Posted by rkeman on Thu, 08 Nov 2012 20:21:10 GMT
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Has there ever been any interest in expanding on the 6Pi or 7Pi by incorporating a folded horn woofer to complement the horn loaded midrange and tweeter? The low end would probably be less extended than the current designs, but the sensitivity would rise and distortion fall.

Posted by Wayne Parham on Thu, 08 Nov 2012 21:45:27 GMT
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I did consider making the bass bin of my constant directivity cornerhorns using a folded horn, like

approach. These considerations are described in some detail in various documents in the FAQ.

It is important to understand that the bass bin of a constant directivity cornerhorn is designed to be a large midbass horn, formed by the expansion of the walls from the corner. It is sort of an extension of the midhorn, designed to provide loading down to the Schroeder frequency or so. Below that, I'm not concerned with what the system does, because we use multisubs for that range, to get modal smoothing and extension. In the modal range, the woofers in constant directivity cornerhorns provide sound sources in the corners, and other locations of deep bass sound sources should be used to augment them and provide modal smoothing using the now well understood multisub approach.

I'm a fan of full-size folded basshorns where maximum acoustic power is required below 100Hz. But I wouldn't want a folded horn in the midbass and lower midrange. Once you get up above 100Hz, you really want a straight horn, for best quality. This is even more true where constant directivity is desired as the frequencies transition into the statistical range, above about 150Hz or 200Hz. So no matter what you do for bass - folded horns or direct radiators - you want a midhorn that is a straight conical horn.

Conical horns are the best shape waveguides for sources that radiate a spherical wavefront. This is the case for cone drivers at low frequencies, where cone size is much smaller than a wavelength. Even though cone movement is pistonic, the radiation produced closely approximates a spherical wavefront because the piston is so small acoustically. A conical horn

cornerhorn is perfect for midbass and lower midrange, spanning the range from the upper modal region through the transition region and into the lowest part of the reverberent (statistical) region, where it tapers off.

The flare profile of the bass bin of a constant directivity cornerhorn is similar to its midhorn, actually, both providing uniform 90° horizontal beamwidth. It would remain constant down to very low frequency if it weren't for room modes. But in large enough rooms, modes don't come into play until the lowest frequencies. It's a pretty amazing configuration, really, the only one I know of that provides constant directivity all the way down into the bass range.

Sensitivity can be modified by changing the compression ratio, making the woofer radiate through a hole that is smaller than its cone area. But after a lot of experimentation, I found I like the 1:1 ratio best, because higher compression tends to make the response increasingly lumpy. That may be a moot point, considering room modes make response lumpy too. But it is a fact, nonetheless, and it's why I choose 1:1 for the bass bins.

So don't make the mistake of thinking the bass bin of a constant directivity cornerhorn is somehow not a horn. It absolutely is a horn, a conical horn formed by the expansion of the walls from the corner. In fact, I think it's the best horn possible for this application, and I would not choose another profile even if the expansion from a corner weren't so convenient.

Now let's look at distortion. There are a few techniques that can be employed, some that work universally and others that are frequency dependant.

Horn loading works well at reducing distortion because it reduces diaphragm motion. Conical horns provide a decent acoustic impedance only at midrange and upper frequencies. Exponential and hyperbolic horns are better at loading down low. So for the best basshorns, you want an exponential or hyperbolic flare. Of course, that plus the fact that they're folded, prevents them from being constant directivity, but at such low frequencies, the directivity is really more dependent on their environment anyway, e.g proximity to boundaries or position in an array of other basshorns. This sort of draws us back into the folded basshorn versus straight conical waveguide analysis, but the point is that horn loading is good for distortion reduction provided the flare profile is right for the frequency range chosen. The bass bin of the constant directivity cornerhorn provides acoustic loading in the midbass and midrange frequencies, reducing distorton and providing constant directivity. But in the modal range, it does not.

A couple other techniques provide distortion reduction. One is shorting rings in the motor structure, and another is push-pull drive. Either (or both) of these can be used in addition to horn loading to decrease distortion even further. Shorting rings are like a transformer winding in the motor, so they only work at midbass frequencies and higher. A properly sized shorting ring placed in the right place in the magnet can provide distortion reduction as much as horn loading, around 15dB, from 100Hz and higher. But below 100Hz, they tend to lose effectiveness and by 50Hz, they don't do really anything. Push-pull drive requires coupling, which is highest at low frequencies. So it's just the opposite of shorting rings, meaning it does the most at very low frequencies, and in most cases, is ineffective above about 100Hz or so, depending on the geometry (locations) of the drive units with respect to one another.

So to me, the absolute best approach is to load the bass bin of a constant directivity cornerhorn with a woofer that has shorting rings. The improved motor assembly provides low-distortion performance above 100Hz, and the conical horn formed by the trihedral corner provides acoustic loading that further reduces distorton in this region.

At the lowest frequencies, a folded hornsub with push-pull drive is best. Of course, indoors, our biggest problem is room modes, so it is more important that we have several sound sources than

to smooth room modes, for example. You can run an outdoor concert with those hornsubs running full tilt, and expect single digit distortion. Not needed in a home theater or hifi setup.

A few direct radiators are probably more than adequate for the job since they will see so little power, compared to an outdoor concert. The fact that there are multiple woofers means each can be driven less hard, which is another way to reduce excursion. So I think it is probably more than adequate, and relatively unobtrusive, to use four direct radiating subs of moderate size distributed around the room in a multisub configuration.

One could perhaps opt for another approach, which is to build direct radiating subs with push-pull drive, slot loaded to keep 'em close enough together for good coupling. This may be a good compromise that doesn't require the size of those massive hornsubs, but still gives you push-pull drive.

One last thing, on the matter of hornsub distortion. If low distortion is really important to you (and not just a talking point) then do not consider a truncated hornsub or a tapped horn. Both create much more distortion than a true full-size basshorn. In fact, tapped horns generate as much distortion as direct radiators, sometimes even more, and it is in a frequency range where it is most noticeable, at the very top edge of their passbands. They make these huge distortion spikes that make a sort of grunting sound. I think some tapped horn owners actually like this distortion. Truncated (undersized) basshorns have roller coaster response in addition to mediocre distortion performance. Distortion is not particularly good in a truncated basshorn, and in fact, is particularly bad at the lower end of their range, near cutoff. So if distortion is really important to you, do not consider those approaches. Some might argue whether it is audible or not, but that is a different argument.