The ER18DXT

11/2009

Summary/abstract

A ported 2 way stand mounted loudspeaker featuring the Seas ER18 7" woofer mated to the Seas DXT tweeter using second order acoustic topology. The second order crossover and the unique waveguide of the DXT combine to create an unusually smooth power response essentially unique to this design. The box design is ported and yet heavily stuffed, using Martin King's MathCAD worksheets in an attempt to minimize internal resonances while extending bass response. The drivers have been chosen for minimum nonlinear distortion as well as a frequency response free of major linear distortions and these qualities have been verified by experimental measurement.

Key Highlights

- Class leading low distortion drivers
- Tightly controlled on axis frequency response +/- 1 dB from 500 Hz to 10kHz, free from any broad low Q peaks or valleys that would affect timbre adversely.
- Uniquely smooth power response, in the range of 1-5kHz due to the second order acoustic crossover and DXT profile, and above 5kHz owing again to the DXT profile.
- Ported box design using Martin Kings advanced simulation MathCAD worksheets allowing simultaneous dampening of internal box resonances and preservation of extended bass response with an in room F3 in the high 40 Hz range and an F10 in the low 30 Hz range.
- Design process heavily influenced by multiple high resolution measurements, simulations, iterative in box adjustments, final voicing by listening, and at least some degree of verification of sound quality by group listening.

Introduction

A number of conceptual threads were woven together to form the basis of this system.

My key goals to achieve for an excellent speaker design are a smooth frequency response, low nonlinear distortion, and a smooth power response. It's fairly easy to choose drivers with low distortion-or optimize a system that way, and with some modest effort, design a crossover for flat frequency response. But, the power response has always been a challenge. The typical box speaker has a certain nonflat response which cannot truly be corrected alone in the crossover. The efforts with waveguide/horns, dipoles, SL's Pluto are all efforts at controlling power response in different ways.

There is a preference among some of the more respected diy audio gurus towards lower order systems. (Yes, I know this is controversial-some, but not all.) Lower order requires the use of very well behaved drivers with somewhat extended FR curves (i.e. paper/poly). Metal cones could be used, but must be chosen very wisely, since they usually have severe breakups which would be difficult to control with a lower order filter. I have always had a preference towards stiffer cones which, in general have slightly lower distortion in their passband and are more pistionic. However, a second order topology has the potential for a smoother power response. You have to accept slightly higher distortion, slightly more cone breakup, as a tradeoff for this.

At the same time, there has been a number of threads on the audio forums, probably the most widely known, are the ones on diyaudio regarding horns and waveguides to control power response. Certainly, the idea has merit if well executed.

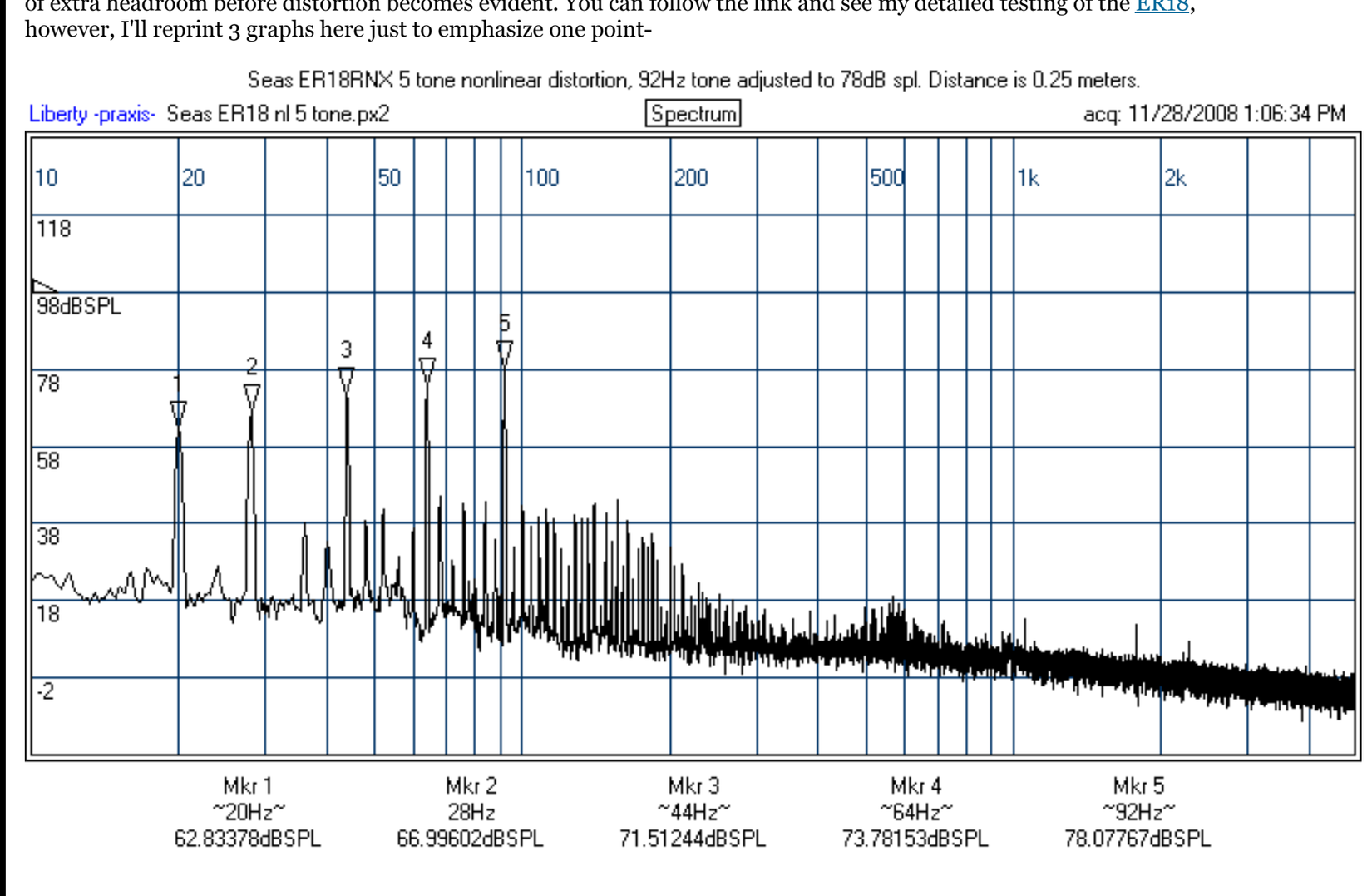
Then, Seas introduced the ER18 and the DXT tweeter. The ER18 is an outstanding paper cone driver with excellent distortion performance and well controlled cone breakup. The DXT is basically a well executed waveguide placed on their outstanding 27 series tweeter motor. The controlled directivity of the DXT didn't extend low enough to get to an 8-10" driver, but a 5-7" driver mated to a DXT tweeter with a second order topology might just lead to an unusually smooth power response-and it does.

