

Introducing the Sopranos

By Jeff Bagby

Introduction

Introducing the Sopranos – they sing in duet (and sometimes with bass accompaniment).



Recently my brother picked up a HT receiver and was in need of some speakers to go with it. I had several sets sitting around, but he felt all of them were too big for what he was looking for, so I suggested that we build what he really wanted. We sat down and worked up exactly what he felt was ideal and then I began to look into potential drivers to use. Mark at Meniscus suggested that I consider the **SB Acoustics SB12NRX** as a possible driver, and since I have designed four speaker systems using all SB Acoustics drivers I thought a fifth one might be in order, so I decided to give it a try.



<http://meniscusaudio.com/sb-sb12nrx254-p-1299.html>

For tweeters I went with another SB Acoustics tweeter as well, the SB26STCN-04 which is a small flange 1" dome tweeter with coated textile dome, short waveguide, damped chamber, and a neo magnet. It turned out to be a very nice tweeter for the money. It works very well for systems with small baffles, tight driver spacing, and even low crossover points.



<http://meniscusaudio.com/sb-sb26stcn4-p-1206.html>

I have designed and built a lot of speakers over the years. In the early days this was done without any serious measurement equipment and with novice working knowledge of speaker design. Still, many of these speakers turned out sounding quite nice. However, there were always some that disappointed me because I never could seem to get them to sound as pleasing as I had expected. Looking back, I was probably dealing with frequency response anomalies that I was not able to tame due to my lack of measurement ability and design knowledge.

As time went by my knowledge of speaker design grew, and with that growth came measurement systems and computer modeling techniques, and designs that were quite refined. It became rare for speakers to not meet my expectations when they were completed, at least from a technical point of view. Sometimes though, their overall sound, imaging, dynamics, etc. would leave me feeling a bit unimpressed. Most of the speakers met my full expectations though, and turned out quite nice, and I was happy to put my name on them. And, every now and then, a design would surprise me and the speaker would come together in a way that would exceed my expectations and leave me quite impressed with what it was able to deliver. This was the case with the “Continuums”, whose vocal resolution was something I had not fully expected, even though that was goal. It is also the case with my “Kairos” Satori two-ways that sound so balanced and resolving that I will probably never give my pair up.

Why do I bring all of this up? Because, the little Sopranos are another one of those speakers that came together to not only meet, but exceed my expectations. I designed them for a certain level of flexibility in placement based on my brother’s application, and that goal was a tremendous success, as these speakers are well balanced whether sitting on a stand away from the walls to sitting on a desktop. Sure, the sound is different in both positions, but there are no serious deficiencies either way and you quickly adjust to their balance in either position – especially if you are using a subwoofer when you have them sitting on stands. Listening to the little Sopranos on a nice tall set of stands with subs dialed-in convinced me that I could live with these speakers indefinitely and would have very few regrets.

It is because of their small size, low build cost, high quality of their reproduced sound, and versatility of placement and use, that I have decided to post the full design here and give others an opportunity to build a set if a speaker like this will meet their needs. I know some of you guys are true craftsmen and artists with wood and I would love to see what you come up with and hopefully, I will get to hear another set or two at some upcoming DIY gathering and happily chat with the builders.

The Cabinet and Low Frequency Design

My brother decided on a cabinet that is relatively small. It even looks small sitting next to my Continuums, which are generally a tiny speaker. Sure, there are some mass produced plastic speakers that are smaller than these, but the Sopranos aren't that kind of speaker....

The cabinet measures 6.5" wide by 10.5" tall by 8" deep. It is made of $\frac{3}{4}$ " MDF with an internal brace. The final volume is 4.7 liters or .17 cubic feet. Both drivers are centered horizontally on the baffle with a space of 3.8" between them. My brother decided to finish his cabinets using a flat black Rustoleum truck bed-liner which matches the color of the drivers so well that finished pics are hard to see well, so I will include some pics before the cabinets were painted for clearer presentation.

