Subject: ?Horn Questions?
Posted by Cuppa Joe on Thu, 08 Feb 2007 03:53:38 GMT
View Forum Message <> Reply to Message

I'd like to pose and discuss a number of questions (over time) concerning horn design and theory, if it's OK with the forum. My math background isn't very strong, so I'll need the "Dick & Jane" versions of Olsen & Beranak. I'd also like to develop a few design ideas, which would be shared for review (and possible entertainment). I'll start with something that seems simple to me:With respect to a rectangular horn mouth, is there a ratio of width vs. height after which the horn's performance begins to suffer noticeably? I'm thinking conical midbass, here.

Subject: Pattern control and mouth size
Posted by Wayne Parham on Thu, 08 Feb 2007 15:16:10 GMT
View Forum Message <> Reply to Message

Mouth size sets the lower limits of pattern control. At frequencies where the horn is large compared to wavelength, the horn walls act as boundaries and set the pattern. But when the wavelength is no longer small compared to mouth size, it begins to act as a diffraction slot. The wall angle is no longer important, instead, the wave launch is that of single slit diffraction.Assuming a constant flare angle, the frequency where pattern control is no longer set by wall angle is determined by mouth size. If the mouth is axisymmetric, then the frequency where this happens is the same in the vertical and horizontal plane. If, on the other hand, the horn is wider than tall, then the horn will act as a diffraction slot that widens the flare in the vertical plane before it begins to do this in the horizontal plane.
Pattern from single slit diffraction

Subject: Re: ?Horn Questions?
Posted by DMoore on Fri, 09 Feb 2007 00:02:07 GMT
View Forum Message <> Reply to Message

PWK gave the only reference I have ever found concerning the proportions of a rectangular horn mouth in one of his patents (try the 1945 Khorn patent) as being between 1/6th and 1/11th Fc wavelength in its longest dimension.DM

Subject: Re: Pattern control and mouth size
Posted by Cuppa Joe on Fri, 09 Feb 2007 01:37:32 GMT
View Forum Message <> Reply to Message

Then, a chosen height vs. width ratio is mostly determined by how much diffraction I'm willing to tolerate in the smallest mouth dimension? Intuition told me that a perfectly square or round mouth would be ideal, so I concluded that rectangular (or elliptical) mouth shapes would begin to introduce compromises in one plane or the other.

Subject: Re: ?Horn Questions?
Posted by Cuppa Joe on Fri, 09 Feb 2007 01:44:14 GMT
View Forum Message <> Reply to Message

I get the impression that almost any common-sense ratio could work, as long as it's not too extreme.

Subject: Re: Pattern control and mouth size
Posted by Wayne Parham on Fri, 09 Feb 2007 03:44:57 GMT
View Forum Message <> Reply to Message

If the low cutoff is above the point where the horn loses pattern control due to its shortest dimension, then there is no penalty. If pattern control is lost, it widens. The pattern from a diffraction slit isn't actually purely radial, but it's close. There are a few nodes that appear off to the sides, in some cases.Look at the two radiation patterns below.See how the one on the left makes a radial pattern and the one on the right makes more of a focused beam? That's because the one on the left is what results when wavelength is large compared with the width of the slot. This is what happens at low frequency, when the horn mouth is much too small. In that case, the flare wall angle does nothing, and the mouth acts as a diffraction slot. The one on the right is closer to the transition frequency, where the horn still directs the radiation angle. As the horn transitions from being large enough to control the pattern and too small so that the mouth acts as a diffraction slot, you'll see the pattern below. Notice that there are nodes of energy separated by nulls in between.You can see how the pattern changes with respect to wavelength in the applet below:
Single slit diffraction applet

Subject: Re: Pattern control and mouth size
Posted by Cuppa Joe on Fri, 09 Feb 2007 05:50:44 GMT
View Forum Message <> Reply to Message

The diffraction applet matched my intuitive concept of how the throat might work (just add horn walls), but I failed to consider that the horn mouth itself could act somewhat like a very large

throat! I have a new perspective now.Could the vertical diffraction effect from a rectangular mouth (narrow height compared to lower cutoff) create obvious comb-filtering problems in a vertical line array of like horns? Would anyone really notice, even if they danced the "Pogo"?