Driver selection

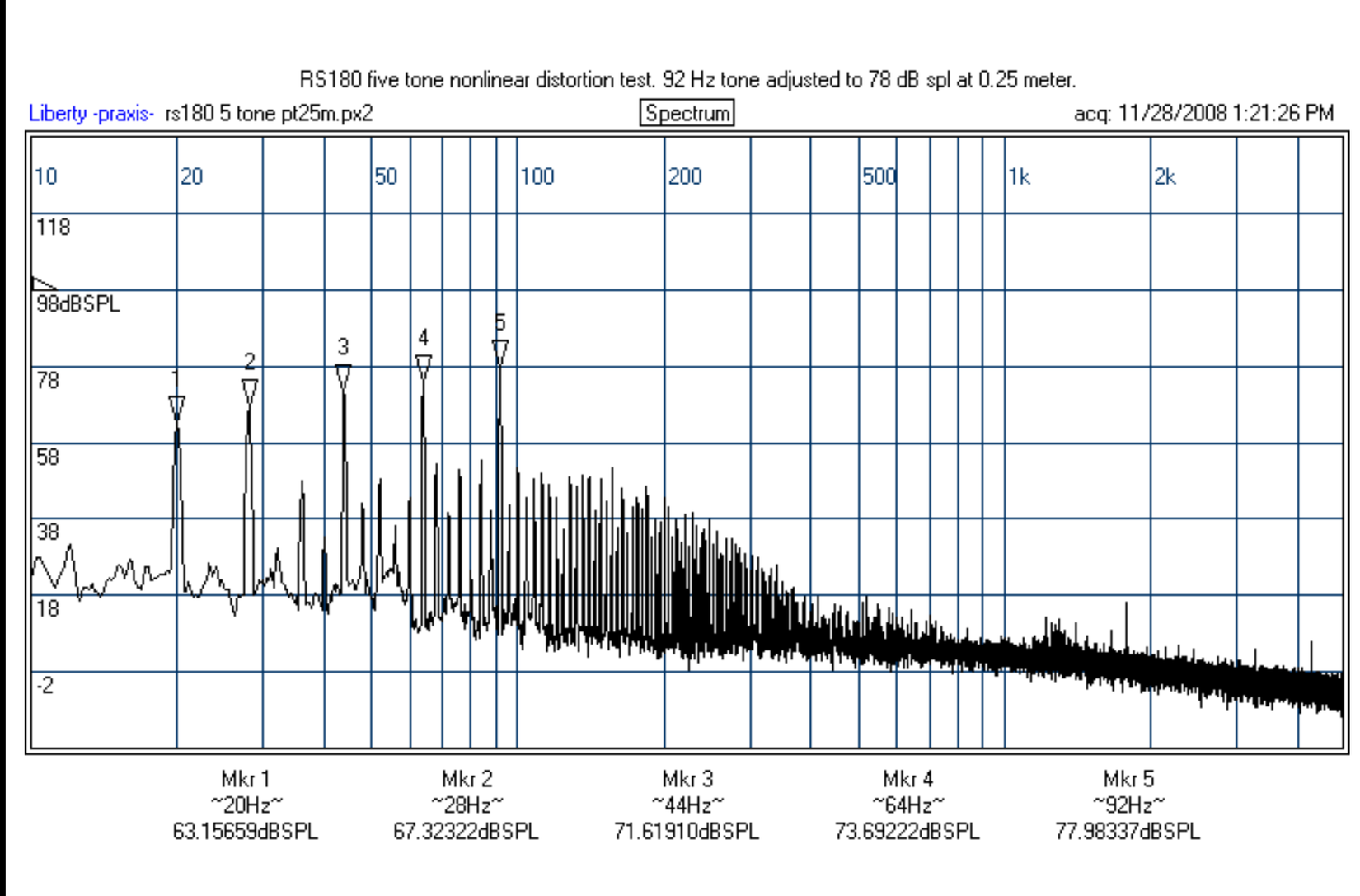
The drivers were chosen for low nonlinear distortion. While the current fad is to discount nonlinear distortion, it is unwise to use this approach when designing the most common type of loudspeaker, the ubiquitous ported 2 way based on a ~7" woofer and 1" tweeter.

Why is nonlinear distortion so important?

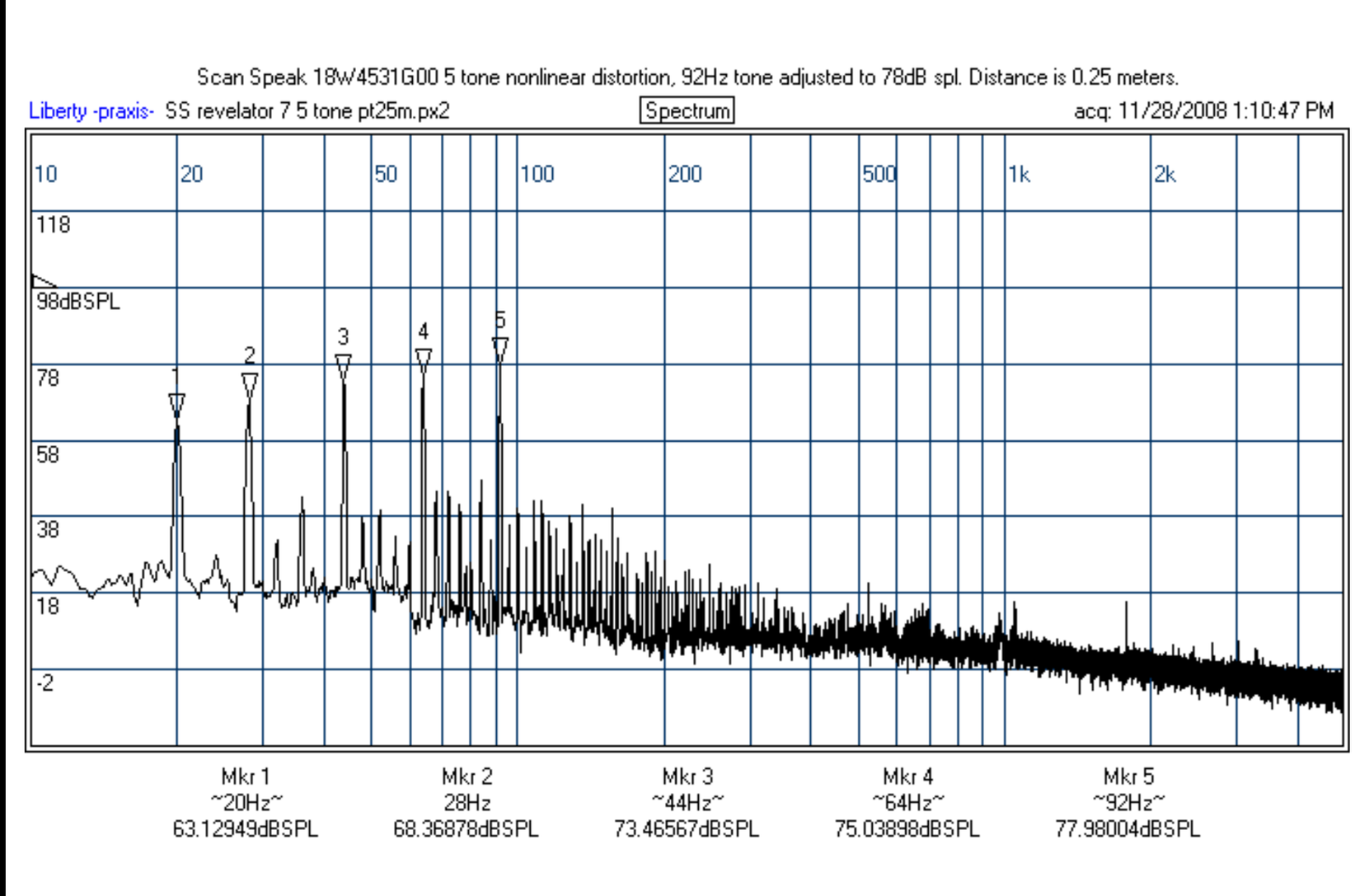
To reproduce bass adequately in a medium room, the woofer is operating close to its excursion limits. Even small differences in nonlinear low end distortion allow the unit to play at louder SPL without sounding strained. As a simple experiment that you can do in your own home, take whatever two way 7" loudspeaker you currently have and turn the volume up on a challenging piece of bass material. A full symphony, some organ music, low bass, etc and see if you can get the unit to distort. I am willing to bet that you can get audible distortion without too much difficulty. In many cases, nonlinear distortion may not audible, but choosing a woofer wisely based on nonlinear distortion allows 3-5dB of extra headroom before distortion becomes evident. You can follow the link below the link and see my detailed testing of the ER18, however, I'll reprint 3 graphs here just to emphasize one point-



Above, you'll see the ER18 with a stimulus of 5 tones, 20, 28, 44, 64, and 92 Hz. The average distortion spectra is down 30-40dB. Below you'll see an RS180 under the same test conditions.



And, finally, a Scan Speak Revelator, 18W.