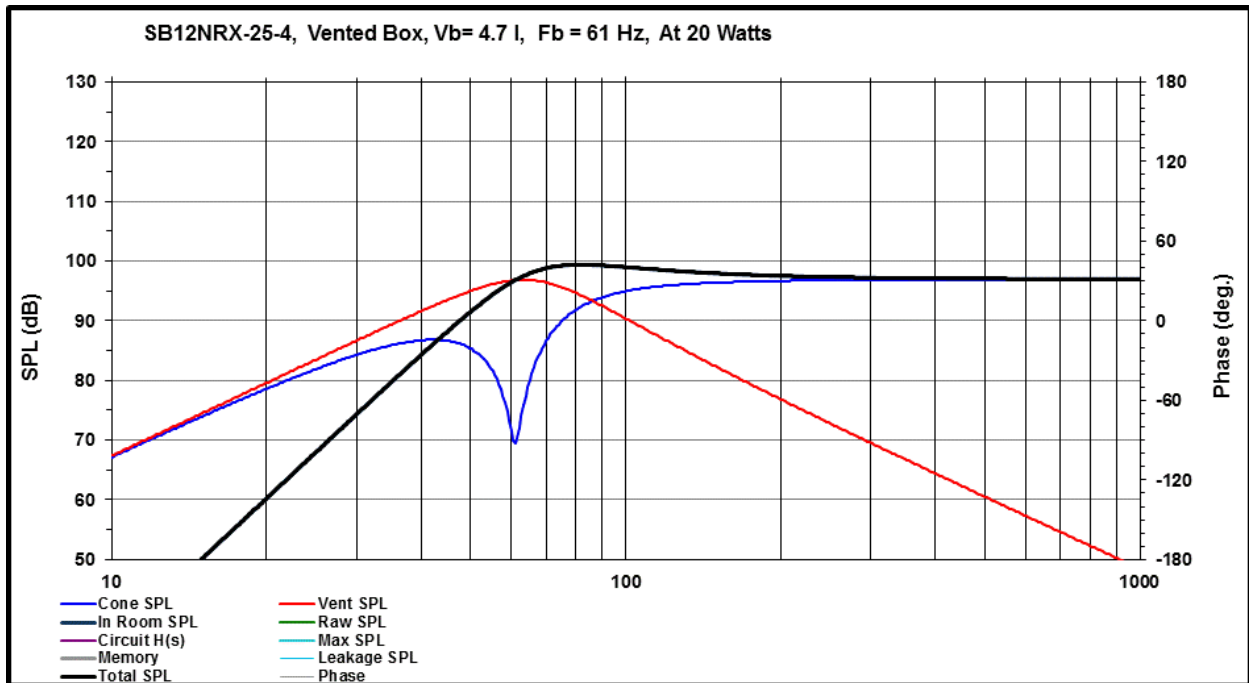


These speakers are ported on the back. I used a standard 1.25" diameter adjustable port that Meniscus sell. To make it even easier, I used only the inside section with the mounting flange. This leaves the port a little over 4" long and tunes this enclosure to 61Hz. However, since this port is adjustable I will give you some options. Here's a pic of the front and back of the finished painted enclosure.

