Subject: Extended bass response from small cabinets
Posted by Wayne Parham on Thu, 12 Jul 2001 23:04:44 GMT
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Everybody wants deep bass from a cabinet no bigger than a lunchbox. Can we build a small box that makes deep bass? Well, yes. But can it also be efficient? The answer is no. Hoffman's Iron Law states you can have low cutoff, high efficiency or small size but not all three.This isn't just a rule of thumb, it's actually a characterization based on physics. Hoffman's Iron Law is a mathematical formula that was later refined by Thiele and Small, whose work now forms the basis of all modern loudspeaker design. Hoffman's Iron Law states that the efficiency of a woofer system is directly proportional to its cabinet volume and the cube of its cutoff frequency (the lowest frequency it can usefully reproduce). The obvious implication is that to reduce the cutoff frequency by a factor of two, e.g. from 40 Hz to 20 Hz, while still retaining the same system efficiency, you need to increase the enclosure volume by 23=8 times. In other words, to reproduce ever lower frequencies at the same output level you need an extremely large box!However, box size isn't the only variable. You can continue to use a small box by accepting a much lower efficiency. In order to retain the same sound pressure level (SPL, meaured in dB's), though, this requires both a very large amplifier and a driver that can handle a lot of power and move a lot of air (requiring high excursions). Furthermore, it must be able to do so with minimal distortion. This is exacerbated by power compression, a phenomenon where the power heating of the driver's voice coil results in a non-linear relationship (read "distortion") between the electrical power in and the acoustical power out.

Subject: Re: Extended bass response from small cabinets
Posted by Paul C. on Fri, 13 Jul 2001 00:52:07 GMT
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So, Wayne, what all this means is that when you want small and low, you trade off for efficiency. This has been my experience... you just can't beat physics. Just can't do small, low, and loud all at the same time. Also, these designs generally depend on active participation from the amp... and EQ boost to flatten out the bottom end... again, taking even more power.You see the sub plate amps all the time as having X db boost at Y hz. This is a part of the design.OK, so why can't we do this... with smart electronics we have these days, why not extend the feedback loop even further, not just in the amp (Wayne, ignore this...Amplifier 101 class: this is the circuit that controls gain in an amplifier, and reduces distortion, forcing the output to mimic the input), but from a transducer (mic) at the woofer end of the chain, feeding back to the amp, to control distortion, overring, compensate for the bottom end rolloff. That is, making the amp a more active participant in the whole process.There is noise cancelling equipment out now... muffler systems that have speakers in them that sense engine noise, and generate 180 degree out of phase signal. Yamaha has a device, Silent Brass, that is a mute for trumpet and trombone, picks up via mic, generates 180 degree out of phase sig, and cancels the sound. The player hears himself via earphones, but no one else can hear it! A college music major could literally practice in his room

while his roommate slept only a few feet away! I have seen this demonstrated, it works!So, the technology is here... we can use it to compare the input of the amp to the output of the spkr, a simple comparitor... one little op amp, and generate a correcting signal to send back to the input of the amp. So, this negative, active feeback loop can extend the frequency range on the bottom end, fix many of our present ills... maybe not with 100 db/wt/meter efficiency, but at least we can make clean bass with smaller boxes.(As far as that junk they pass off as high-end car stereo these days, I have never heard a real bass drum boom as long as these cars do. In fact, a bass drum does not sound like that at all. I play with drummers, they work hard to get a sharp, fast, impact sound, not a long, resonant boom. They put damping in their bass drums to kill the resonant booooom, and instead get a fast, precise whop! So, I just stick a pair of Jensen 6x9 2 ways in the doors, and try not to listen too critically.)Like you, Wayne, I have run the numbers by hand (with a calculator, actually), with various programs, and still, if I want to feel the T Rex walking in Jurassic Park, I need boxes big enough to really PO the wife about the new living room decor.

Subject: Re: Extended bass response from small cabinets
Posted by Wayne Parham on Fri, 13 Jul 2001 06:26:06 GMT
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Thanks for posting your observations! As a musician, you really have an excellent grasp of what you're listening to. And with your technical experience, you're in a very qualified position to describe and quantify what it is that defines these qualities in a system.I agree with you about not liking the resonant boom-boom sound of some woofers. I call 'em mudmotor woofers because that's exactly what they sound like to me. Must be tons of motor nonlinearity, and they just sound terrible. Distortion free bass and proper damping is really important to me.

Subject: Re: Extended bass response from small cabinets
Posted by Paul C. on Fri, 13 Jul 2001 07:08:36 GMT
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Wayne: I thank you for the compliment. When my oldest son was in high school, he played drums in the high school band. I drove into the driveway, and I could hear the drum line practicing. I was wondering why they were in MY backyard, why couldn't they do that at school? I went around the side of the house, and there was my son and one of his buddies. They had

pushed my big PA speakers out into the back yard, strung out cable back inside to the stereo system (I have my stuff all modified to take 1/4" phone plugs). They had it cranked up, live level. They were pushing maybe 5-10 wts, according to the meters on my amp. They were listening to a demo tape of a drum feature, and wanted to get the "live" effect. Well, it fooled me. So, my PA spkrs passed the drum test for me!I listen to percussion, and not electronic technopop, but real percussion for judging speakers. With good speakers, you hear not just the cymbal, but the tap of the stick on the cymbal, too. And in general, highly efficient speakers, particularly horns, pass the realism test for me.Oh, guys, real string basses (double bass) do not have real smooth response. Some notes pop out, some you can barely hear... this is due to resonances of the bass's wood body, and also room resonances where it was recorded. Smaller rooms are more pronounced in this effect. Doesn't mean anything in this discussion, just an off the wall observation. When you listen to a jazz group, don't think your speakers are doing funnies.There is a Paul Winter recording... they warn you on the liner notes that an African drum on the intro of the first track has a rattle, that they want to reassure you it is the drum as recorded, not a rattle in your speakers... LOL! And just today, another musician was over here with a recording he made... and he and his wife said at the same time, "that drum IS there!" They could not hear a certain drum on their home system, but it was clearly audible on mine. And all this time he thought he had not mic'd it properly.My point is, percussion is the toughest to reproduce correctly, not just low notes.