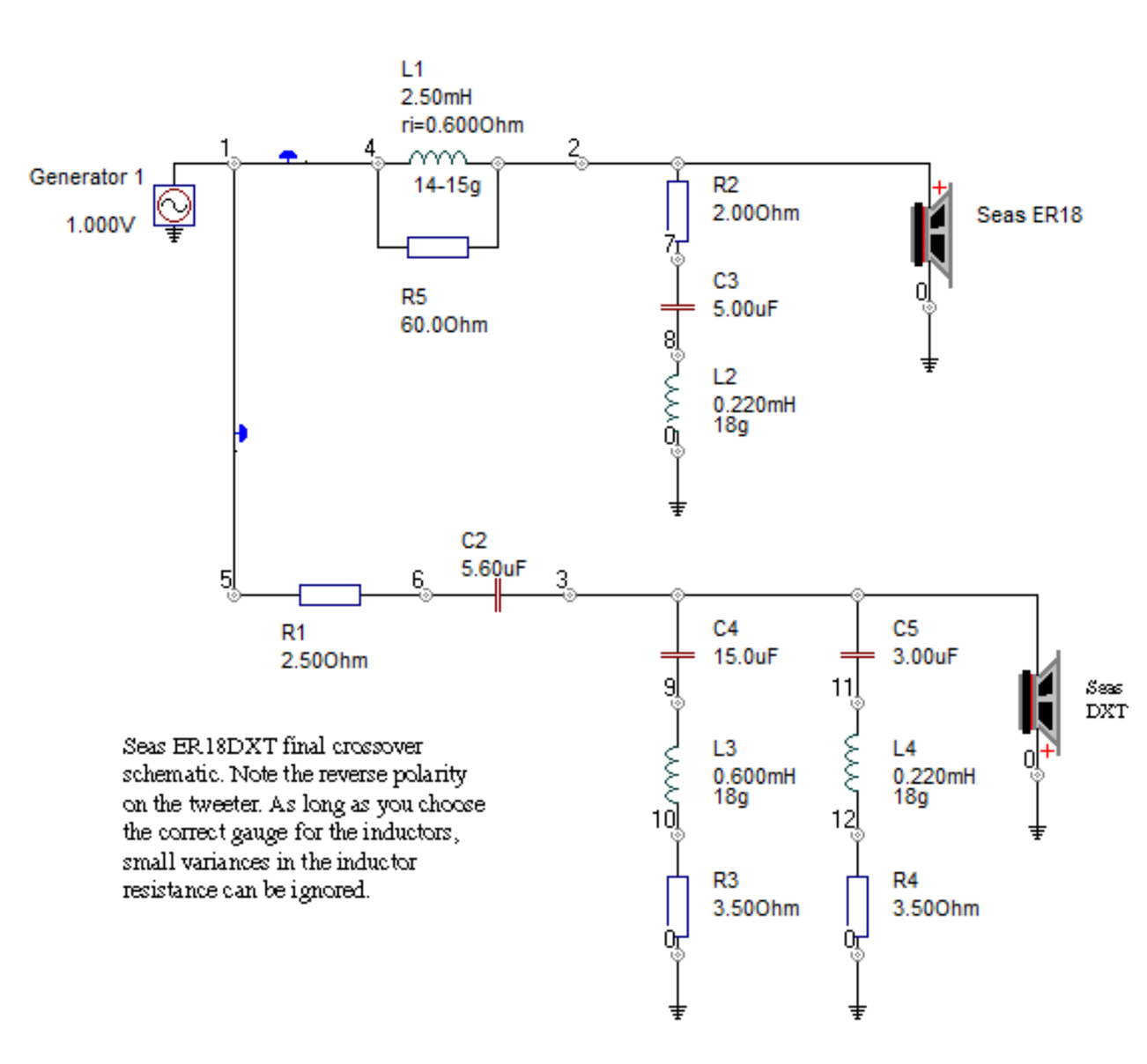
As nice as the RS180 is, the ER18 average distortion spectra is 10dB lower than the RS180 and statistically difficult to distinguish from the Scan. This translates to 3-10dB of headroom before bass distortion occurs.

Along with nonlinear testing, consideration was given to frequency response smoothness and extension given the proposed second order slopes.

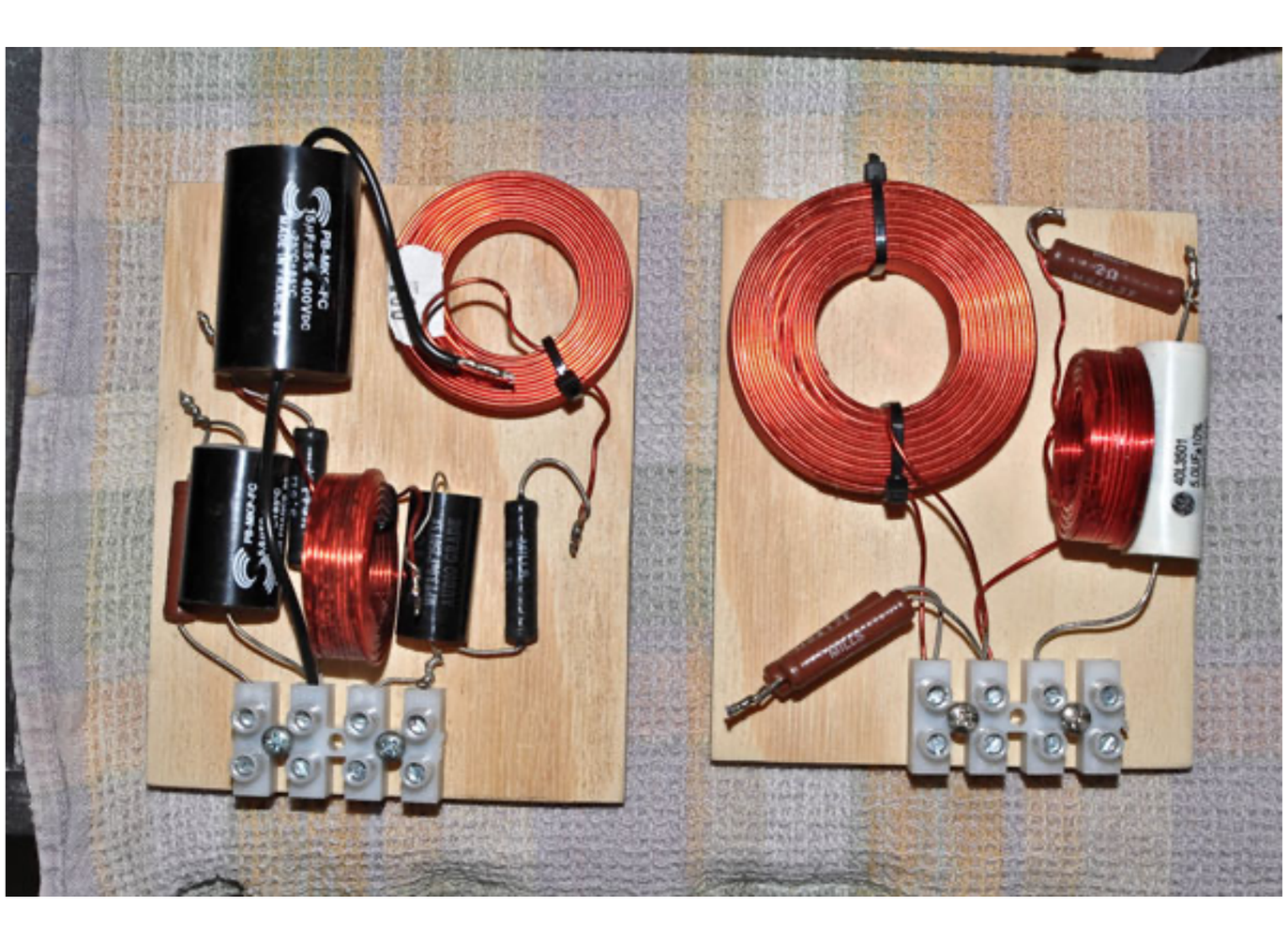
What about the tweeter? Elsewhere on my site you can find analogous detailed testing of the Seas DXT. Given the proposed design would attempt to target a second order acoustic alignment to achieve a smooth power response, my hypothesis was that the waveguide loaded DXT would extend the favorable power response of the crossover from 1-3k out to past 5k. My prior tests had confirmed that this tweeter is an otherwise worthy performer in the league of the 27 series, which is currently the class leading series in it's price range and there does not appear to be any similar 1" dome waveguide loaded tweeter that performs this well.

