

Biamping the NHT M3.3

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A PLEASANT SURPRISE

An email came. I could get a set of one of my all-time favorite commercial speakers at “a ridiculously low price.” Would I be interested? I did not hesitate.

Rewind. If you were to make a short list of the all-time best speakers in the “cone-in-a-box” paradigm, certainly the NHT M3.3 would be there. The design was a mix of the conventional (four-way floor-stander with plastic cone drivers, metal dome tweeter, passive crossover) and some very innovative thinking. Rather than rehash the logic behind the angled front baffle, the side-firing woofer, and the obligatory against-the-back-wall placement, I’ll refer you to the reviews in [The Audio Critic](#) and [Stereophile](#).

I had heard these speakers on a few occasions and was always impressed; though I’ve owned and built some pretty decent speakers, these seemed to do things well that mine couldn’t. The dynamics seemed totally unrestrained, the spatial definition astounding- it was easy to hear every mistake and manipulation by the recording and mastering engineers. Though I was a devotee of electrostatics, I thought that if I had to live with cones-in-a-box, I could be pretty happy with the M3.3s; they certainly sounded at least as good as any other conventional system I’d ever heard. And to be perfectly honest, I was an NHT fanboy- I have always admired the solid engineering and non-mystical approach to loudspeaker design, along with their consumer-friendly pricing. Though the company was pulled in several directions through the years when it was being passed back and forth between owners, the quality and ingenuity of their products remained high.

Jack Hidley, one of the M3.3's designers, was cleaning out the NHT warehouse and put their surplus stock of drivers on sale. I bought the midrange and upper bass units for the M3.3, with the intention of finding some 1259 woofers and a reasonable replacement tweeter and cloning them. Jack was very helpful and made some suggestions on how to pull it off. A few weeks later, he ran across some relic M3.3s and remembered me.

How lucky!

These particular units were warranty returns that had gone partially silent during a sonically abusive party. According to Jack, it's pretty hard to burn out the drivers, and the greater likelihood was that some crossover components would have to be replaced. Besides which, I had already bought several driver sets, so if any needed to be replaced, I could do that. And the cabinets would save me a ton of time and effort. Jack and I dickered over the price for about 10 seconds before reaching accord. Without hesitation, I grabbed these beauties and ran like a bandit before he changed his mind.

On examination, the drivers were indeed intact. After I had tracked down the problem and replaced two capacitors in the crossovers (the old ones were spectacularly blown), the speakers worked like new. And they were just as good as I had remembered them. I must admit that after several decades of mini-monitors and ESLs, I succumbed to temptation more than once and managed to see the needle of my SPL meter bounce into the three figure range...

Gilding the lily, Jack casually mentioned that he had worked out some modifications to the speakers, specifically addressing the weak point in any subwoofered design- the woofer to upper-bass/midrange. Well, well. Of Course I had to do this. And this is the story of Jack's Superized version of the M3.3s, with one or two little twists.

MODIFICATION OUTLINE

Being who I am, I cannot leave well-enough alone. Though the M3.3 was claimed to be designed without compromise, of course there are some. And the biggest compromise is running the speaker full range from a single amplifier. Anticipating this, the NHT engineers provided a simple way to separate the upper section from the lower; the low-pass crossover to the Foster 1259 woofer and the high pass crossover to the rest of the drivers were brought separately to individual pairs of rear terminals. For normal use, the two terminal sets were strapped in parallel. To bi-amp, the user would remove the straps, run the preamp outputs to two separate power amps, and run the output of each power amp to the corresponding speaker terminals.



This way of bi-amping is foolproof, too, because this separation leaves all of the original passive crossover in play- the crossovers are exactly as they were, so the user can only screw things up by setting the relative levels incorrectly. The passive crossovers take some of the load off of each power amp, since the impedance presented to their respective power amps is quite high outside of their pass-bands.

But foolproof as it is, the built-in bi-amp method is compromised. For example, if one wants to use a powerful bass amplifier that requires low-pass filtration before its inputs (for example, the 500 watt VT-3 amp by Sunfire that I wanted to use), the amp **MUST** be presented with a signal containing no high frequencies or Bad Things Happen. Another example is using a tube amplifier as the amp for the upper section- it will still see lots of low frequency signal at its input, but the rising load impedance at LF can cause severe problems to the output transformer (tube amps do **NOT** like to be run full steam into an open circuit!). And one of the biggest advantages of bi-amping, the tighter coupling between drivers and power amp output, is thrown away.

