Subject: Re: Constant directivity, compression drivers and crossovers
Posted by Wayne Parham on Sun, 02 Aug 2009 20:08:21 GMT
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The R1/R2/C1 network is something I came up with a long time ago, and it is designed to produce an initial shelf of flat response followed by a second region where network output increases 6dB/octave to conjugate the mass rolloff slope of the driver (as shown below). This is what I always referred to as "top-octave compensation." I think it's the best approach, better than using peaking coils and/or notch filters.

You're right that R2 is the main resistor setting the load on the core splitter filter. That's what does the biggest part in setting the Q. But R1 and the driver are in parallel with R2, so they have an influence. It's probably best to think in terms of the R1/R2 values as a pair.

When I first came up with this network topology for CD horns, I was using Spice models to come up with the right transfer function. I initially calculated the positions of the lobes and nulls using crossover phase, baffle position and depth. I described the lobes as "windows", with the nulls being cancellation notches from path length differences. The forward lobe is what I described as the "most desirable window", with the nulls being areas that should be designed to be off-axis, outside the tweeter pattern where possible.

My calculations were useful, but all I could really use was driver position and crossover phase. It was an approximation. In hindsight, after using measurement equipment, I did a very good job but was lucky that the drivers I was using didn't have too many "warts" that shifted things, because they can.

I also found with measurements that the transfer function could sometimes be tweaked a little bit depending on driver and horn. Some horns have more quarter-wave mode peaking down low than others. Those will generally need more damping than horns that are smoother down low. A lot comes in to play at the bottom end, from diaphragm resonance to acoustic loading (resistance verses reactance and quarter-wave modes) to directivity (ripples as the horn gains control).

As far as the midwoofer is concerned, there's a lot going on there too. In a matched-directivity two-way speaker, you're pushing a large cone pretty high. It will tend to start flexing up high, and that can make a difference both on-axis and off-axis. Also, if the crossover slope (electrical and acoustic) doesn't create a pretty well-defined stop band, the midwoofer may be making sound high enough that its side lobes may narrow into the pattern. So there are a lot of variables that determine the response and directivity of the midwoofer besides the textbook behaviour of collapsing DI of a round radiator.

There are a lot of moving parameters in a speaker like this, particularly in the critical crossover region. The woofer is getting close to breakup and its off-axis self-interference angle is growing smaller. Breakup is a function of cone flex and damping, and self-interference is a function of collapsing directivity, of frequency verses diameter. The tweeter horn is just starting to gain directivity control, and if asymmetrical (as it should be) then directivity is different on each axis.

resistance verses reactance, and at the transition region, you'll likely find impedance ripple.

As you can see, there is a lot to try to include in a mathematical model for simulation. It's much better to start off with something you know is close and then fine tune using measurements. That includes not only the transfer function set by R1/R2 damping but also the position of the lobes and nulls, by setting the core splitter filter (electrical) frequency and slope. It all comes into play, interacting with each other in a (hopefully balanced) set of competing priorities.

In the end, I think you can do a lot with simulations, manual calculations and other forms of mathematical models. I used them for years with good results, even without the benefit of good measurement equipment. But the crossover region is a tricky one in a speaker like this, because there are a lot of competing priorities and a lot of "variable drift", meaning that things are moving and changing.