The crossover

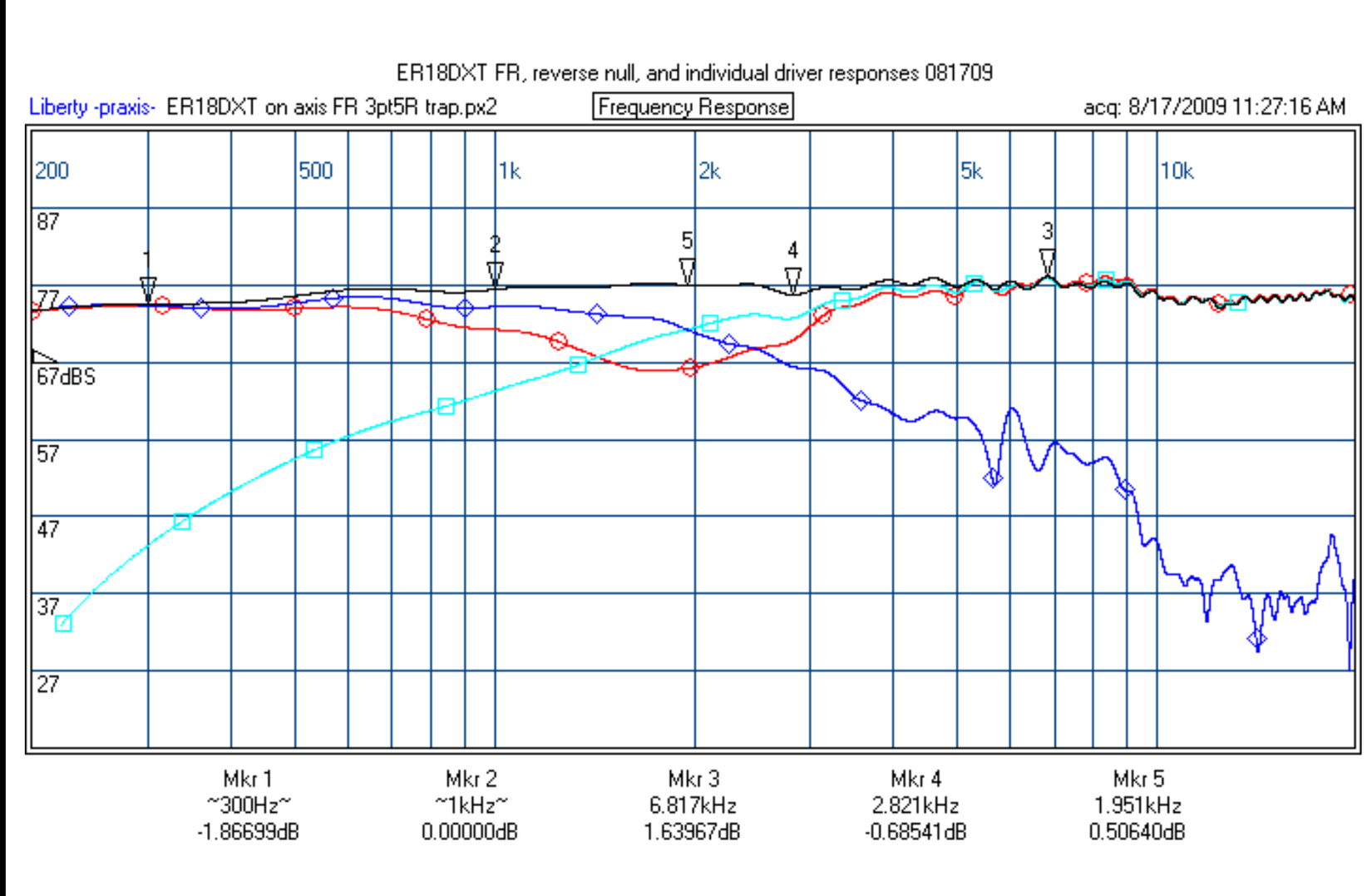
The final crossover schematic is below.

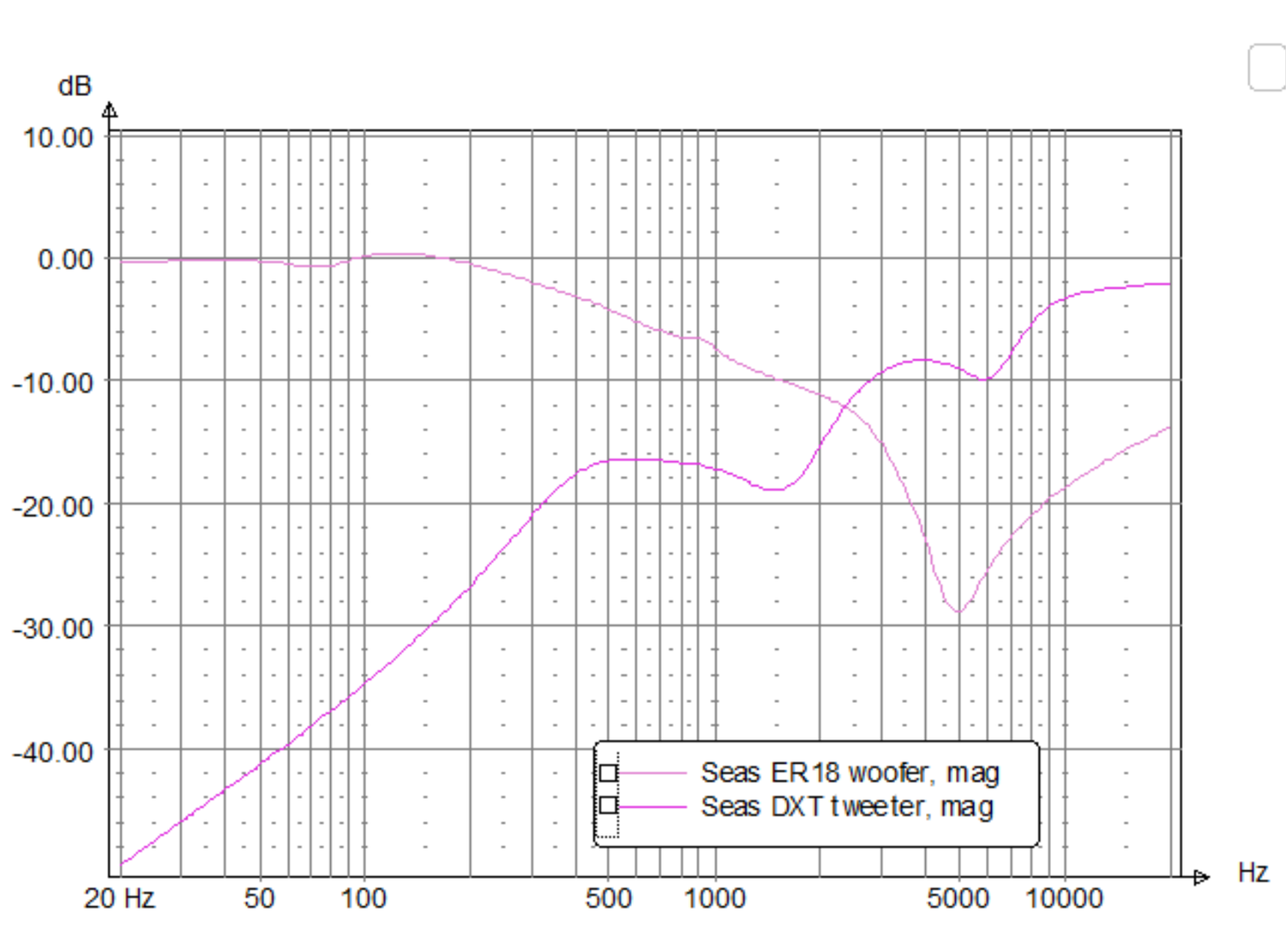


The physical layout of the crossover is below. Two separate boards are used and each is mounted on the side panels inside the speaker. Space is tight within the 0.5 cubic foot box.



