
Subject: Basshorns - Pros and Cons

Posted by [Wayne Parham](#) on Sat, 26 Aug 2006 16:28:05 GMT

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I've had a long-time infatuation with horns of all sizes. Tweeter horns and midrange horns don't have to be terribly big to work very well, so I've always used them. But bass horns have to be large, so they're usually size-prohibitive for home hifi use. Room corners help reduce size limits, and in fact, the corner all by itself is a horn with $DI=9$. Horns are devices that increase directivity, and a trihedral corner has the same directivity as a square pyramid-shaped conical horn with 70° flare. So corners can certainly be used to advantage below 300Hz or so. But the fact remains that basshorns have to be very large to be effective. A horn that's undersized becomes a sort of horn/transmission-line hybrid. That in and of itself isn't bad, and in fact, with the right tuning can be very good. But there's a difference in implementation that is significant. Transmission lines are damped to reduce unwanted standing-wave modes. They are designed to encourage some modes and attenuate others, using careful driver placement and damping. Horns, on the other hand, are usually made without damping and with the diaphragm at or near the apex of the horn. They are so-called wide-bandwidth resonators and so resonant modes aren't damped. The designer intends for the horn to load the diaphragm resistively, not reactively, so it is expected to act as if it weren't a resonator. But the undersized horn does act reactively at low frequencies. That's why I've characterized it as a horn/transmission-line hybrid. A horn decreases diaphragm motion in its passband, so distortion is reduced. It increases diaphragm load and that improves efficiency. Between increased efficiency and increased directivity, a horn amplifies sound volume in its passband. All that is good news. But when a basshorn is undersized, its loading decreases as frequency drops. Worse than that, it fluctuates loading instead of being uniform. This tends to create ripples in response. Another thing that can hurt performance of an undersized basshorn is using it below the horn's passband, in a direct radiator mode. This is tempting to do in order to increase bass extension. It may be a worthwhile compromise in some cases, but it should be noted that this mode increases distortion more than a direct-radiating front-loaded design. The reason is pretty simple - The horn amplifies harmonics, so it amplifies distortion. Fundamentals in direct-radiator mode are not amplified by the horn, but the harmonic distortion is. This can result in harmonic distortion that is actually louder than the fundamental. A well-executed basshorn provides high-output and low-distortion. If made large enough, it can provide deep response. Sometimes smaller horns can be used in groups to achieve the necessary size. But when a basshorn is used too low in frequency, it can actually sound worse than a direct radiator. It is good to look at the matter realistically when deciding what kind of bass system is best for any particular installation.

Subject: Re: Basshorns - Pros and Cons

Posted by [wunhuanglo](#) on Tue, 29 Aug 2006 08:18:57 GMT

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You hit the nail on the head with the phrase "particular installation". There's certainly a fun factor to a bass horn, but if you have to live with it in a domestic space the size / performance trade-off is a no-win for the horn. The thing that Bill Fitz always harps on in his articles is "look at the output in

the passband". That's all well and good in a club but the horns he builds are almost always best for kick drum on up - that 60-70 Hz region. For music reproduction you need good response at 40 Hz and that just makes it impractical listening at 10 or 12 feet away. Edgar has his fancy horn designs but he always has to have a sub for realistic reproduction. ALE horns go all the way down, but with a mouth at 5 feet X 5 feet they're pretty hard to accomodate in a ranch house. Every design I end up admiring looks like the 4Pi - which looks like Lansing's original Iconic - which looks like the JBL K-series speakers - which looks like every Westlake plus a heavy dose of steroids. For audio in a domestic environment it's simply the best way to go.

