Posted by Wayne Parham on Thu, 23 Jun 2011 22:21:53 GMT
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LABhorn was initially designed as a DIY horn for prosound use with an intended passband of 30Hz to 100Hz. But as with many other things, someone proposed using it for home theater, and using EQ to boost the deepest bass to match the passband level. I responded to that saying I thought it was a really bad idea, because distortion would be through the roof. This cascaded into a fairly heated discussion about hornsub power, distortion and general bravado.

My position was that a horn tuned for 30Hz should probably only be used down to 30Hz, and that even at relatively low power levels, a 20Hz signal presented to it would create triple digit distortion. Then add to that the fact that they were going to boost the band below 30hz by 10dB+, it seemed to me to be an ugly proposition. I mean, I am a horn enthusiast, but this just wasn't a good idea to me. I even understand the spectacle of huge basshorns, how cool that is and all. I like big powerful motors and fast cars and motorcycles, all that good "guy" stuff. So I get the cool factor of basshorns in the man cave. But still, my position was that direct radiating subs tuned appropriately for the band, like reflex boxes tuned to 20Hz, would be better. I had begun to study and implement the Welti multisub approach around the same time, so I felt the best approach was multiple direct radiating subs, per Welti.

The LABhorn proponents were fairly zealous, and I equally so. Neither side really relented. They said the basshorn was so powerful, that at home theater levels it would be loafing. I said that at 5 watts of passband power, the (10dB+) EQ below 30Hz would bump that range up to 50 watts, making distortion rise to the triple digits, over 100%. They said I was just a naysayer, and I should be tarred and feathered. Then they asked me a key question, which was "what would you do?"

I had already told them what I would do in a home theater, which was multiple direct radiating subs, bass-reflex probably. Each box wouldn't have the output of a hornsub, but it would be more than adequate for the environment. They would be tuned appropriately for the passband, so distortion wouldn't be bad at moderate power levels. And of course, each box is much smaller than a hornsub, easy to place and quite good for a multisub configuration.

But then the question was rephrased, and I was asked, "what would you do to improve the LABhorn?"

At first, I disregarded the question, knowing it was rhetorical. It was just another argumentative forum post from a LABhorn lover.

As days passed, though, I realized that I could actually answer this question with a new design

There were three areas I was focused on. First was the lumpy response when used in singles or even small groups. I've designed a lot of horns, and I knew I could reduce the big dip the LABhorn had just above cutoff with careful front and rear chamber size, and possibly by making the mouth just a little larger. Second was to use push-pull drive to reduce the distortion at very low frequencies. And third was to improve cooling. The LABhorn suffered from thermal stress, but the common conception was that failures were excursion related. I knew I could make the drivers more robust by improving their cooling.

The LABhorn guys saw this effort as an attack, and the adversarial posture of the two "sides" widened even further. Pity, because there is so much overlapping development. I actually made the cooling plugs so they would fit the LABhorn, making easy retrofit possible. I initially had planned to use an entirely different layout, but by maintaining some of the same basic shape, it allowed cross-fitting of parts.

Changing the response to make it a little smoother was relatively easy. Hornresp is a mature program, and allows easy development of basshorns. You can expect acoustic measurements of your physical model to match the Hornresp model's predictions. So I was able to sim up an improved design within a short period of time.

The push-pull drive was kind of a no-brainer too. The LABhorn used two drivers, so it seemed natural for me that they be configured in push-pull. My thoughts were that passband distortion levels of a good basshorn were already very low, but push-pull couldn't hurt. Might shave a little more distortion. Down near cutoff, where the horn starts becoming more reactive and can't load the cone as well, I thought it might help even more. And below cutoff, where distortion skyrockets, I thought push-pull might keep distortion in check. There's not a lot of VLF content in a prosound event that would cause this distortion, where it might occur, high-pass filtering is probably wise. But whatever might be down there, push-pull will reduce distortion. So if someone just has to run a basshorn below cutoff, this is the one to do it with.

The cooling system was where I put the most effort. At first, I was under the impression, like many other people, that the best way to remove the heat was with forced-air convection. My assumption was that the air in the sealed rear chambers was getting hot, causing the cooling vents to lose effectiveness. So my first efforts involved ducting the vent to a heat exchanger to remove heat from the box. My biggest design problem for that first system was to introduce unidirectional flow so I could have a hot side and a cool side, but to do it in a way that didn't create an asymmetrical load on the cone. Couldn't valve it in a way that caused any pressure differential on alternating half cycles, or in fact, anywhere in the cycle. The acoustic load of whatever ducting arrangement I might create had to be perfectly uniform at all frequencies and all displacements.

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In truth, that was the easy part. I was able to make a "valve" that succeed in introducing unidirectional flow without causing any pressure difference in any part of the cycle. It used two orifices, each allowing laminar flow through it in one direction but causing turbulence in the other direction. One orifice was oriented to flow one way, the other allowed flow in the other direction. This made unidirectional flow without any change of pressure at any part of the cycle.

So that part was done, but the problem was that the air flowing through the vents wasn't all that hot. There was no energy to remove. The bursts of air were strong, so it isn't as though the air passing through the gap was too slow. That's really the key to forced air convection cooling - airflow. And the driver has plenty of that, of course, assuming excursion isn't limited by the acoustic load. But when the driver is moving, the venting is working well, and there just isn't a lot of heat to remove.

But what was hot was the pole piece. It would get hot enough to cook on during my tests. Before I gave up on it though, I tried putting the speaker in different ambient air temperatures, to simulate the heating of the air in a small rear chamber and also going the other way, refrigerated air just to see what effect there was. Nothing. The range of ambient temperatures matters if it changes by hundreds of degrees (as I later discovered), but not if only by a couple dozen.

So that's when I focused on that super-hot pole piece. I decided to make a plug that would contact the pole piece and wick heat away. I put holes in the plug so it wouldn't restrict the cooling air vent. The improvement was striking. I tested this extensively, going through a few drivers in the process, to find out exactly what the limits were, both on the bench and in a loudspeaker system. I eventually patented this system, because it worked so well.

What happens is the voice coil magnetism creates eddy currents in the steel pole pieces, which cause direct heating. It also radiates heat into the magnet structure and some heat is transferred by convection too. The motor core, its ceramic magnet and pole pieces being a thermally insulating material surrounding a metal core, form the perfect heat storage device, just like a Thermos bottle. Even if the voice coil is being cooled from cone motion, the motor core temperature will still rise to temperatures approaching the boiling point. This makes the local ambient temperature surrounding the voice coil be very high, shifting its operating point. The situation is made even worse when the driver is used in cabinets that limit excursion, like basshorns.

In the end, the cooling plug approach proved very effective. It is fairly simple to manufacture and

access panels. The panels then serve dual purpose, being both a way to access the drivers and also as a heat sink. Tests have shown that it increases power handling over 225%, making the