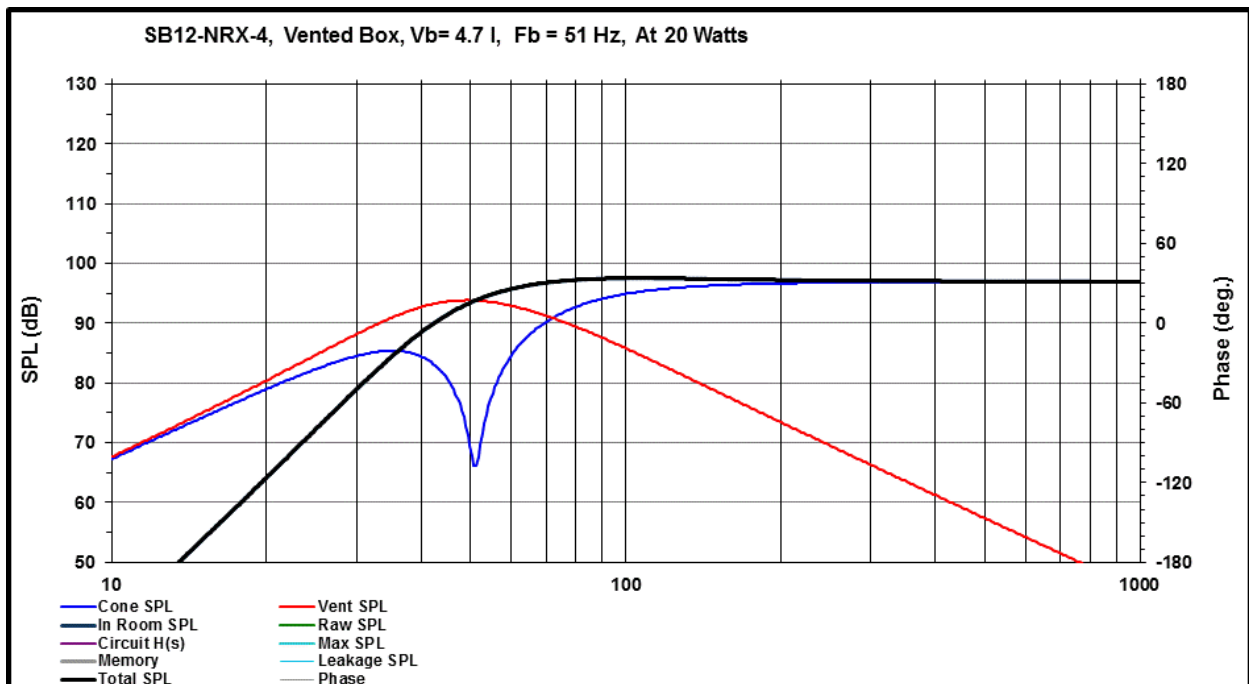


One of the things I have learned over the years concerns the relationship between the room, the speaker's F_3 , bass tuning, and our perception of the bass response. I have found that when speaker roll-off in the 100 – 70Hz range a small hump of 2-3db just above the roll-off frequency can make the speaker sound more balanced and even more extend. This is the same thing Harwood did at the BBC in designing the LS3/5a. But if a speaker extends into the 50Hz range then a little hump works best, one of only 1-2dB. If a speaker extends to 40 Hz or so then it sounds the most balanced if it is as flat as possible. And finally, if a speaker extends below 30hz, and especially if it reaches 20Hz, then an over damped response with a gentle drooping at the bottom end sounds the most balanced in most rooms due to room pressurization gain.

The SB12NRX25 is able to reach below 60Hz in this tiny box – a nice surprise, indeed. Because of this, I designed a small hump in the response of 2dB centered at 80Hz using the 61hz tuning frequency. This nets a -3dB down point of 59Hz and a -6dB point of 53Hz. Here is a graph showing that response using the single inner port section that is about 4.2 inches long.



If, on the other hand, you prefer a flatter alignment then you can use both sections of the port and glue it for an overall length of 6.5". This gives you a tuning frequency of 51Hz, a -3dB point of 53.6Hz and a -6 dB point of 45 Hz, but power handling with a be little less at too. Here is a chart of that response.

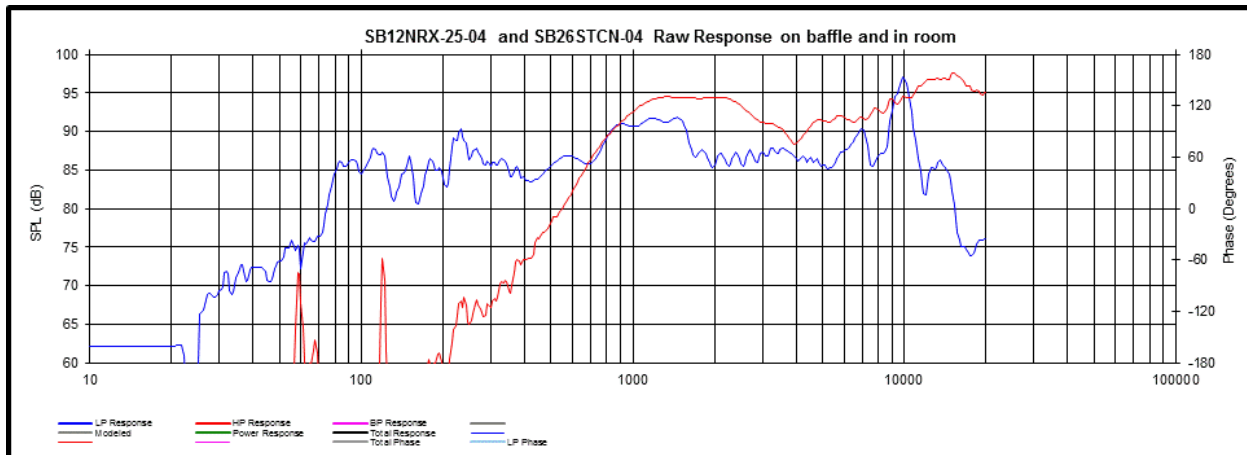


Of course, you can set it anywhere in-between and tune to taste as well.

Crossover Design

The problem with a small cabinet is the somewhat more severe impact of cabinet edge diffraction and the effects of a small baffle. In this cabinet there is a pronounced diffraction peak in 800 – 1.5kHz region in the midwoofer's response and the tweeter has a broad diffraction peak centered at about 1.8kHz. Edge diffraction also results in a notch in the tweeter's response at 4kHz.

Here's the raw response at one meter on the baffle - no fancy smoothing here.