Note the woofer electrical filter is 6dB/octave, and really, more of a shelving filter given R5, R2, L2 and C3 form a notch that smoothes out the woofer breakup. The tweeter also has a first order electrical and two notches to achieve the target. Below you'll see the individual driver responses and the sum, as well as the actual transfer function curves.



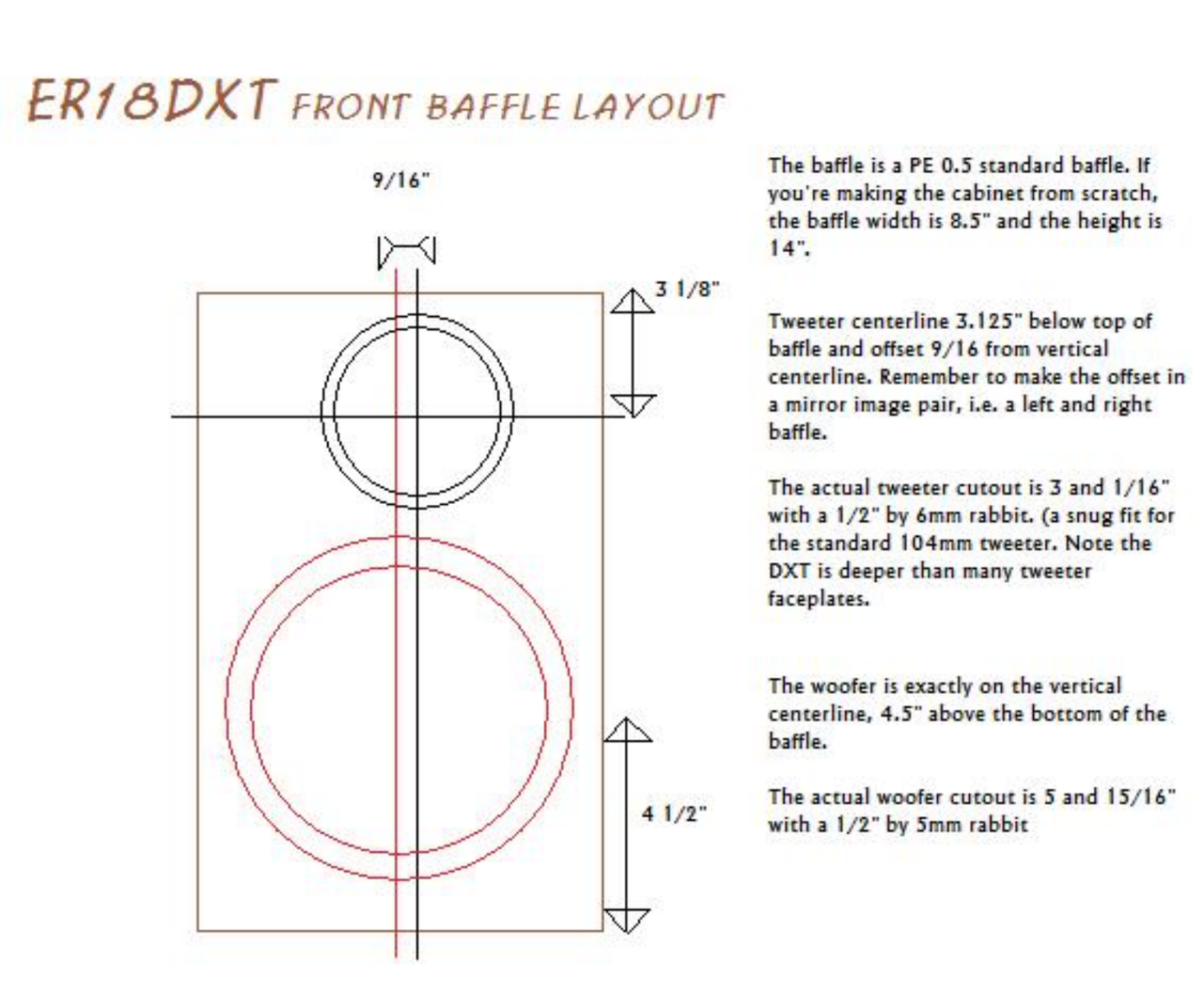


I know what you might be thinking-first order electrical will not protect the tweeter enough. It will suffer excess distortion. That's what I thought might happen. However, distortion testing has shown that not to be the case. See my blog for the confirmatory graphs if you remain unconvinced. However, success hinged on using low distortion drivers, and a topology that fairly rapidly attenuates the tweeter 15-20 dB at the crossover.

Box design

The cabinet used is the Parts Express 0.5 cubic feet cabinet, however you can just as easily use the curved side version. In fact, probably with some minor adjustments, the corresponding Madisound cabinet could be used. The MAD baffle is already precut for the DXT and ER18. (If anyone wants to send me a MAD cabinet, I'll be happy to do any minor crossover adjustments-just send me an email.)

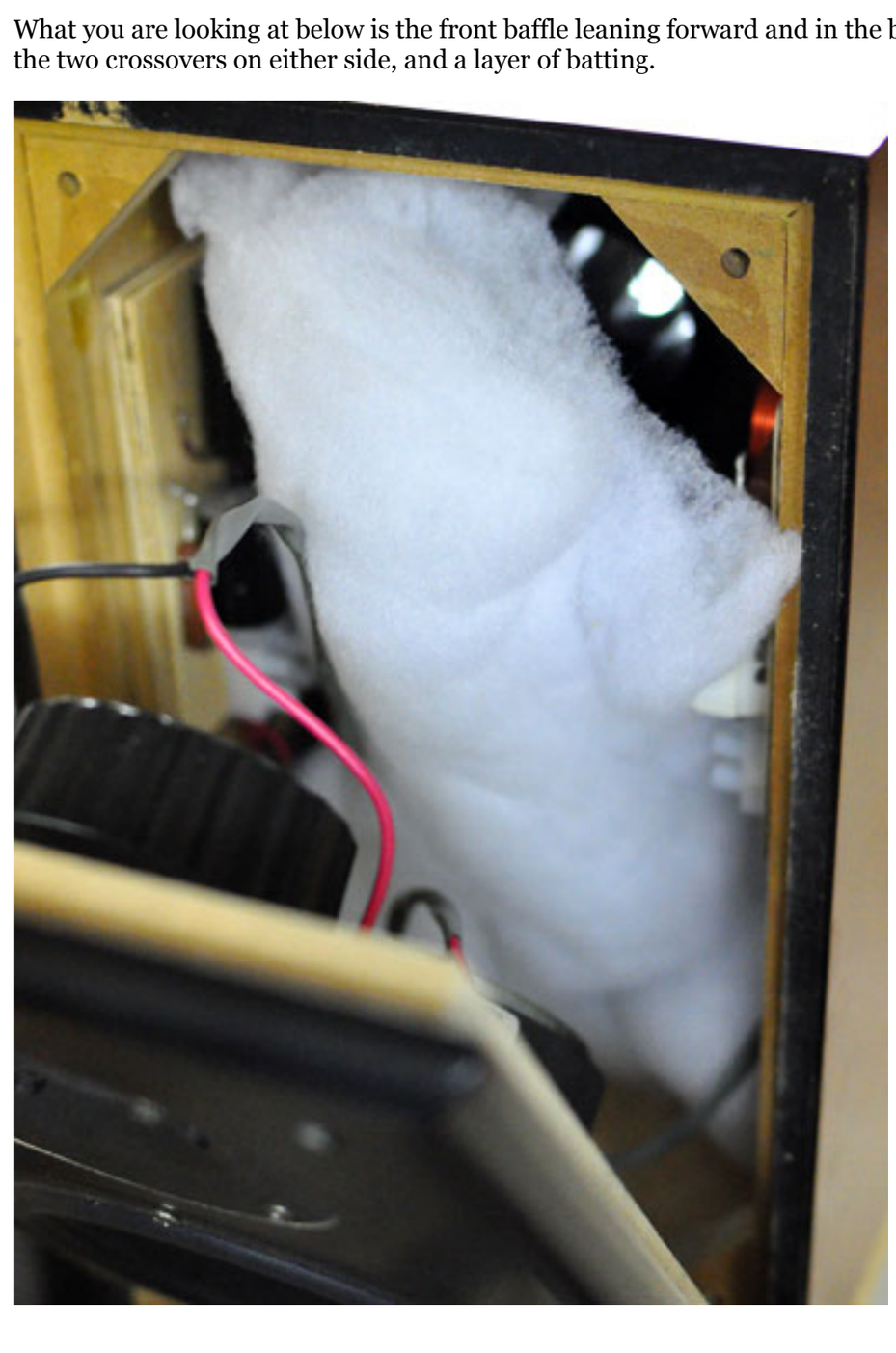
The baffle info is below.