Subject: Re: Basshorns - Pros and Cons

Posted by [Wayne Parham](#) on Tue, 29 Aug 2006 15:47:48 GMT

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I'm with you on this. If you want to hit the really low notes, it's hard to properly implement a horn. There are ways to do it, but they all result in a pretty large package. Using a transmission line or tapered pipe is a worthy compromise. But so is a bandpass system, bass-reflex or sealed sub. There are always tradeoffs with any design. Don't get me wrong, I love horns. And I've made some really great basshorns that I'm proud of. But the problems that present themselves when designing a basshorn are challenging. Seems like people tend to want to ignore some of the facts about horn loading when it comes to basshorns. This is true especially when they want to make their basshorns portable. The easier a speaker is to carry, the more popular it will be, especially if you can push the idea that it works as well as a real horn of adequate dimensions. Fitzmaurice's basshorn designs are usually pleasantly small and easy to carry. But they also tend to suffer in terms of quality, having response curves with lots of peaks and dips. Further, his designs depend on the woofer as a direct radiator for the lowest frequencies. In my opinion, the way they're tuned pushes the driver way too hard, way beyond its mechanical limits. The rear chamber is large and Fitzmaurice generally suggests light-cone, low-excursion drivers. That approach is acceptable for a light-duty system, but I wouldn't suggest it for high-power basshorns. His approach makes a couple very unattractive things happen. One is driver over-excursion. I expect that's probably the main failure mode in Fitzmaurice designs. The other is distortion. Since he often suggests that his basshorns be used well below the frequency where the horn is useful, it basically becomes a direct radiator in a large box. So driver excursion goes way up, distortion skyrockets and the harmonics produced are amplified by the horn. In a design like this, distortion is louder than the fundamental for a good deal of its range. It would be interesting to see distortion measurements of Fitzmaurice designs, but he doesn't have any good measurements of his horns, just graphs made using primitive sound meters. I've also seen the opposite argument made just as forcefully. Tom Danley was on a crusade pushing low-fs drivers a while back on Audio Asylum. I think his basic deal was that his Servodrives had high-mass drivers because of the fact the motors were pushing belts and pulleys in addition to cones. So he was forced into finding horn solutions that worked with high-mass drivers. Of course, on a bass system, mass isn't your enemy like it is on higher-frequency drivers. So he was able to design with it pretty successfully, and when using linear motor drivers, he tends to choose drivers with similar specs. Danley pushes the idea that basshorns should have high-mass, low fs and loose suspensions. His opinion is that the rear chamber volume should be used as the main suspension force and that the driver's mechanical suspension should therefore be loose. Danley suggests that the driver's suspension isn't

uniformly compliant, and that's why he likes using the rear chamber volume as the main suspension instead. But to tell the truth, I don't think acoustic suspension is the real reason Danley likes this tuning method. I think Danley likes high-mass drivers because that's what the Servodrive motors have, and it is what he is comfortable with. All of Danley's newer designs tend towards this same approach, with a twist like using boundary reinforcement to augment mouth area or making a tapered quarter-wave pipe having similar proportions and characteristics. Edgar is a different breed, since he doesn't ask as much of his basshorns. He doesn't ever expect them to see more than a handful of watts, so excursion is never a problem. He tends towards the same idea as Fitzmaurice, which is to use a light cone and to push the driver well below horn cutoff, using EQ to extend bass response. In Edgar's case, this is an acceptable compromise since the horn will never be pushed very hard. But I do wonder what kinds of distortion are generated by his basshorn designs. I don't think I've ever seen distortion measurements of an Edgar basshorn. Edgar tends to use high quality drivers, so that helps a lot. I've always liked Edgar's choice of drivers. But his choice to increase output below horn cutoff with EQ is something that even the best driver can't help. Shorting rings are ineffective below 100Hz. So distortion must rise pretty steeply at subwoofer frequencies in his basshorn sub design. When a basshorn is used below cutoff, the harmonic distortion is amplified by the horn but the fundamental isn't. So distortion may be louder than the signal sent to the driver. For all these reasons, I've generally preferred direct radiating subs. A good horn sub can be made, but it must be large. And I think it wise to employ other distortion reduction mechanisms like push-pull drive. That's how I've made basshorns that worked well, using a combination of each of these things. My thinking is this: If a basshorn is going to be a compromise, why build the basshorn at all?

Subject: Re: Basshorns - Pros and Cons
Posted by [j.luis cruz](#) . on Wed, 30 Aug 2006 22:51:57 GMT
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Hy Wayne ..where the human ear is more sensitive to detect distorsion in the high frecuencies , in the mid-range-bass frecuencies or in the sub frecuencies . thanks

Subject: Re: Basshorns - Pros and Cons
Posted by [Wayne Parham](#) on Thu, 31 Aug 2006 00:05:26 GMT
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Our ears are most sensitive to the upper midrange, as is shown by the Fletcher-Munson curve. This is also called an "equal loudness" curve, in that it graphically illustrates what frequency/energy levels sound equally loud. Any spot on a given frequency curve should sound equally loud as a 1000 Hz tone of a given SPL. The thing is, distortion at bass frequencies manifests itself as harmonic components in the midbass and midrange. That's why bass distortion is so noticeable. Look at the Fletcher-Munson curve above and you'll see that it falls rapidly below 100Hz, indicating that our ears become more sensitive to sounds as frequency rises

from the deepest bass range. Harmonics above about 100Hz are troublesome, and these are generated as second-harmonic distortion from fundamentals above 50Hz and/or third-harmonic distortion from 33Hz signals and above. So you can see that bass systems aren't exempt from the requirement that low distortion be needed for good quality sound.

