Subject: Re: Uniform Directivity - How important is it?
Posted by Wayne Parham on Wed, 12 Jun 2013 15:16:53 GMT
View Forum Message <> Reply to Message

Based on my observations over the years, I have made three basic assumptions that largely drive my design choices:

My first working assumption is that speakers with constant beamwidth always sound better than speakers that don't, provided everything else is equal.

A second assumption is that speakers with non-constant beamwidth but uniform-directivity - those having just gradual change - sound better than speakers with directivity that shifts radically somewhere in the passband. This is especially true if the directivity shift happens in the peak of the Fletcher-Munson curve where we are most sensitive.

When I say "directivity shift", I'm not talking about 20%, by the way. I'm talking about at least 50%. Beamwidth that stays constant within 20% is perfectly fine, certainly, at least for home theater or hifi. It's the shift from 90° to 180° in less than an octave that you'll hear, not the little bulge of 10° or 20° in a pattern that averages 80° or 90°. A 20% shift amounts to about 2dB at the very edge of the pattern, which is completely inaudible. But a 90° to 180° shift is 6dB at the edge of the pattern, which is most definitely audible. A shift like that screws up the spectral balance in the reverberent field.

So speakers with collapsing directivity (like DI-matched two-ways) can sound very nice provided the directivity change is smooth and gradual. The DI-matched two-way approach is a worthwhile compromise where constant directivity is impossible or impractical.

My third assumption has to do with the "provided everything else is equal" part. This assumption is where sound radiators are concerned, those with truer (flatter) amplitude response sound better than those with peaks and dips. This is true not only of direct radiators but also of horns.

Waveguides offer the promise of smoother response than constant directivity horns, but at the expense of slightly less pattern control. For example, without a diffraction slot in the throat, they cannot maintain beamwidth in the top-octave, narrowing instead to the compression driver exit angle. They sometimes waistband a little at the bottom end of their range too, depending on the shape of the flare nearest the mouth. But in general, a waveguide provides constant directivity and also provides much smoother response than a constant directivity horn.

Waveguides are designed to provide smooth wavefront propogation. The wave, where it contacts the waveguide, is always perpendicular to the surface of the flare. This provides a nice, clean spherical section as the wavefront exits the mouth. It makes them act something like tractrix or LeCleach flares, but with nearly constant directivity. But different shapes and flare profiles offer different optimizations, and correspondingly different performance metrics. Some geometries provide smoother response than others.

An argument can be made that as long as response ripple is constant across all axes, then it can be equalized flat. The idea is that if directivity is constant, then the power response is the same shape as the on-axis response, so equalization in one plane is appropriate to all planes. I think there is merit in that argument, but I do not agree that just because a horn is equalized flat, it will sound as good.

There is a big difference between equalizing for mass-rolloff and using a series of tank circuits to tame response ripple. The conjugate filter for mass-rolloff is a simple single-pole high-pass, and is not a resonant condition. That is quite different than the conditions that cause ripple, and I have not found any cases where the underlying mechanisms that create this ripple come without additional penalty. Sound quality suffers.

You can always take a constant directivity horn and EQ out the ripple. Take the JBL 2370 and 2380 horns, for example, which exhibit 5dB peaks in the passband. They can be equalized flat, but even so, those kinds of horns still sound harsh. And we have seen that some waveguides also generate a peaky response chart, such as the SEOS family of devices we compared with earlier. The SEOS device produces some ripple, a result of its geometry. Here's some discussion about it, where Bill Waslo claims it to be audible, but suggests a way to correct for it in the crossover, using multiple notch filters:

Bill Waslo wrote on Sat, 3 March 2012 21:12It's those Inductor-Capacitor-Resistor (LCR) strings that go across the CD driver. Can't just take them out, other stuff would need to be adjusted to compensate or it would sound awful. I did run some designs without those LCR, but really think they should be left in. One of the bumps they deal with is at 2kHz, which is a terrible frequency to have a bump at (near where ears are most sensitive). Why go to all the trouble of waveguides and CDs and then cheap out on a few components?Bill Waslo comments on the audibility of the ripple inherent in the SEOS deviceConsider that 5dB represents a 3x increase in power. Equalization requires a significant power shift - To remove a 5dB peak means the power is cut 3x at the peak, which also means that it must be raised in comparison by 3x everywhere else. This also means excursion is increased and everything else that goes with it. That is not the only issue, in fact, it may not even be the most significant issue. But whatever it is, there can be little doubt that a constant directivity horn is nowhere near as smooth sounding as a properly designed waveguide.

I have said many times before, I even prefer a good radial horn to many constant directivity horns, purely because of their sound quality. I can remember so many discussions over the years with tractrix horn guys, many that use a simple first-order capacitor and nothing else. They trade everything to get smooth response - out goes directivity, power response, excursion at the low end, etc. And when I say "out goes directivity" I don't just mean the horizontals, but even more so the verticals, because with a single cap, the forward lobe becomes a paper-thin strata. But still, they love the pure sound they get in that one pinpoint spot.

What I like about a good waveguide is we can achieve this kind of smoothness, and still provide nearly constant directivity. It really is a design approach that has one foot in the constant directivity world and the other in the audiophile response purity world. Of course, there is a continuum of optimizations one can choose, spanning between those two worlds. The waveguide can be more constant directivity or more smooth, or somewhere halfway in between.

Which brings me back to the first observation/assumption, that speakers with constant beamwidth always sound better than speakers that don't, provided everything else is equal. Or more precisely to the qualification, the "provided everything else is equal" part. It's why I said earlier that a good waveguide should not "throw the baby out with the bathwater." We do not want to use a waveguide that is excessively peaky in a high-fidelity loudspeaker. I'd say a worthwhile criteria is no more than 3dB variance in an octave, i.e. +/-1.5dB. Above that, and the response ripple becomes audible. Why settle for audible ripple when you don't have to?