51:38 GMT
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Can somebody explain the success of tube amps ? It's probably the best distortion source in a system !I don't like provocation but I would like to understand...

Subject: Re: And what about tubes ?
Posted by Wayne Parham on Wed, 02 Mar 2005 19:23:06 GMT
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I think a lot has to do with nostalgia. The better tube amps are very atractive. People that are over 40 years old can remember tube radios and amplifiers, and it is nice to see them again. Americans also love classic automobiles when they are restored and made beautiful. The flowing graceful lines and large polished chrome bumbers and trim are verty much like art.There is also the matter of types of distortion. Tube amps generate mostly second and third harmomnics. Class A tube amps generate mostly second, which most agree sounds more natural than say

seventh. Class AB tube amps generate mostly third, which is still fairly low. When the amp nears clipping, the output reduces gain as it approaches the peak, sort of like a built-in compressor. So the edges are rounded and sometimes it is hard to hear the onset of clipping with a tube amp. You notice it when you really press into clipping, but the start is barely noticeable. So I think these are the things that attract people to tubes. The beauty and the character.I've grown to really enjoy nice tube amps. I love the looks and the sound. But if pay attention only to the music and the amp is kept well below clipping, a nice solid state amp is wonderful. I have some excellent solid state amps that produce very pure sound and a lot of power, more than I ever could expect from tubes. So that is important to me also.You'll notice that many of the same people that are die hard SET lovers have been attracted to the very inexpensive digital amps. These are opposite ends of the technology spectrum, so I think some just like to be on the edge. They like what is unique. They are probably attracted to sound qualities too, but I think the novelty aspect cannot be overlooked.And there's the aesthetics too. When a piece of equipment is like art, the beauty will capture you. There can be a beauty in simplicity, a plain black chassis with no controls. But when you see a chrome chassis with black accents and tubes glowing, the amplifier becomes art in light. I'm sure that grabs as many tube converts as anything else. If it looks like that and sounds good too, it has a very sensuous allure.
 "A Taste of Tubes"

Subject: Best of both worlds
Posted by wunhuanglo on Thu, 03 Mar 2005 08:30:12 GMT
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Tubes do, in my experience, produce euphonic coloration that can be very appealing. At the same, time tube amps are a megabuck experience if you need anything greater than modest power output (and lately even some mini-watt amps cost as much as a new car).In the past I've run a tub pre-amp with a sand power amp - the result is the "tube sound" without the high $/watt penalty.

Subject: Another link
Posted by akhilesh on Thu, 03 Mar 2005 11:59:09 GMT
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I agree Wayne! Tube amps are a lot like older cars. Fun & involving!Here is another link that describes why tube amps may be better than at leas tthe earliest sand amps!-akhilesh
 Tubes versus Transistors

Subject: Some useful links

Posted by Eric Mainardi on Fri, 04 Mar 2005 08:38:31 GMT
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http://www.pcavtech.com/soundcards/techtalk/dist_sound/index.htmhttp://www.pcabx.com/technical/index.htm

Subject: Re: Some useful links
Posted by Wayne Parham on Fri, 04 Mar 2005 08:59:01 GMT
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Those are good links, thanks!Akhilesh was telling me he found a webpage that had wav files of distortion. I'll bet the http://www.pcavtech.com/soundcards/techtalk/dist_sound/index.htm page was it. The other page, http://www.pcabx.com/technical/index.htm is very good too.