Subject: Re: Extended bass response from small cabinets
Posted by Wayne Parham on Fri, 13 Jul 2001 08:43:06 GMT
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I'm glad you brought that up about recordings of acoustic bass. There's a lot going on in the acoustic realm when you put a microphone near an acoustic bass. There are bass body modes and there are room modes. That means where you put the microphone matters, and there is virtually no location that will make all the notes the same volume.I have heard a few recordings - some that come to mind by the Stray Cats - that had acoustic bass with all the notes sounding pretty close to the same volume. Brian Setzer and producer Dave Edmunds did a good job on those, I was impressed.

Subject: Re: Extended bass response from small cabinets
Posted by AudioLapDance on Fri, 13 Jul 2001 14:36:46 GMT
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Speaking of finding things in music, I drove a buddy nuts by pointing out that in Zeppelin's "Since I've been loving you" you can hear Bonham's bass pedal squeaking. He can't listen to the song on a revealing system anymore, he he he (evil grin)

Subject: Sound and perception of sound
Posted by Paul C. on Fri, 13 Jul 2001 17:35:13 GMT
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OK, I have been holding off doing this.. but here goes. Wayne, if this is too long, delete it.I had alluded to this in another thread some months ago, that when in college I made, to me, other discoveries in the way we perceive sound, what makes instruments and other sounds sound the way they do. Well, the clarinet, for example, has a waveform that approaches a squarewave. It has only odd overtones. So, it is easy to generate a squarewave... but it does not sound like a clarinet, sort of, but not really. In playing with parametric equalizers, I found that the clarinet tone can be closely imitated, enough to fool a clarinet player, by inserting some high Q resonances, fooling with Q (width and height of a resonance... a high amplitude, narrow frequency range resonance is said to be "high Q") that are fixed in frequency, rather than following the frequency of the fundamental, give the instrument its timbre (tonal character or tone quality). Perhaps this is because the clarinet, being a piece of wood, has inherent resonances in the body of the clarinet itself, that are excited by the fundamental and overtones of the vibrating air column. Also, there are room resonances, both the recording room AND the room in which you listen to reproduced music. So, these vary from room to room, and instrument to instrument, and also player to player. Have 10 saxophonists play the same saxophone/mouthpiece/reed, and you get 10 distinctly different saxophone tones.If you sample a sax tone (or trumpet, or whatever) with your keyboard, and then play up and down the scale, it does not sound like a sax or trumpet or whatever. Certain fixed frequency resonances are missing. The way a player begins and ends a note is missing. Many factors in what we identify with that sound are not present. So, there is more to a sound's identity than just its frequency.Ditto the string bass, only it is more pronounced. In fact, the fundamental of the lowest notes hardly resonate the body of the instrument, only the overtones.The bass saxophone was very popular in early recording... old 78's, the very early dance bands, on radio. You can hear the bass sax in the old black & white cartoon soundtracks, too. The early crude mics, record players, speakers (sometimes only a bamboo needle driving a diaphraghm, coupled to a horn)... the string bass or tuba could not be heard. However, the reedy sound of the bass sax came right on through, you could hear the bass line. Actually, the reedy tone was strong in the overtones...the listener heard the overtones and thought he was hearing the bass notes. You can listen and you know you are hearing a bass sax playing low notes. (I would be glad to send a short MP3 of a bass sax, and you can play with your Winamp's sliders to see what I mean.)So, my conclusion is that a perfectly flat frequency response does not necessarily make a great speaker. A few humpty-bumps in the response curve does not mean it is a bad speaker. The mind just adds these minor imperfections in with all the other resonances and holes and it just blend in with effect... the tone quality of a voice, instrument, whatever is

slightly altered, but not really in a way that sticks out... unless it is a huge hole, or a very sharp, very high resonance.HOWEVER, the way a sound begins and ends has a huge impact on how we perceive a sound. We identify direction by sharp, quick transients, a snapped twig, a pebble kicked, a bump. We understand words by the transients added by our articulation... this is what makes good diction easier to understand than mumbling.I had a friend in college, a trumpet player, she got consistent low marks in her end of semester juries for her "tone". Her trumpet teacher told her, "I have been listening to you, your basic tone is good, it is your attack and release that is sloppy." They worked on just those two factors, how she began and ended a note, for the entire next semester. And on her next jury, across the board, comments such as "Excellent! Tone much improved!"SO, in my opinion, what makes a good speaker is not necessarily how it handles frequency (flatness of response curve) but how it deals with sounds in time (precision, lack of overring, damping, etc). And for me, good horns do this very well... the way the couple the signal to the air, the impact, the quickness... makes them much more realistic sounding IF they are well designed, and reasonably smooth in response. I will give up a few hz on each end of the response curve, if what I have in the middle is precise, low distortion, quick.

Subject: Re: Sound and perception of sound
Posted by Wayne Parham on Fri, 13 Jul 2001 21:09:39 GMT
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Nice post! I wouldn't dream of deleting it. I agree with you, by the way, 100%. In addition to amplitude response, I think the impulse response is important, and I think a large dynamic range is important too. Another item that is rarely considered is uniform directivity, which is important in the prosound world for arrayability but in home hifi situations it is regularly disregarded. I would argue that in home it is even more important, because uniform directivity translates into a uniform reverberent field, which is one of the most important things for tonal balance.