Subject: Re: Basshorns - Pros and Cons
Posted by [DMoore](#) on Fri, 02 Feb 2007 00:59:52 GMT
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I think the one thing to consider between the above mentioned horn designers is that either they are into designing specifically for the PA market where portability is the major concern, or the Hi-Fi (domestic) market where perhaps appearance is the main concern with a built-in footprint size constraint, but generally speaking, not both. There are very few "crossover" designs that I can see. It makes sense that they also tend to stick with what they know and what they know works for their particular application. I watch all of the horn designers/manufacturers as to their general practices and especially what they are doing within their targeted niche to give their design an edge compared to the competition. It seems that the design goals for PA are actually quite different than the goals of Hi-Fi. For now, I'll throw HT into the Hi-Fi group. One thing I derived from reading about PWK is that he tended to stay with what worked - he didn't tend to take risks, developed some preferred characteristics and used them repeatedly, so his designs seem related to each other even at a cursory glance. I also like the fact that he tended to publish and in those patents and AES papers, he attempted to teach others about what he was doing and why - anyway, I don't regard it as mere advertising, too much usable information for that IMO. I suppose it lent credibility to his designs, but since the particular designs were being sold, the actual proof was in the performance that anyone could hear. So with that in mind, I find I also like Edgar, for the same reasons. He is pretty conservative in his designs, too. The interesting thing is that Klipsch is heading for the HT market with their horns. Halfway between PA and Hi-Fi, I think that is the future of the horn market, too. That's not to say that the PA market is going to go away, but it probably won't grow for horns either. The dedicated home theatre room is one place where perhaps a large speaker footprint IS not only acceptable, but even expected, or even actually DESIRED! We can only hope...DM

Subject: Re: Basshorns - Pros and Cons
Posted by [Wayne Parham](#) on Fri, 02 Feb 2007 02:03:42 GMT
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I agree with you about Paul Klipsch. He seemed to go out of his way to educate people, much more than marketing. My take on using undersized basshorns for PA is that it is a dubious compromise. I mean, on one hand, if you use several of them, it's a reasonable compromise. But then again, if you're going to compromise, why even go to the complexity of using a horn? A direct radiator subwoofer is exceptionally flat and easy to use. I think bass-reflex subwoofers get

maligned too much by us "horn guys." I've measured some pretty bad basshorns. Some of them have become pretty popular with enthusiasts that boast proudly about their one note wonders. I guess it's builders pride. Then again, like I said, when you get enough of them going, they smooth out a bit. Funny to watch a guy use two of them though. Yuck! The thing that intrigues me is the hybrids. The transmission lines with additional resonators for higher mode reactance annulling. I think that's a pretty good idea, a way to make a horn with a small footprint. Whatever label you put on them, transmission lines, horns, hybrids, half horns, stubs, resonating lines, tapped horns - the idea still has merit. Use the rear chamber for annulling the reactance of the first standing wave node, and then use additional resonators to annul the higher wave nodes. That's a clever approach. Aaah, but then again, if you have the room for a full size basshorn...

Subject: Re: Basshorns - Pros and Cons
Posted by [DMoore](#) on Fri, 02 Feb 2007 18:11:29 GMT
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This link is from the Klipsch forum and was posted by ELENA from Italy, who saw a similarity with one of my front-loaded annulled designs. His design (which we will call the ELENA horn) is a front-loaded reflex-ported corner horn of short length. Here is his paper in pdf format on the subject. Since the reflex porting eliminates the possibility of annulling the driver, he has come up with a unique approach which uses tuned cavity filters along the horn pathway to reduce the reactance peaks and tuned ports along the channels to increase the response in the troughs caused by the short pathway and unannulled driver. The back chamber is also ported to the front of the cabinet. It's well worth investigating. DM
ELENA horn pdf document

Subject: Re: Basshorns - Pros and Cons
Posted by [DMoore](#) on Fri, 02 Feb 2007 18:17:52 GMT
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Here is the link to his plan he posted for the ELENA horn. It is a top-view cross-section in axially mirrored form, so it needs only be shown on one side of the axis, in other words, and that's what you see in the plan. DM
ELENA cross-section plan view