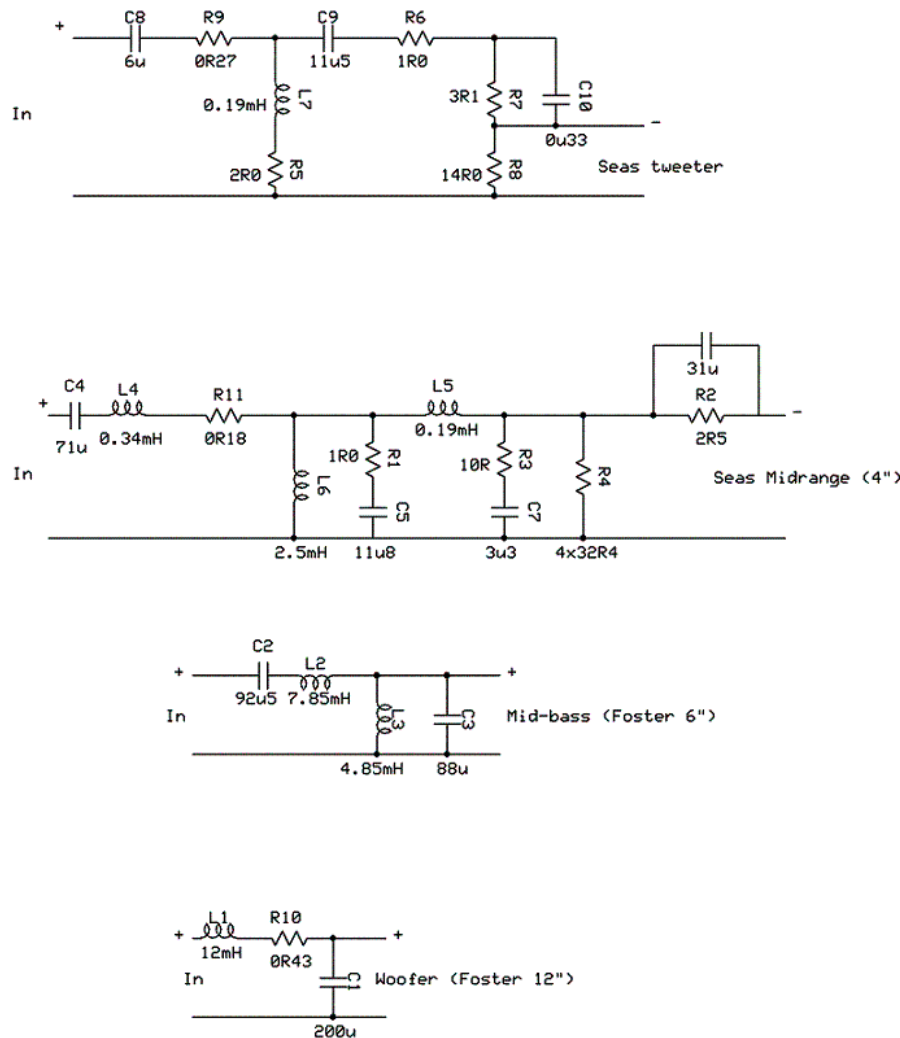
One interesting compromise in the stock M3.3 was the woofer-to-upper-bass transition. If you look at the frequency response curves of the individual drivers, you can see that the woofer rolls off at 12dB/octave (2nd order) for a low-pass, and the high-pass response for the upper bass driver is 24dB/octave (4th order). Why the unsymmetrical slopes? The answer appears to be “phase.” The setback of the woofer from the plane of the other drivers is on the order of a meter. So there’s 3ms of an all-pass delay with respect to the other drivers. This corresponds to something like 100-110 degrees at crossover, which is not desirable. In theory, a passive LC all-pass could be used to compensate for this and allow the use of a more symmetrical transfer function; this will smooth out the in-room bass lumpiness around the crossover region to a surprising degree. But such a line would be really, really big, and really, really expensive.