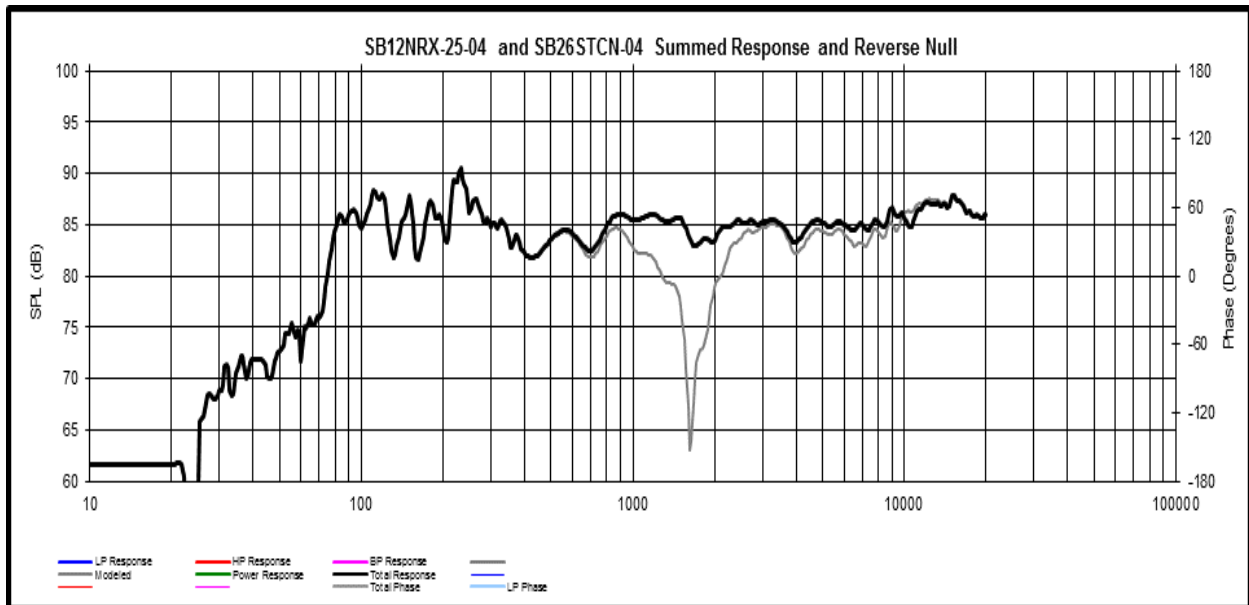
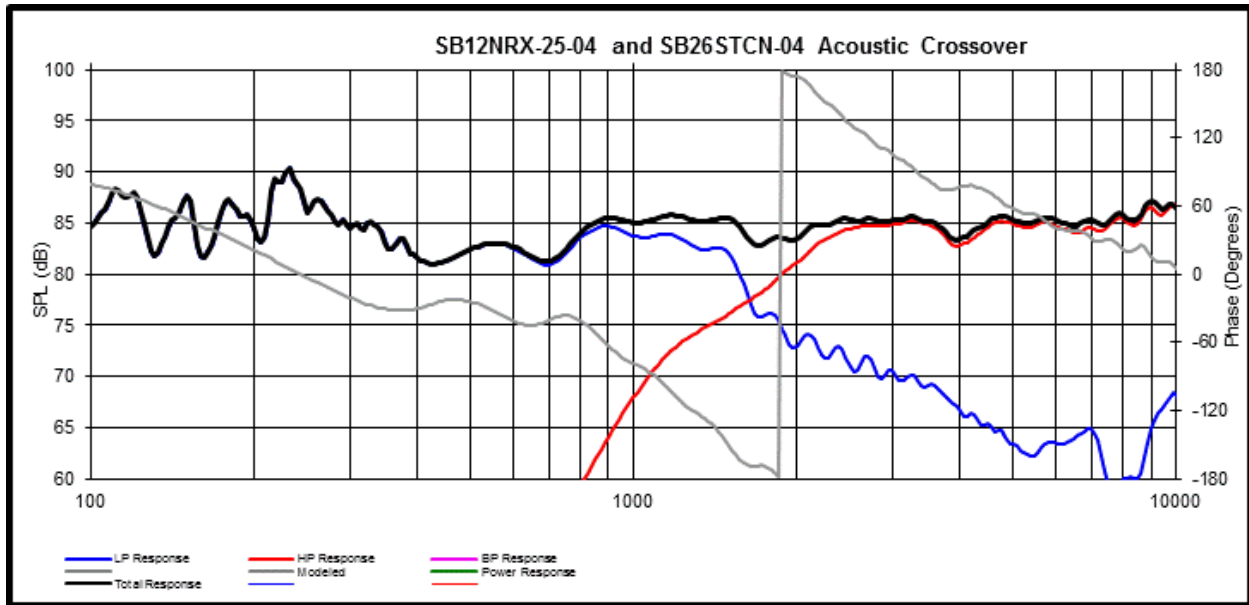


A crossover will need to deal with these diffraction affects as well as blend the drivers for a smooth, flat summation and deal with the acoustic offset as well. For those who are interested I measured the relative acoustic offset between the tweeter and midwoofer to be 17mm (woofer acoustic center behind the tweeter's acoustic center).

