Subject: Crossover optimization for DI-matched two-way speakers
Posted by Wayne Parham on Thu, 09 Jul 2009 21:33:09 GMT
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Recently I started a new project, and like all of my loudspeakers, I designed it to provide uniform coverage over a 90°x40° pattern. As most of you know, this means the loudspeaker has to be capable of providing good response throughout its coverage area, which is not an altogether easy task. To test its performance, you have to move the microphone and measure off-axis in several places in addition to straight in front of the speaker.

I have found it isn't too hard to obtain uniform horizontal coverage. That's largely a function of the horn used, which must provide constant directivity along the horizontal plane. The only thing in addition to that are the crossover points, which must be done where the sound sources have matching coverage. In the case of a direct radiating midwoofer and a horn tweeter, the frequency where they match is determined by the size of the woofer and the angular coverage of the tweeter. When using a 90° horn, the woofer matches directivity at the frequency where wavelength is approximately equal to diameter. There is a pretty wide margin here though, I've found that as long as you're within about a third octave, the pattern is still very uniform.

It is harder to get the vertical pattern right. This is because of path length distances between the listener and the woofer and tweeter. Movement along the vertical axis causes the path length

I did a little video that shows these nulls, hoping that would give a clearer picture of what to expect. Some people are already very familiar with this, so it's not news to them. But many people struggle with the concept of vertical nulls, what they are, and how to find them. Hopefully, this video will be helpful, because it shows one of the things I do during development, and it also shows a speaker that I think is a good example as far as vertical coverage is concerned. It has a tall forward lobe that is useful at most any listening distance.
Vertical NullsWatch the response curve on the laptop computer, lower right of the video. The S&L measurement system is sending a series of bursts to the speakers, and the microphone captures the signal. When the microphone is positioned anywhere between the vertical nulls, the response curve is basically flat. (Unless I'm talking, of course)

There are dips and peaks at the bottom end of the response curve, but you can disregard them. Those are room modes, a consequence of measuring indoors. You won't see them in an anechoic measurement, response is flat until rolloff begins, which is smooth and gradual, free of those room mode dips.

When I move the microphone to the bottom edge of the speaker, you'll see a notch form in the response curve. That is the lower null. Later, I move the microphone to a position beyond the top edge of the speaker. Watch the response curve as I move the microphone, you'll see it remains flat until I reach the upper null, where a dip again forms.

When I moved the microphone to show the lower null, I moved it just a smidge too far - just past the deepest part of the null. But you can still clearly see the upper and lower nulls, and the smoothness of response in between. Pay attention to the response curve as I move the microphone, you'll see it stays nice and smooth all the way between nulls, over a wide vertical range.