With biamping, of course, an all-pass is incredibly cheap and easy to implement. So we can neatly remove **THAT** compromise, too.

So, let’s see how to do all of this, and keep our eyes open for other potential improvements along the way.

PLAYING THE STOCKS

The crossover circuit for the stock M3.3 is shown here.



The low-pass crossover to the 1259 woofer is usually on a separate board and is strapped in parallel with the crossovers used for the upper section by the external jacks; the upper three drivers' crossover inputs are wired in parallel on the main crossover board.

As usual for an NHT design, the parts chosen are absolutely suitable for the intended purpose; substitution of designer parts would increase the price and very possibly degrade the performance. The measured impedance curve can be seen to be a very kind load for a power amplifier- impedance compensation is cannily chosen to minimize the roller-coaster ride of impedance magnitude. In-room SPL response is quite flat; at certain heights, I can see a notch at 4kHz, but otherwise, it is exemplary.

We first consider the high-pass portion to the 6" upper bass driver (an excellent unit by Foster, proprietary to NHT). The driver's Thiele-Small parameters are given in this table:

<u>Fs (Hz)</u>	<u>Qes</u>	<u>Qms</u>	<u>Qts</u>	<u>Sd (m2)</u>	<u>Vas (l)</u>	<u>Mms (g)</u>	<u>Res (ohm)</u>	<u>Le (mH)</u>	<u>Sens</u> <u>(dB/1M/2.83V)</u>
38.3	0.325	1.543	0.268	0.0139	43.31	14.7	5.8	0.55	88.5

The mid-bass driver is enclosed in a separate sub-chamber with an approximate volume of 13.5 liters. The near-field SPL response with the stock crossover is shown here:



The high pass is seen to be acoustically a 4th order slope with a response resembling a Butterworth (Q=0.7). With the crossover disconnected and the driver addressed directly, the near-field SPL is shown here:



We can see that the roll-off, as expected for a sealed box, is second order. But note that the response looks a bit over-damped- it conforms quite closely to what Thiele-Small predicts, i.e., a Q of 0.50. Evidently, the high-pass filter formed by C1 and L2 helps peak the driver's response near resonance to sharpen the transition to roll-off, bringing it up to pretty near an acoustic 4th order Butterworth. Removal of that passive filter means that we will have to peak the driver some other way.

Because our goal is to make the crossover symmetric, the target functions will be 4th order Linkwitz-Riley. One way to do it is to design an active high-pass filter with a sufficiently high Q to “peak” the overall acoustic response and sharpen the shoulder. That, of course, will only be possible at the driver's resonant frequency. The (to my mind) simpler and more versatile way is to reduce the chamber volume and use the box to achieve the same response. That way, one can achieve the acoustic 4th-order Linkwitz-Riley by cascading a standard second-order high-pass Butterworth active filter with a second-order Butterworth driver-box response.

A bit of examination of the parameters in Table 1 suggests that reducing the box volume from 13.5 to 6 liters will do the trick; the stuffing level can be adjusted to fine tune the Q and resonant frequency. The response of the driver in a reduced volume box, the passive high-pass crossover removed, and an active 110 Hz 2nd order Butterworth inserted is shown here:



It can be seen that the response is similar to the passive system, but with a bit more “hump” at 160-170Hz as the new transfer functions interact with the remaining 300Hz passive low-pass filter. This will pay dividends as we will see later.

Practicalities: Upper section

Make sure that your electric screwdriver’s batteries are well-charged: you’ll be pulling and remounting drivers repeatedly. First, demount the 6” Foster midbass driver. It may take a little urging with a thin-bladed screwdriver to break the seal. Remove and save the stuffing from the chamber. Our task is to reduce the volume by roughly 6-7 liters. The easy way to do this is to cut various lengths of 2×4 that add up to the right volume, then glue and/or screw them in place. You can artfully play with length, orientation, and position to try to break up any box modes (probably not an issue), but be careful of the driver clearance. The slanted front of the box makes the fit quite tight.

If you are truly a sick puppy like me, you’ll remember the old joke: “What’s gray, howls at the moon at night, and is filled with cement?”