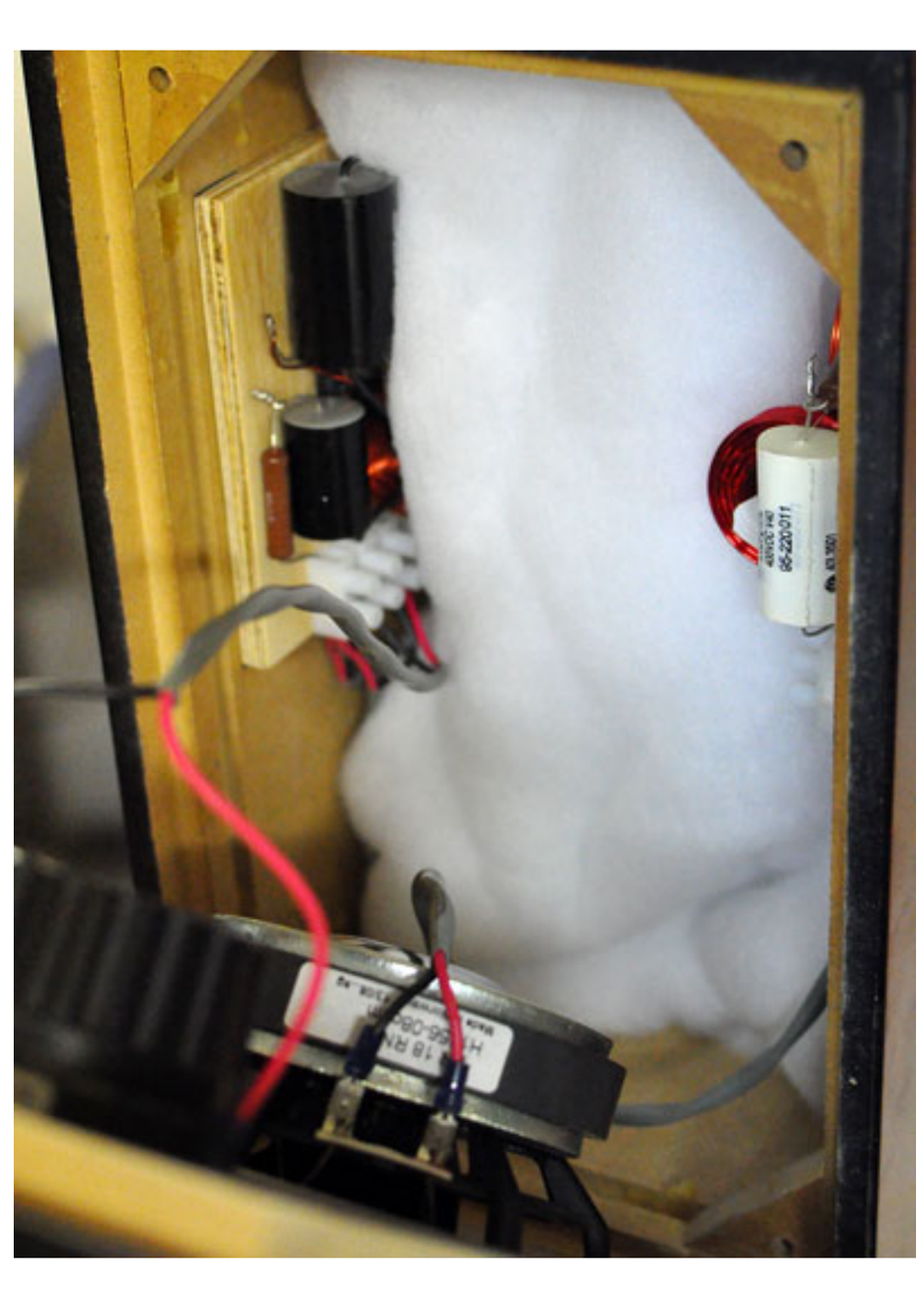
The port is the Precision Port 2" flared port available at PE. It is placed on the rear of the cabinet, on the vertical centerline, directly behind the tweeter.

The stuffing is a combination of 6 ounces of free poly fill behind the center brace, and one half sheet of poly batting between the drivers and the center brace(yes, covering the flared point end-between the tweeter and the flared port!). The actual stuffing is a twelve ounce bag of Mountain Mist fill split in two, and the batting is the same brand of Mountain Mist. Why Beverly's? Err, it's down the street from me. You may use Acousta-Stuff or similar, and some other more "audiophile" batting, though you'll have to figure out how much. The idea was to use 6 ounces of free polyfill and 2 ounces of batting per speaker. You can rip out the batting and fill from an old flame's pillow, stuff it in one of her old pair of nylons, and it would probably work as well...

What you are looking at below is the front baffle leaning forward and in the back you can see the inner end of the port, the two crossovers on either side, and a layer of batting.