Subject: Re: Pattern control and mouth size
Posted by Wayne Parham on Fri, 09 Feb 2007 06:52:51 GMT
View Forum Message <> Reply to Message

Arraying horns, or any sound source for that matter, presents potential combing issues. If sound

interact with sometimes positive interference and sometimes negative interference, depending on their respective positions, distances and phase relationships. Their size and shape matters too, since a sound source that is small radiates a different pattern than one that is large. When several sound sources interact, their pattern begins to act like multiple slit diffraction, which makes interference patterns in addition to the nulls you saw from single slit "sidebands". Look up double-slit diffraction to see more information about how that works.Again, all horns that are

single sound source and will act something like double-slit interference. If the horns are axisymmetrical, then they will behave the same in the vertical and horizontal planes. If not, they will act differently in each plane. That may or may not make arraying more difficult, depensing on what kind of array you need and what frequencies are required.Usually, a sound engineer strives for single sound source summing. But that is not always the case. In some cases, it is desirable to have dense interference, in order to smooth the sound field. For example, if sound sources (or

way to correct for that is to add sound sources that increase energy in nulls formed by interaction betwen other sound sources. Ironically, multiple sound sources spaced apart cause nulls to form, but adding a few more can average the sound field. This is called dense interference and it is a very useful technique.
Horn Arrays

Subject: Re: Pattern control and mouth size
Posted by Cuppa Joe on Sat, 10 Feb 2007 02:26:19 GMT
View Forum Message <> Reply to Message

Just for clarification, does the 1/4 WL distance refer to the center-to-center spacing of the horn mouths? I wasn't completely clear about that aspect of the Pat Brown article. I've skimmed that article before and I have it bookmarked for future reference. Very depressing! The 1/4 WL restriction for proper coupling is difficult to achieve without violating some patent or copyright (Danley's unity horns, etc.). The "dense interference" technique is my weapon of choice for the vertical HF section in one of my design ideas. Whatever happened to the more relaxed, full-wavelength coupling criteria of the V-DOSC? Does it only apply to direct radiators arranged

and spaced a la Christian Heil? Back then, the thinking seemed to be that direct radiators were meant for coupling and horns were meant for segregation when coupling was no longer feasible.

Subject: Re: Pattern control and mouth size
Posted by Wayne Parham on Sat, 10 Feb 2007 03:54:34 GMT
View Forum Message <> Reply to Message

Most things with wave interactions aren't firm "brick wall" things, but are more fluid than that.

that is essentially a double-slit interference issue and there are single-slit issues too. So it really depends a lot on the size and shape of the horn in relation to wavelength, in addition to the spacing between horns.As for patent infringement, I don't mean to be disrespectful but the Unity horn is not unique in design principle at all. It is multi-driver horn arrangement with drivers offset down the throat, intended to sum properly within the horn, approximating physical offset with electrical phase. There are other implementations of this design approach that preceded the Unity, however, the patent office apparently found some aspects of Danley's implementation to be unique enough to grant a patent on it.This does not mean that any loudspeaker that limits spacing

speakers have this as their goal. I think the Unity patent covers the specific implemention of placing midranges and woofers staggered down the horn wall with a crossover that attempts to stagger phase to match the physical offset. It doesn't cover coaxial horns, not tight pack arrays, not speakers with crossovers designed to provide proper summing, not horn speakers with drivers offset from the apex of the horn.I'm not entirely clear what arguments were made to set apart the Unity from the earlier Renkus-Heinz CoEntrant design that preceded it. It's not something I've been interested in. But I want to reassure you that you can find many ways of building a speaker that keeps spacing to a minimum without infringing on the Unity patent.

Subject: Re: Pattern control and mouth size
Posted by Cuppa Joe on Sun, 11 Feb 2007 05:33:48 GMT
View Forum Message <> Reply to Message

Oh yeah, I do remember the Renkus-Heinz CoEntrant, and how it fascinated me at the time! It reminds me of a design I encountered at www.burton-manor.co.uk/Audio/HLCA.htm. Fun and interesting stuff!Even the 1/3 WL spacing center-to-center is a tall order given the mouth sizes of most midbass/midrange horns with a single driver (assuming they're being tightly arrayed). With baffle-mounted cones in a vertical array, I'd need a stack of differing diameters to cover the ranges up to the typical 1" horn/driver combo. This challenges one of my goals for each design: a 3-way active system (triamp with active x-over/processing). As my design ideas are aimed toward live sound reinforcement, I will likely see how often and to what extent I can "cheat" the C-to-C coupling guidelines, with as little compromise to sound quality as possible. In many live

applications, the listeners are farther away from the audio source than with a home system, meaning more room to squirm for the live audio designer!

Subject: Re: Pattern control and mouth size
Posted by Wayne Parham on Sun, 11 Feb 2007 19:40:40 GMT
View Forum Message <> Reply to Message

I don't think center-to-center spacing will be as much an issue when splayed, either vertically or horizontally. In the range where each of the horns have pattern control, overlapping fields would be more of an issue. The tight pack array, for example, has drivers physically close, with the apex of adjacent horns right next to one another. The wall angles are splayed, and adjacent walls nearly touch. This makes the pair of horns act similarly to a single radial sectional horn.In the case of crossover between horns that cover different bands, the region of interest is the overlap

two sources will act as a single sound source.In any event, if sound sources are too numerous to allow for tight pack spacing, then the next choice is dense interference. There are merits in this

that result from reflections in the environment.