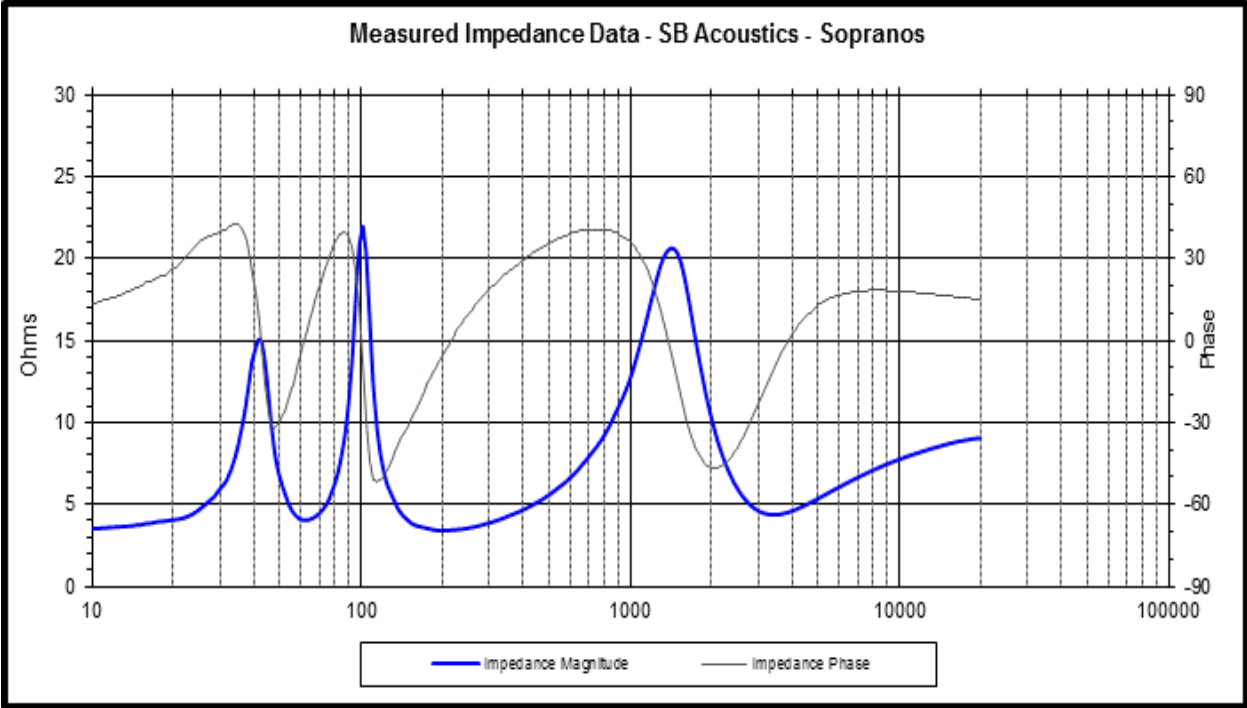
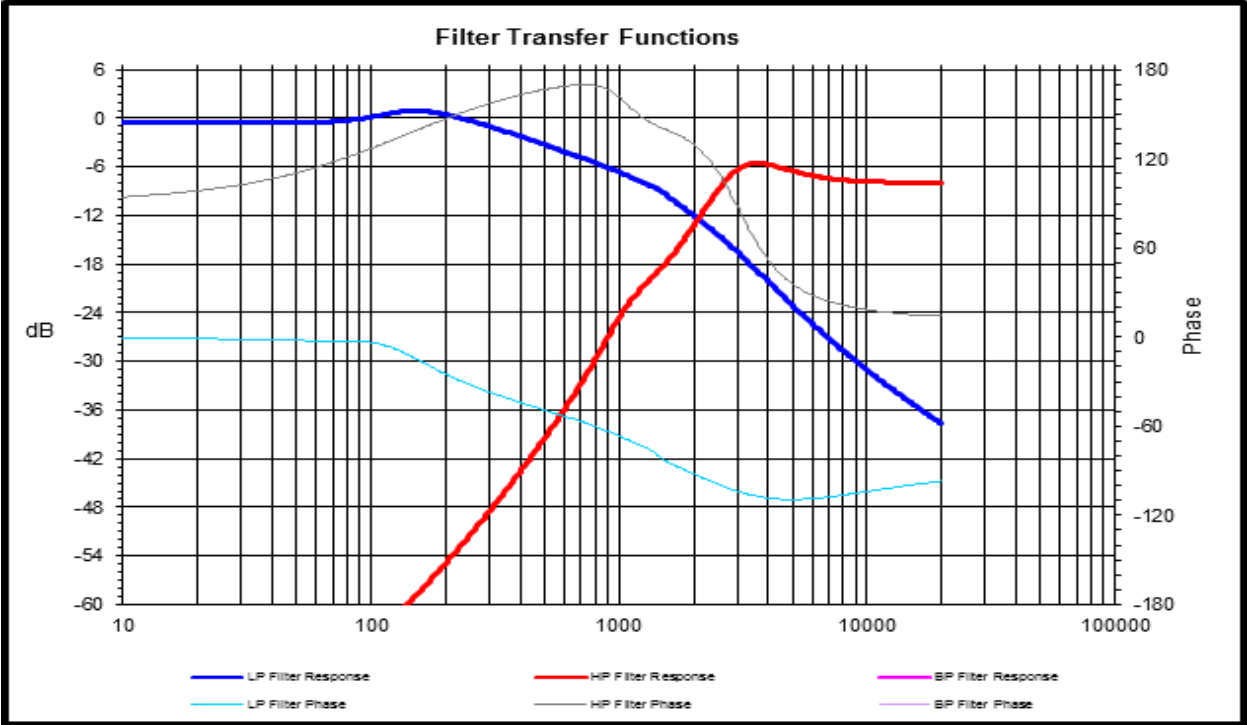
As is typical, I used asymmetrical slopes in the crossover to accommodate the driver offset. I found that shallower slopes resulted in a better summation, integration, and better phase tracking between the drivers. As a result, the woofer is rolling off second order acoustic (12dB/oct) and the tweeter is rolling out at 18 dB/oct in the crossover region. The best results were obtained with a fairly low crossover point of 1.7kHz, which also gives a very wide, smooth off-axis response.