“I don’t know, what?”

“A wolf.”

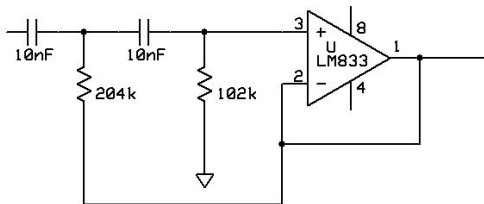
“A wolf isn’t filled with cement!”

“Oh, I just threw that in to make it hard.”

So this is how I took up the volume:

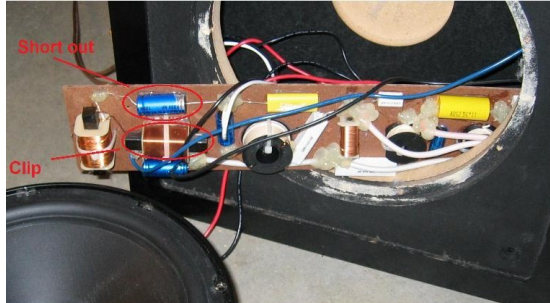


By playing with the stuffing density and distribution, you can tune the box pretty close to 100 Hz with a Q near 0.707. Use impedance measurements to verify, but if you put about 2/3 of the original stuffing in, you’ll be close enough. With the driver box providing a second-order Butterworth high-pass, the electronic crossover becomes easy to implement. Here’s a typical Sallen-Key network with appropriate values:



There’s nothing magic about this- there are any number of commercially available crossovers which would be suitable, and no shortage of buildable designs. An optimal way to do this is in the digital domain using either a soundcard or one of the many excellent digital crossover-equalizers like the popular Behringer DCX2496. We also need to get rid of the high-pass portion of the stock passive crossover, formed as a second order network by C2 and L3. C2 gets shorted, L3 gets clipped out. First, we need to get to the crossover. In most M3.3s, the crossover is built on two boards, with a smaller board for the 1259 mounted on the back wall and a long board for all the other drivers mounted on the bottom. The 1259 needs to be unscrewed to get in there, and will generally need

some urging to demount. One way to do that is to back out all the screws just slightly (maybe half a turn to a turn), then run a high level 10-15Hz signal into the woofer. When it lets out a fart, that means you've broken loose, so turn off the signal and remove the screws. With the woofer out, pull out some stuffing to expose the crossover board. You'll probably need to unscrew it and physically remove it to get to the parts that need



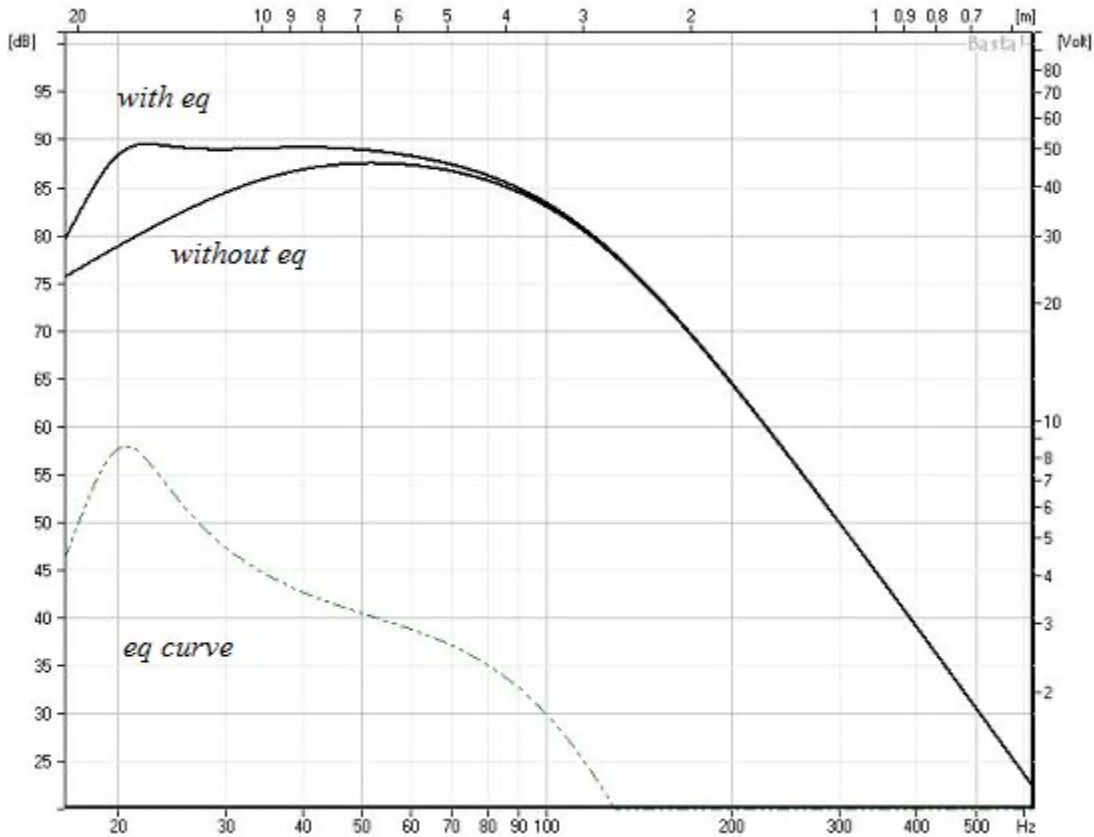
excision.