Subject: Re: Basshorns - Pros and Cons
Posted by [elena](#) on Sun, 04 Feb 2007 06:07:31 GMT
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Hi, I'm ELENA. I've got this link from Dana Moore. I see your intriguing for the hydrids, I can share my small experience in making small footprint bass-horn. I went the way you tell for annulling the stationary/standing waves within the horn, but I don't have a clear idea of how to substantiate, I mean to measure what I made. You say you measured bass-horn, would you give me advise what is the way to go and measure effectiveness of the cure? To determine el. resonances or el. transient response by oscilloscope could be good? This could be in my power, acoustic measurement would be beyond my reach.

Subject: Re: Basshorns - Pros and Cons
Posted by [Wayne Parham](#) on Sun, 04 Feb 2007 17:42:35 GMT
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I've seen your idea, and I think there's merit in your approach. Please do elaborate here though, because I think it is interesting for everyone that reads this forum. The easiest way I can think of to measure the effects of your resonators is to run an impedance sweep. That's not difficult at all. I would definitely suggest to do frequency response measurements too. You might want to download Speaker Workshop. It will do both an impedance chart and measure acoustic amplitude response, so it will be very useful for you and it's free to download.

Subject: Re: Basshorns - Pros and Cons
Posted by [DMoore](#) on Mon, 05 Feb 2007 23:27:42 GMT
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Speaking of the reduction of reactance peaking in rear-loaded horns, here is another example, although not as elegant in implementation as the ELENA, is the 1956 Glenn (General Electric) patent for a rear-loaded short-path-length folded horn this time with a purposely too-small mouth size for the Fc, US patent# 2,765,864. Dana

Subject: Re: Basshorns - Pros and Cons
Posted by [elena](#) on Tue, 06 Feb 2007 13:01:36 GMT
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Hi, thanks for replying. Actually I'm abroad, as I'll be back home I'll start elaborating. The .pdf document is totally missing the [twin] reflex operation above the cutoff of the horn, I'll give a practical perspective of the system, and all formulae sufficient to calculate and build a system. I feel we together may pursue this way further and get an even better result, for instance employing a hyperbolic horn at the throat and a tractrix at the mouth, along the line of the "rubber throat" of the Klipsch design. This case the resonance frequency should be more better determined by

empirical method, rather than from the theory, as a closed form to solve the integral of the formula could be missing. Beyond the theory, there's the practice, so it's time to take the drawings, build the cabinet and test the system. We must not forget that the cabinet lodges a 55 Hz horn, with a optimum mouth on the eighth space, and due to reactance annulling and front reflex porting capable to go down to 30 Hz, as the [twin] reflex operates with a tuning frequency which coincides with the free-air woofer frequency, that is 29 Hz (half the cutoff of the horn). Even without porting along the horn pathway, the system would be worth making. This is what I am willing to embark on, a 2.nd system with the hyperbolic horn to be the testbed of the approach. It is clear that this is a home system, as the PA and sound reinforcement don't need such an arrangement to best the performance. But for your home it could help to balance room availability and performance, reducing space requirement without affecting the transient ringing in the low bass band.

Subject: Re: Basshorns - Pros and Cons
Posted by [elena](#) on Mon, 12 Feb 2007 15:30:37 GMT
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Patent 4549631 of BOSE Corp. may be helpful to illustrate operation of multiple porting loudspeaker, what I call twin reflex. It is clear from the patent document that, in case of equal frequencies porting tune, emissions cancel out each other, that is the practical principle of the horn reflex porting, by far forward and reflex waves damp out each other. This would achieve better than a pure Helmholtz's resonator operation does, in effect I forecast the use of both of them, but in my practical prototype I employed the reflex principle solely (the cut-away view of the system clarifies that, the top elevation view is somewhat misleading, find out the pictures at the Klipsch forum link posted by D-MAN). The reflex technique is a feed-forward open loop, far better than a feedback closed-loop like an Helmholtz's resonator. I shall explain better if anyone is interested. On the other hand, below the cutoff the half frequency reflex porting -in the system the woofer resonance is at 29 Hz and the cutoff at 55 Hz- ensures good operation, according to the design criteria of a twin reflex system. By the way, I am seeking for an oscilloscope on e-bay Italy, I hope to satisfy the commitment to myself to finally test it and ... cheer up, we have got something good! Good vibrations ELENA