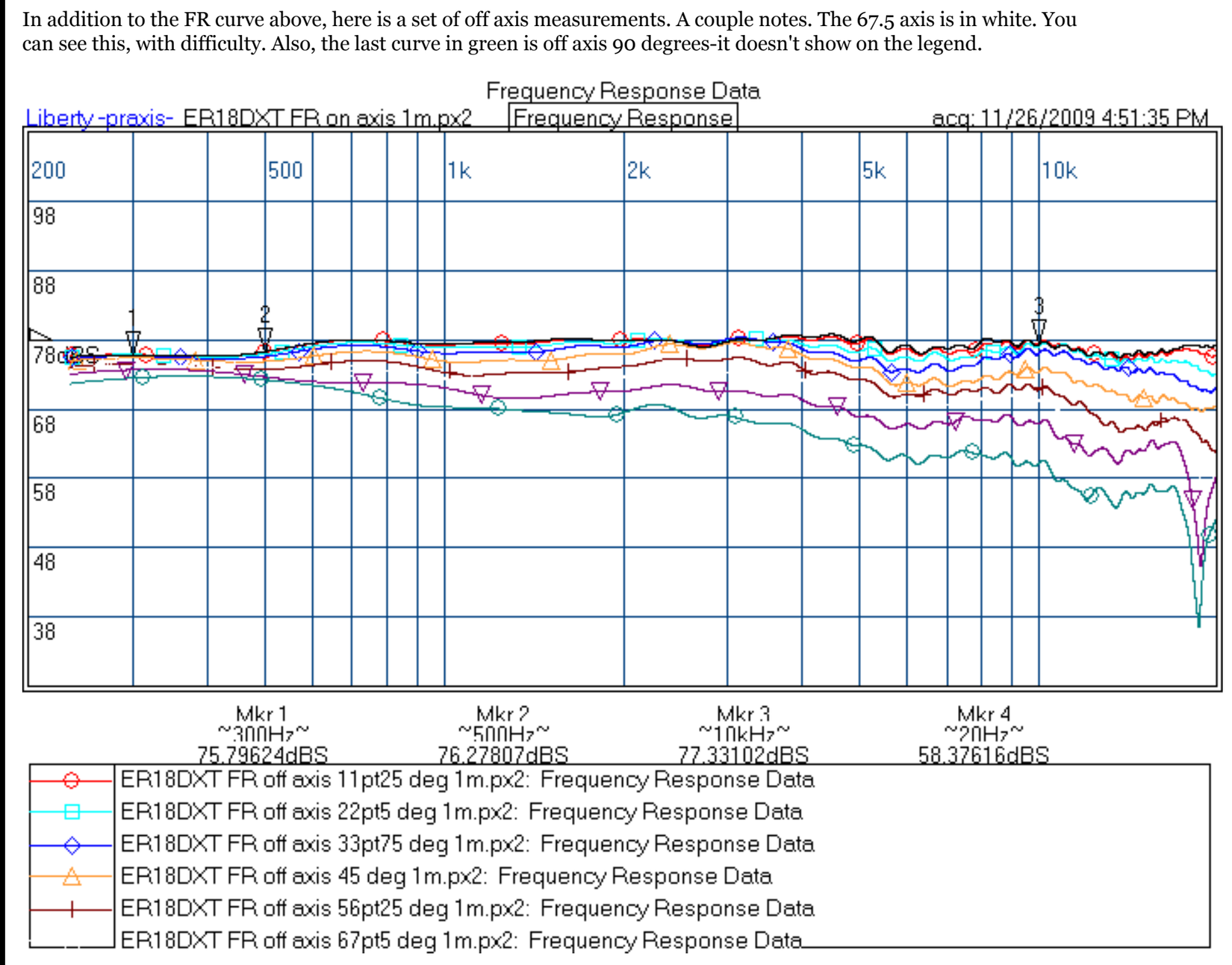


What's not clear in the above is the polyfill. You can't see it because it's behind the middle brace which isn't really visible. As you can see below, the single sheet of poly batting covers, yes, covers the inside end of the port. Does this dampen the flow? Yes, a little bit. Still, resonances are bad. If for some reason, you want a bit more bass, you can probably adjust the amount and location of the batting. I've done a number of listening and measurement tests that demonstrate meaningful bass output to ~35 Hz, so I recommend building it as is, listening for a while, and then decide. Of course, I you know you're using a sub, build it sealed...

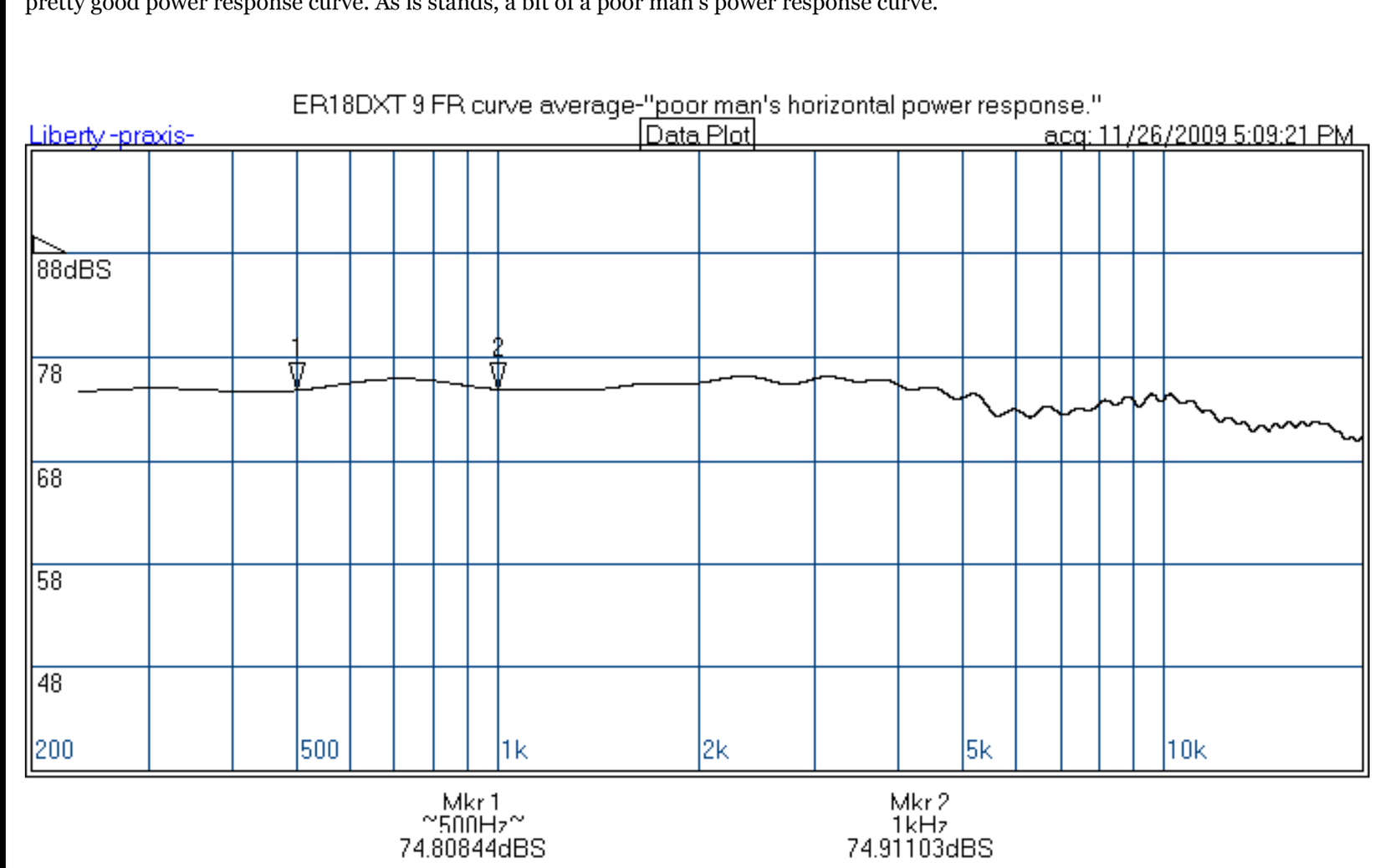


Measurements

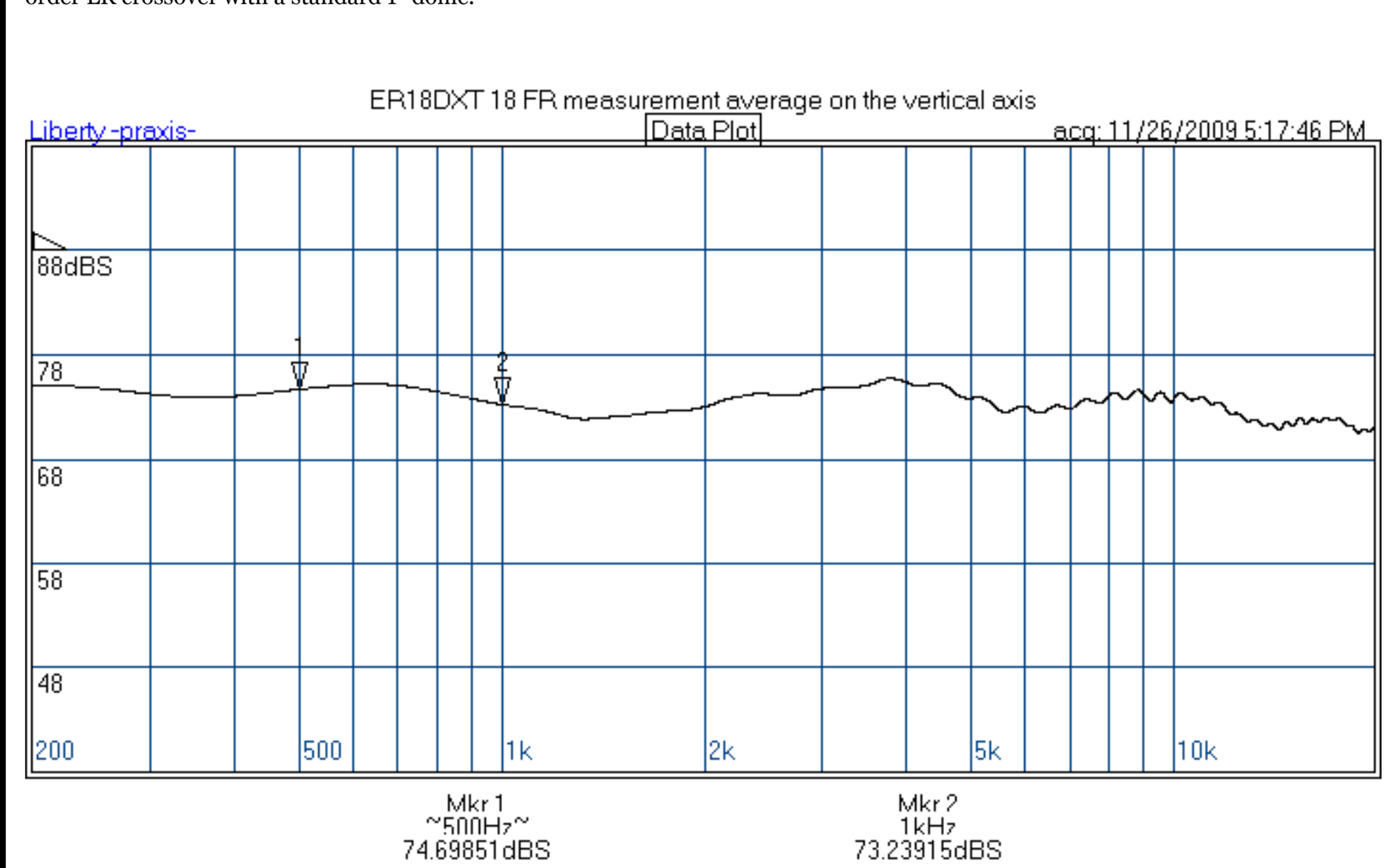
In addition to the FR curve above, here is a set of off axis measurements. A couple notes. The 67.5 axis is in white. You can see this, with difficulty. Also, the last curve in green is off axis 90 degrees-it doesn't show on the legend.