The Bass Section

Ok, I'm going to say something heretical- in this speaker, renowned for incredible bass, the bass is compromised. The Foster 1259 12" driver has a very strong motor and can pump a lot of air; the designers chose to mount it in a very well-damped sealed enclosure with multiple chambers. This yields a very tight and well-defined bottom end, with the woofer rolling off gracefully, albeit not at as low a frequency as it could. The slight limitation on bass extension keeps the speaker box volume relatively reasonable, though still not exactly tiny, at just under 3 cubic feet.

Now as compromises go, this is a reasonable one; the woofer will handle lots of power and be difficult to bottom. There will be no tendency to boom with casual placement and a -3dB point just below 30Hz isn't too shabby! A major contribution to this clean, well-defined bass is the superbly inert cabinet, and that gets prohibitively difficult to manufacture if the cabinet were to be made larger in the interests of extension. As it is, the enclosures weigh over 120 pounds because of the heavy construction and extensive bracing.

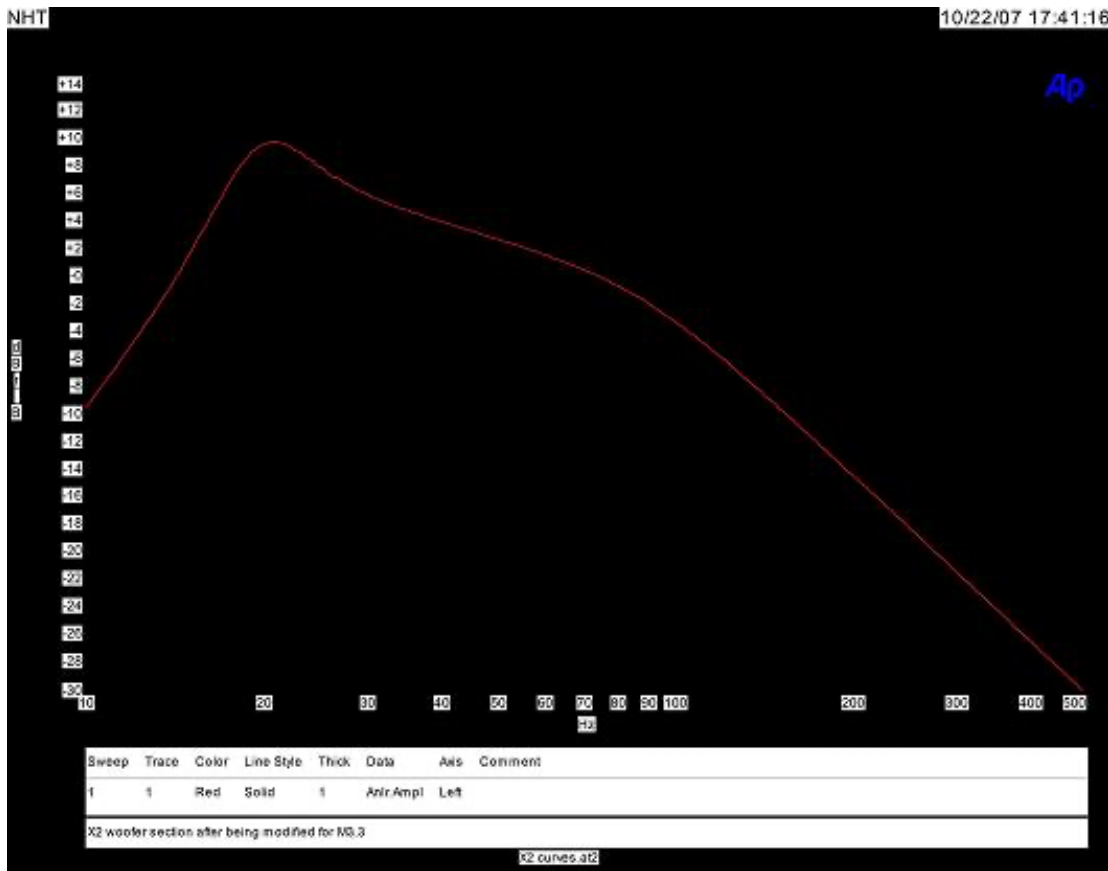
The curve below marked "without eq" shows the response of the 1259 driver in the M3.3 cabinet.



