Subject: Woofer directivity
Posted by Pan on Sun, 13 Jul 2008 20:12:25 GMT
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Hello everyone,All the talk about matching directivity of a woofer and horn makes me wonder. How do you know the directivity of a woofer? Is is purely empirical or is there a formula based on size? Is there any way to know what frequency a 12" or 15" woofer has beamwidth of 90 degrees?Pan

Subject: Re: Woofer directivity
Posted by Wayne Parham on Sun, 13 Jul 2008 23:58:37 GMT
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There is a formula to find the directivity of a direct radiating woofer but understand that it is just an approximation. You can expect a rigid flat piston radiator to generate a 90° pattern (-6dB) at the frequency where diameter equals wavelength. Chapter 3 of the JBL Sound System Design Manual has a few polar plots of direct raditors that illustrates this. It's a nice little reference guide for sound system installs too.The reason this formula is an approximation is the woofer isn't a rigid piston. Not only is the surface not flat, but ripples appear across the surface at midrange and higher frequencies. So directivity is more complex than a single formula can describe. The cone shape (including dust cap) modifies directivity, and cone flex modifies directivity at high frequencies too.Regardless, the approximation is useful to expect 90° radiating angle where diameter equals wavelength. This is radiating diameter, not advertised diameter, by the way. The radiating diameter is the moving part of the cone, and it is generally approximated as being the midpoint of the surround.I've noticed a few of the new DI-matching converts forget that if summing is constructive, horizontal directivity merges. Provided on-axis summing is good, it remains coherent to very wide horizontal angles, usually close to 150°-180° which is almost double the useful pattern of a 90° horn. In other words, the sound source with the widest radiation pattern sets the overall pattern. Say one is collapsing and the other is slightly wider. Summing is constructive horizontally off-axis so nulls don't form. The woofer and tweeter add together where both have strong patterns, and at larger angles where one may start to falloff, the one with slightly higher directivity works alone. This tends to soften the edge of the coverage pattern in the horizontal plane through the crossover overlap band.This fact gives you some wiggle room in the crossover point. You're not nearly so concerned about matching the horizontal pattern exactly as you are other things. It is enough to match the horizontal angle approximately, and there is about an octave wide range where they'll be close enough to give very uniform polar response.It is also important when selecting the crossover point to consider the null angle in the vertical plane. I like to set it just outside the vertical angle of the HF horn at high frequencies. This matches directivity in the vertical as well as the horizontal. Vertical directivity is much harder to get right than horizontal, so my suggestion is to pay a lot of attention in this area.Don't just focus on the (relatively easy) task of matching the horizontal pattern of a CD horn with a midwoofer at the crossover point. That's important, to be sure, you want uniform directivity in the horizontal plane and uniform coverage throughout the room. But energies directed at the ceiling are part of the reverberent field too. In fact, ceiling reflections are often a problem so vertical pattern control is

important.  It is good, in my opinion, to limit HF energy to small vertical angles and for the spectral balance to be as uniform as possible.Other things that are obviously important are using midwoofers that have well-behaved cone flex.  All midwoofers used to frequencies high enough to match directivity to 90° HF horns are beginning to flex the cones.  They're not acing as rigid pistons at the upper range of their bands.  So cone breakup must be well damped.  Another thing to watch for is HF driver behavior at low frequencies.  The horn needs to have the right polars, and it should also be capable of smooth amplitude response.  Sometimes, I've noticed lately, in the zeal to match directivity, there is a tendency to forget the simple stuff.  If the amplitude response of the horn has ripples on axis, then off-axis directivity is perhaps a secondary concern.Some of this may have veered a little off-topic, but my point is there are other important things to balance while matching horizontal directivity.  It is important, but this aspect must be balanced with other competing priorities.  It isn't hard to do it right, but you have to watch some of these other issues too, so it is important that you not simply get out the calculator and pick the frequency where advertised diameter equals wavelength.  There is some wiggle room that allows optimization of other parameters and still uniform directivity in the horizontal plane.  Since the wavefronts are in phase, the blend is smooth and the pattern is largely set by the source with widest pattern.  It is probably at least as important to pay attention to what the horns are doing in the vertical plane, and set the crossover point and vertical spacing where it will match the off-axis nulls to the HF horn's vertical angle.

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Subject: Re: Woofer directivity
Posted by David McBean on Thu, 24 Jul 2008 08:01:11 GMT
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Hi Everyone,"You can expect a rigid flat piston radiator to generate a 90° pattern (-6dB) at the frequency where diameter equals wavelength."Just out of interest, the effect described by Wayne in his statement above can be readily demonstrated in Hornresp.A circular piston with an area of 929.41 cm^2 has a diameter of one wavelength at 1000 hertz.  To simulate in Hornresp, set Ang = 2.0 x Pi (for infinite baffle), S1 = 929.41, S2 = 929.41 and L12 (Exp) = 0.01.  Calculate the results, then run the Directivity Beam Width tool from the SPL Response chart, and Sample at 1000 hertz.  The -6dB beam width is calculated to be 89.5006 degrees (which rounds to 90 degrees, as indicated by Wayne).Kind regards,David

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Subject: Re: Woofer directivity
Posted by Wayne Parham on Thu, 24 Jul 2008 17:37:47 GMT
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I don't know if I've said so recently, but I want to thank you for your excellent Hornresp program and all the support you've given over the years.  I've been using it for probably what, ten years now?  I have an old copy of v.3.10, maybe even some versions earlier than that.  I don't know why I kept them, but it's fun to look back and see your improvements over the years.I've modeled

everything from simple straight conical horns to more complex folded horns.  I have models of horns in every frequency range - tweeters, midrange and basshorns.  The models I've made with Hornresp have always proven to be extremely accurate.  So much, in fact, that I consider Hornresp predictions to be more accurate than measurements in some cases.Sometimes the measurement equipment itself is a variable, sometimes the environment being tested in.  Some use primitive testing equipment.  Some try to measure basshorns indoors, even though there's no way to gate the reflections, to separate the room from the horn.  So when I see someone's measurement that doesn't square with a Hornresp model, I tend to discount the measurement.  Where basshorns are concerned, unless acoustic measurements are made outdoors with a good test system, I'd rather trust the Hornresp model.I have the most confidence in data when I see a Hornresp model match acoustic measurements of a particular device.  That's when I am most comfortable with the accuracy of the data.  I've grown to really trust the program, and depended on it heavily in the past decade or so.Thanks for all you've done.  The build/measure/modify cycle is history, now we can all enjoy the kinds of benefits large companies have, sort of like rapid prototyping.  It's a much more level playing ground, thanks to you.  What-if scenarios can be done on the desktop, allowing physical models to be proofs rather than tests.  Now none of us horn builders have to build blind!

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Subject: Re: Woofer directivity
Posted by David McBean on Fri, 25 Jul 2008 08:42:43 GMT
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Many thanks Wayne for your kind comments, they are much appreciated.Hornresp has certainly evolved considerably since Version 3.10 was released, that's for sure. Kind regards,David

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