Subject: Baffle spacing, phase angles and time alignment, revisited
Posted by Wayne Parham on Wed, 14 May 2003 04:56:30 GMT
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In this post, I'd like to revisit the issues of baffle spacing, phase angles and time alignment. It's been a while since we talked about this, and I think it would be good to come at it from a different angle.

Bad pun. Sorry.

There's no way to make two sound sources be phase-aligned at all points in space and at all frequencies. Not even an infinitely powerful DSP algorithm on an infinitely powerful computer can accomplish phase correction of two or more sound sources at all points and all frequencies simultaneously. But a designer can pick their target locations and range of frequencies and align for them. The better products are those that have design choices that limit dispersion and crossover overlap such that anomalous conditions are only present outside the dispersion window, and so are not developed by the loudspeaker at all, or at a highly suppressed level.

The reason for this is simple. When there are two points in space generating a wave, there can be path length differences between the observer/listener and each source. If those path length differences are at odd multiples of a half wavelength, then cancellation results. So there are positions and frequencies that will cancel, resulting in nulls.

The most common solution is to align sources vertically, so that movement on the horizontal plane results in no change to the distances between the observer/listener and each source. That means that the problem will only present itself at certain positions along the vertical plane. I'll provide some illustrations below, which are from the AES Journal paper called "Improvements in Monitor Loudspeaker Systems."

The illustration above shows the window of locations where response will be good for this loudspeaker. Generally, if the crossover region is narrow, one can assume that both subsystems will be online only over a very small band of frequencies around the crossover frequency. Frequencies above or below this region will be generated by only one sound source, but in the crossover region, there will be two sound sources that are separated by space and time (phase). Where the angles between sound sources cause path length differences at odd multiples of a half wavelength, interference nulls are formed. Really clever designs have these nulls positioned at the edge of the coverage pattern, where they actually become useful, serving to abbreviate pattern cutoff.

The normal listening room is wider than it is tall, so the ideal coverage pattern is too. One problem that presents itself is a flare angle that is wider than it is tall terminates in a mouth that is also wider than it is tall. This means either the horizontal flare must be oversized to allow the vertical flare to develop enough to get pattern control, or the horn can be made smaller but it will sacrifice vertical control. However, if the adjacent drivers are stacked vertically, then interference nulls are formed at angles above and below, with the angle determined by the positions of the

sound sources. If carefully placed, these nulls will act to reinforce pattern control, by providing it at low frequencies where the undersized horn is not able to provide vertical control solely by its dimensions.

tweeter and midwoofer is somewhat distant for aesthetic reasons. It wouldn't look good to have a large box with two drivers stuck closely together. But there is also some reasoning behind the choices, as is shown by the analysis below.

tweeter-midwoofer spacing of 13.25" yields

d1 = 0.33m (13.25") between the tweeter center and the midwoofer center

a = 19° or 2a = 38° (arc between nulls)

This is equal to the vertical dispersion of the HF horn. The nulls are set at the edge where HF dispersion falls off.

This is my favorite implementation, and why I prefer asymmetric horns to round or square ones. Not only is the target listening area asymmetric, but the vertical placement of sound sources tends to work in your favor if you choose such a pattern. I like a consistent radiation pattern in both horizontal and vertical planes, or at least a uniformly collapsing one. But with vertically stacked sound sources, one must pay attention to coverage angle and driver placement in order to avoid having an off-axis null right in the middle of the pattern. In my opinion, the best way to handle this is to limit the vertical pattern to the location of the first null.

The bottom line is that there are a handful of things to consider when bringing two subsystems together as a loudspeaker system. The slope of the crossover sets the phase relationships of the motors and the overlap frequency region. The directionality, position and orientation of the radiators sets the acoustic phase relationship in space as well as the amount of energy delivered to that space. So if the two radiators are nearly matched in directivity and output in the crossover range, then the transition will be seamless and the reverberent field will be uniform, resulting in the most natural sound.