As one may surmise from the titles on the other curves, I'm heading toward shifting the compromises around. For a speaker that will primarily be handling music, we can throw bottom-octave caution to the wind and use some electronics to compensate for the bass roll-off and get a bit more extension. Again, this is an advantage of biamping- what would be a huge and impractical passive EQ network with about a hundred pounds of iron and a bank of capacitors the size of a suitcase is a piece of cake to do actively with a few ICs.

The eq curve shown is not exactly complete, it's just the closest I can model in Basta. But it does show the effect of adding 10dB of boost at about 20-21 Hz. The "real" eq curve will have a broad hump at about 35 Hz, so it won't show the broad dip of the modeled curve.

The actual target eq curve is shown here:

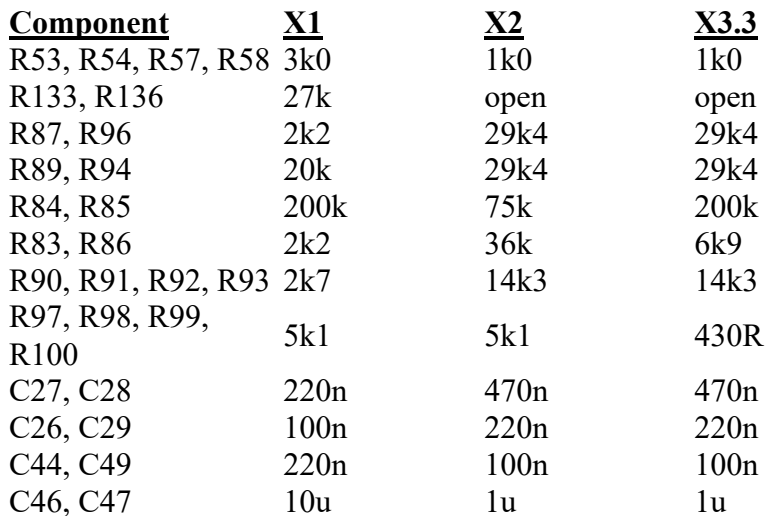


This is pretty easy to implement with some op-amps or digitally.

Practicalities: Bass section

A very elegant way to do the required equalization is to modify one of the X series electronic crossovers from NHT. The commercial versions were the X1 and X2- these crossovers are very similar, but have some of the boundary equalization and LF highpass filtering shifted around a bit. With some effort, they can be found new, in which case what I describe here voids the warranty, and does so with extreme prejudice. However, X crossovers are pretty easy to find on EBay, Audiogon, and other For Sale sites. Figure to pay \$150-\$200 for one in good condition. For your money, you get a very nice case, great control flexibility, variable phase, and a built-in reasonably competent high pass filter for the upper section. Inputs and outputs are available balanced (XLR) or unbalanced (RCA). The schematics and parts numbering for both models is the same; only a few values are different. Likewise, either can be converted to run the M3.3 project, providing the proper EQ to the 1259 woofer.