How about averaging these out? Praxis allows you to merge these together. If you did an infinite number, you'd have a pretty good power response curve. As is stands, a bit of a poor man's power response curve.



How about the same thing in the vertical direction? 18 measurements, 9 above and 9 below. It's a bit more uneven, due to the noncoincident drivers on the vertical axis. Still, overall quite smooth, much more so that the typical fourth order LR crossover with a standard 1" dome.

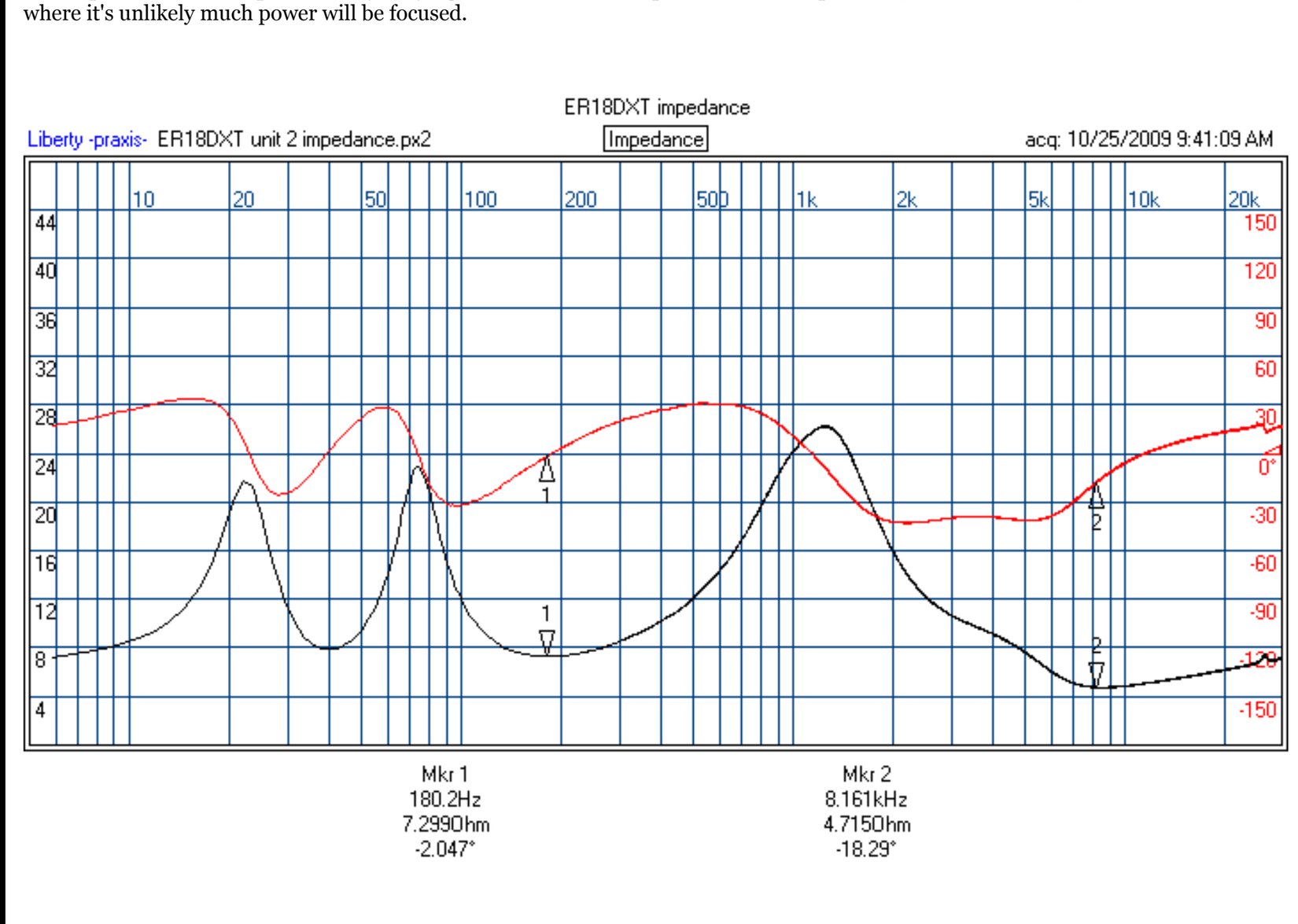


If you're interested below are a set of praxis horizontal and vertical polar response files. You do need praxis on your computer to view these. Also, they are limited by the number of measurements (it would have been nice to do every 5 degree measurements in the forward hemisphere and every 10 in the rear, but my turntable is not functional currently. The measurement is not quite detailed enough to see exactly where the lobe is pointing since the steps are every 11.25 degrees. Still, again, you get the idea.

ER18DXT horizontal polar response.px2

ER18DXT/ER18DXT vertical polar response.px2

The impedance curve is quite friendly, staying around 8 ohms except for a modest dip below 5 ohms well above 5k where it's unlikely much power will be focused.



Final system sensitivity is 84-85dB/2.83v.

What about bass extension? I could post a nearfield spliced curve, but I think these are misleading. Multiple in room measurements using stepped tones, pink noise, RTA as well as nearfield curve indicates useful bass into 35-40Hz. One of the comments when these were demo'd was "where's the sub..." Now, no two way stand mounted unit can generate high spl at 25-35 Hz, so it depends, of course, on your expectation level...

Parts list

From Mad

component	cost for 2
Seas ER18RNX	155.10
Seas 27 DXT	104.30
Total driver cost	259.40

From PE

Invoice in xps format for PE parts list   188.52 not including the cabinets (the invoice shows the cabinets added)

From Beverly's crafts

Mountain Mist fill 12 ounces (6 ounces for each speaker) $5.99

Mountain Mist 36x45, one package (1/2 half package per each speaker) $4.99

So, total cost as of 11/09

159.40+188.52=347.92-Drivers plus crossover parts. Add $200 for cabinets (occasionally on sale!) plus another $30 for poly fill, wiring, and binding posts and the total is $580.

So, under $600 with prefinished cabinets, or, under $400 if you do the cabinets yourself.