With this crossover point a relatively simple crossover circuit accomplishes many things at the same time. I get smooth on-axis summation, excellent phase tracking between the drivers, and excellent control of the diffraction effects, all with a crossover with relatively low cost and parts count.

Here are some charts showing the acoustic crossover, the reverse null, the crossover transfer functions, and the resulting system input impedance, which is typically a 4 ohm system, but also a fairly easy load to drive for the most part.



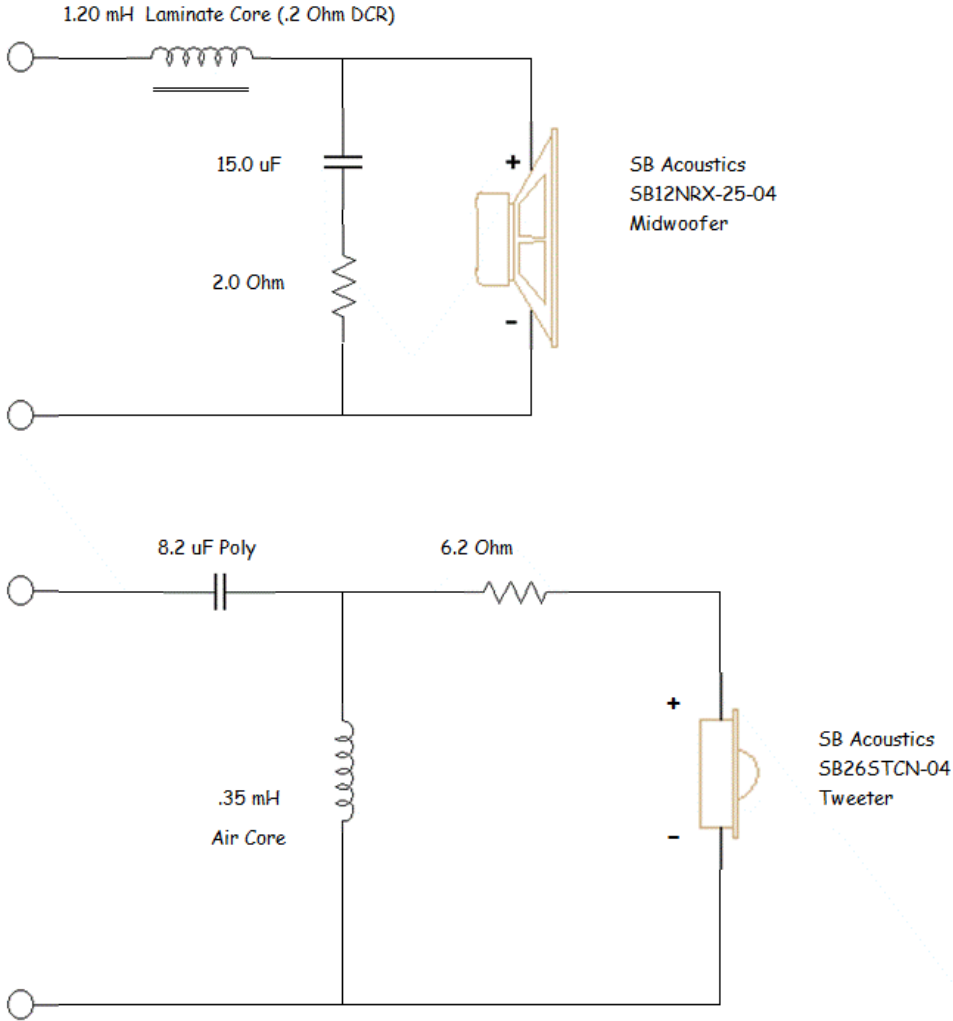
(Ignore the response below 300 Hz in this chart due to the gating time used)



Here is the crossover schematic.