Here is a schematic indicating the parts which are different between the crossover models and a table showing the values for the X1, X2, and the X conversion for the M3.3: (click to enlarge)

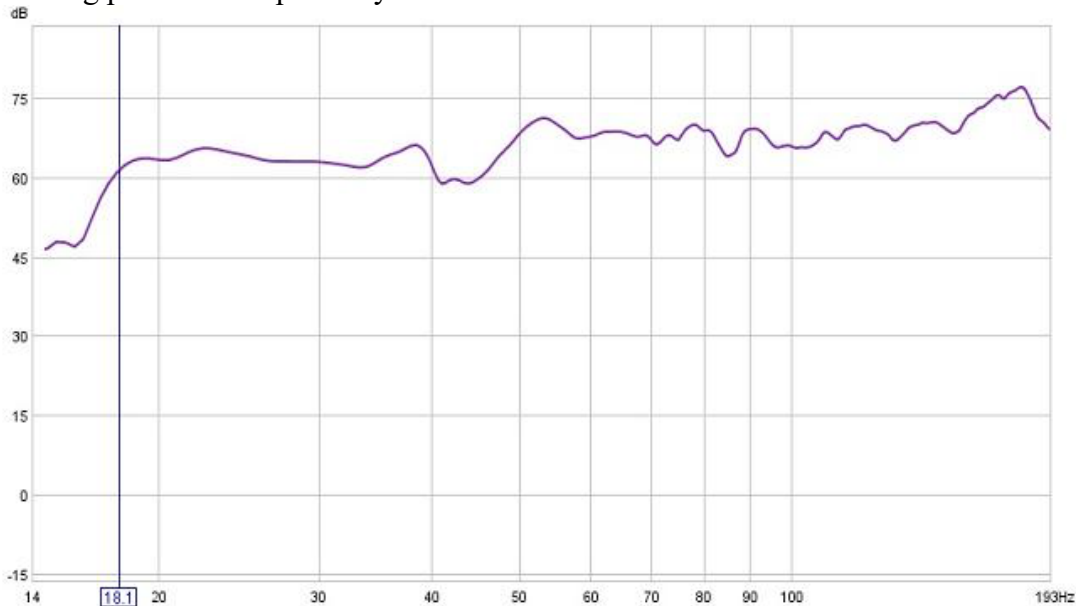


12

The snooty audiophile, like me, will avoid using the high-pass section of the X3.3 and will build his (I use the gender deliberately) own 2nd order Butterworth at 110Hz. In my case, I used a tube buffer similar to the Heretical. But for the other 99% of the world, the circuit in the X3.3 is Good Enough.

Proof of the Pudding

How does it all work in practice? Here's a spectrum, using the excellent REW software, of the in-room response of the stereo pair at my listening position (about 2.5 meters). 1/48th octave, so no makeup. The SPL scale is relative, not calibrated- SPL at the listening position was probably about 85dB or so.



There are a few things of note. The bad news is the glitch at about 40 Hz and the 3dB shelf-down of response below that point. This is a nice measure of the point at which the plasterboard room boundaries cease to be reflective and the walls “breathe” with the bass. Yow! Well, I can’t blame the speakers for that. The good news is our 110 Hz crossover point- it’s seamless! I can wave the mike around for a foot or so without seeing any sort of notch or peak there. Given the large driver separation, that’s pretty damned impressive. More good news is that the Allison dip in the 160Hz range is entirely absent. Credit the hump in the mid-bass driver’s response, along with careful attention to the phase through the crossover range.

The faster-than-textbook HF rolloff of the midbass driver also contributes to the impressive midbass, compensating for baffle loss and flattening out the response through its passband.

And I hesitate to mention it, but... notice the bass -3dB frequency?

Subjectively, the bass seems almost casually even and well-defined. There’s no sense of the transition between the various drivers, images are solidly fixed. Effortless and natural.

[illegible]

14