Subject: Re: Baffle spacing, phase angles and time alignment, revisited
Posted by spkrman57 on Wed, 14 May 2003 09:22:54 GMT
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Wayne, Good explanations there, I will admit that I do more skimming of information like this than I actually do understand it. I do catch the general theory if not the math involved. I have found some of these things out the hard way(I am old-school trial and error student), so get many of the same results, just takes me longer to get there. I have found that using Martinelli horns(current setup), I have to extend the front of the horn about 1" in front of the woofer board.

That gets me the 7 1/4" half wave length in regards to the woofer VC. I am close to the "horn-to-woofer" distance of 13 1/4" spacing you mentioned. I have experimented with different spacing between the woof/tweet and have noticed much interference in the sound around the upper midrange. I have also noticed that if I place the woofer too high off the ground(closer to ear level), I pick up too much unwanted sounds from the woofer. Thanks for the furthering education !!!!! Ron

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Subject: Re: Baffle spacing, phase angles and time alignment, revisited
Posted by DRC on Wed, 14 May 2003 09:50:57 GMT
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Holy cow, Wayne!I'm gonna have to have my morning coffee and try this again.I'm constantly amazed at the way you wade (swim, Scuba?) into the depths on these design considerations for the benefit of the forum folk. I feel like the least I can do is try to get a handle on the issues at hand.Now, where's my coffee mug . . . Keep your ears and your mind open.

Subject: Re: upward axis shift
Posted by Sam P. on Wed, 14 May 2003 13:21:28 GMT
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Wayne, if the tweeter crossover delays the signal, doesn't that cause an upward axis shift? How much does the woofer (big mass/big inductance) delay the signal... are they about equal? Sam

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Subject: Re: Baffle spacing, phase angles and time alignment, revisited
Posted by mikebake on Wed, 14 May 2003 15:28:38 GMT
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Whaddaya been doin', dude?

Subject: Re: upward axis shift

Posted by Wayne Parham on Wed, 14 May 2003 18:06:13 GMT
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The tweeter driver is shifted back because of the horn, but isn't really that much further back than the woofer. As you said, woofer inductance makes a delay too. The amounts of each are set by the properties of the drivers themselves.

Subject: Re: Baffle spacing, phase angles and time alignment, revisited
Posted by Robert Hamel on Wed, 14 May 2003 21:34:01 GMT
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Thanks WayneIt was a pleasure meeting you at the MAF and I enjoyed the Crossover Seminar too. I have to look this over. I will be back later with some questions for sure!

Subject: The $64,000 guestion, how do you determine how much tilt you have??
Posted by Robert Hamel on Thu, 15 May 2003 12:25:24 GMT
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Let's say you get it down to figuring out the delay is phase from the crossover and the actual path length because of the voice coil offsets at crossover or the overlap range where both driver have significant output. My intuition says its simple geometry but how do you do it?? Second question if you know you slopes, I use 24db how much overlap or what frequencies above and below crossover would you be interested in. How do you determine this based on your slopes??? Thanks

Subject: Re: The $64,000 guestion, how do you determine how much tilt you have??
Posted by Wayne Parham on Thu, 15 May 2003 21:44:29 GMT
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You're right that it's a matter of geometery. You can calculate the source locations, but you have to know the crossover phase, acoustic phase and physical position of each driver. You can also measure each driver with a click test and see the delay between them. That will tell you exactly what the source location is. Knowing the positions, you can determine the centerline and the arc of the off-axis-nulls.

Subject: Re: Hey BOB
Posted by Sam P. on Fri, 16 May 2003 19:21:34 GMT
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Robert, How'd the Q-sound "thingy" work out? Sam

Subject: Hello Sam
Posted by Robert Hamel on Sat, 17 May 2003 10:15:30 GMT
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Sorry but I just ordered it! I have my mom moving in so I have been preoccupied with that. I will drop you a line when I get it. I really can't wait to see what that box can do!