Crossover Network for The Sopranos

by Jeff Bagby 1/4/2013



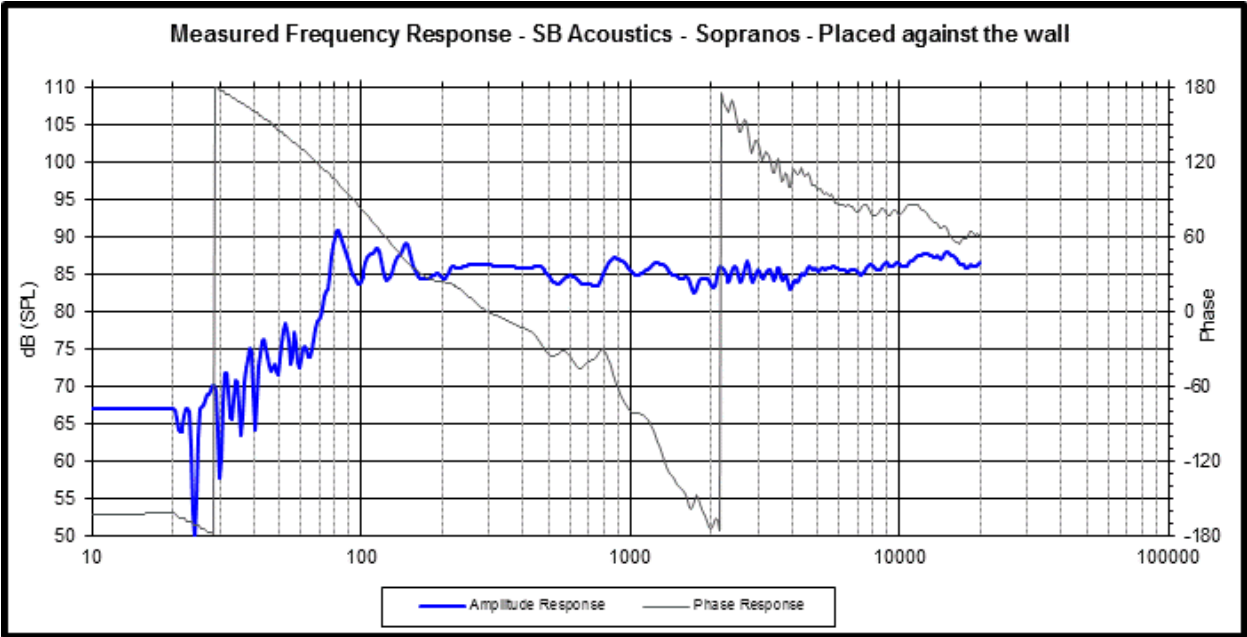
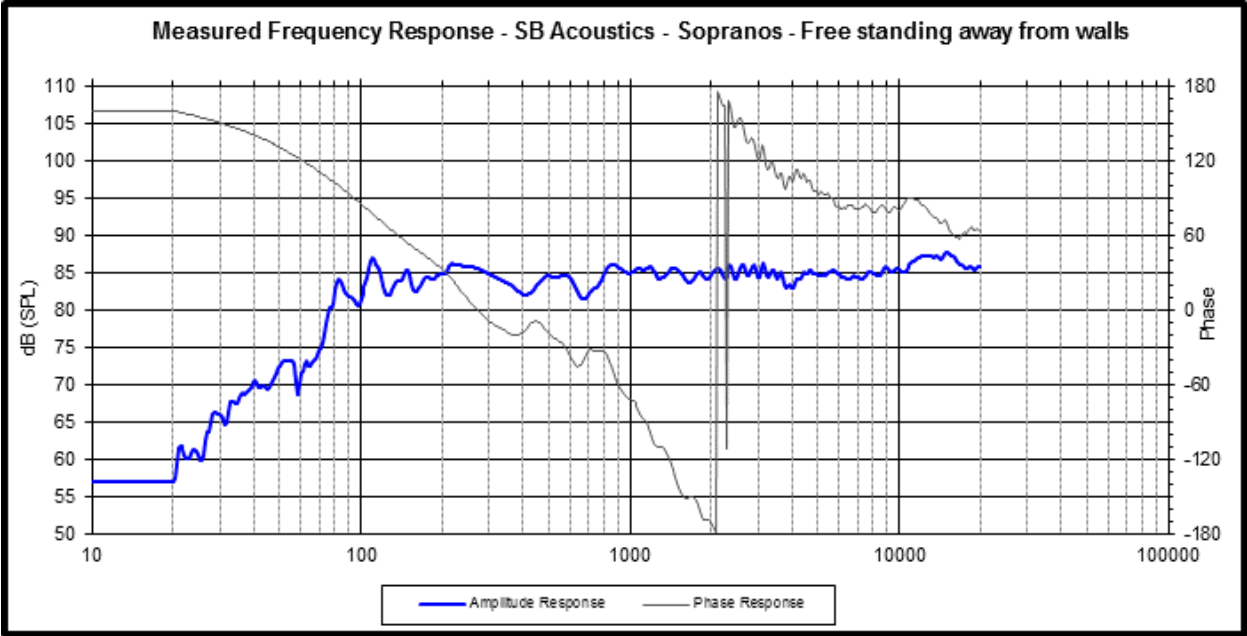


Make sure your crossover boards can fit through a hole 3.75" in diameter. Here's how I laid mine out on the board.

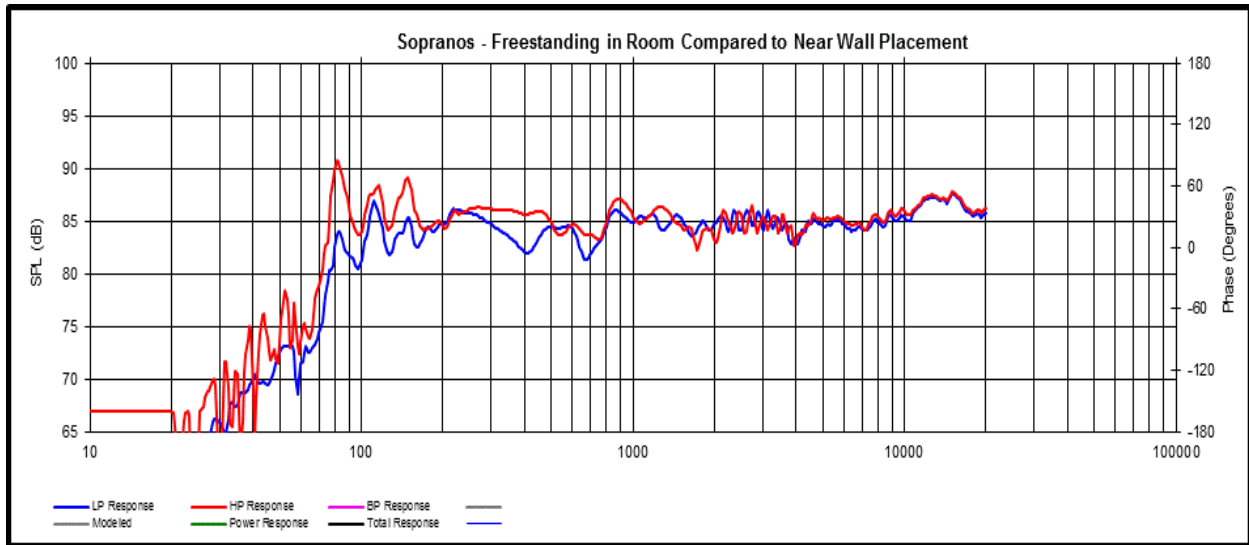
Placement Applications

As I mentioned earlier, this speaker was design to work as well as possible in a wide range of applications. I listen to small speakers typically on a stands away from the walls. My brother, on the other hand, will have these on shelves or wall brackets flanking his TV. I also knew that some people might like them on a desk as computer speakers powered by something like the Dayton DTA-100 or other tripath amplifier. So, I compromised the tonal balance to fit between to extremes of boundary reinforcement. The sound is a bit different, but whether sitting free-field or against the wall (with a couple inches for port clearance) or on a desk, they sound satisfyingly balanced to me and I am quite happy with them.

Here is the actual measured response at one meter on stands in the middle of my family room and with the stands moved up against the wall.



Here they are overlaid for comparison:



The effect of the boundary can be seen, but the design works well in either location. The dip in the response in the free-field response is similar to that of the LS3/5a and is not nearly as noticeable as you might be inclined to think, and vocals sound extremely lifelike and open from these speakers. These Sopranos really sing.

Final Comments

For a size reference here is pic of the Soprano next to the Continuum, which is normally considered a very small speaker. As you can see, the Soprano is smaller yet.



I have developed a very small high output subwoofer for my brother as well with very good results. I will present that design in another thread.

I hope the Sopranos will appeal to many of you looking for a small speaker with high sound quality and available at a fairly low cost. And at the very least, I hope this write-up will help to illuminate the design process a bit for those just stepping out in DIY speaker building.

If you would like a set of Sopranos, contact Mark at Meniscus and he will set you up with all of the parts discussed in this report.

Jeff Bagby

