

The Live Edge Beryllium Dipoles

Perry Marshall

With plans & links to digital crossover files



SB Acoustics finally released their long-awaited TN29BNWG Beryllium waveguide tweeter. This driver delivers an *insane* level of holographic 3D imaging, clarity and definition – to a degree most listeners have never experienced. Best tweeter I’ve ever heard. Guitars, drums and percussion instruments reach out and grab you with incredibly realistic detail. Ride cymbals sound like real cymbals instead of polite imitations of a drum set.

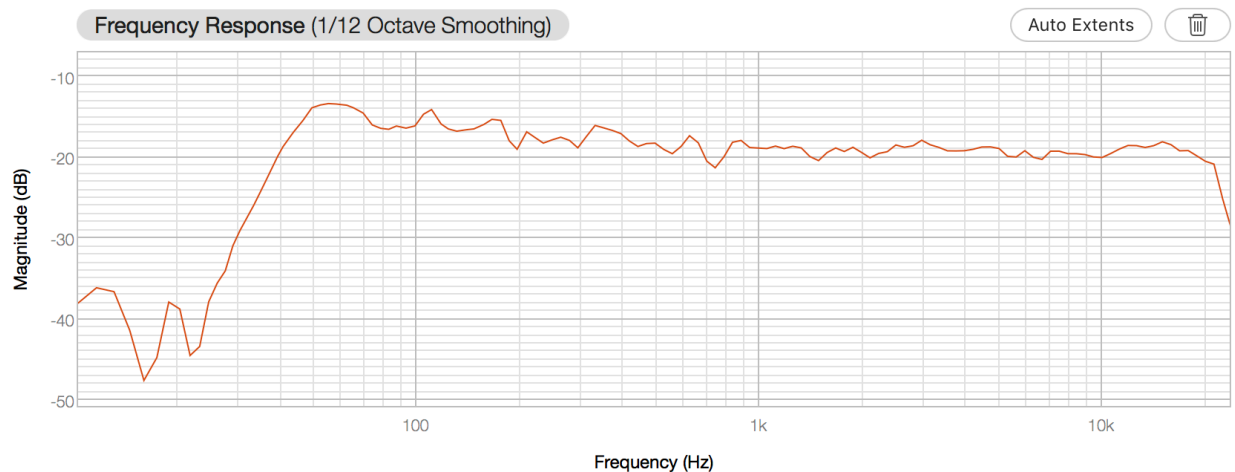
It’s paired with a 15” Lavoce WAN153 midbass driver on a Live Edge Cottonwood Open Baffle “U-shaped” design with digital crossover. The system projects a constant directivity radiation pattern across the entire spectrum with super wide bandwidth, making these one of the most high-definition speakers ever made.

The stereo imaging is stunning and three-dimensional. Instruments solidly present in the space front of the speakers, filling the room with the illusion of live instruments. And for carefully engineered reasons I am about to describe, imaging stunning for every seat in the house, not just the sweet spot.

These extend from 39Hz to 35KHz. Sensitivity averages around 98dB, and the low bass which needs EQ to compensate for the open baffle, SPL is around 90dB. That’s why these have incredible dynamics and dynamic range to burn. They are incredibly fast and transparent with exquisite detail and resolution. At the same time they have a rich, warm lower midrange and ambient bloom.

If you’re into Single Ended class “A” tube amps and the like, these will play as loud as you like on tiny amounts of power. If you’re into ZZ top and 200 watt amps, add a subwoofer and these will tremendous power and produce 120dB with ease.

Because of the Open Baffle design, they have a *huge* soundstage and a rich, warm, room-filling lower register that beautifully complements the extreme high-definition top end.



Above: Response in a real room 18” in front of the speaker.

The cabinets are cut from slabs of live edge cottonwood purchased from Schroeder Hardwoods in Harvey Illinois, constructed by Seth Cothron of Studio38 Designs (@Studio38). Seth beautifully angled and rounded the sides, adding light stain and lacquer. He fashioned flush grill hoops that mount perfectly flush with the drivers, eliminating diffraction problems.

They are biamped. The only passive components are a resistor and capacitor on the rear tweeter. Front-firing woofer and tweeter are wired directly to the amp for maximum control. A MiniDSP 2x4HD digital crossover provides a 1500Hz handoff between the drivers with zero phase shift.

You can never achieve great imaging without careful attention to radiation pattern!

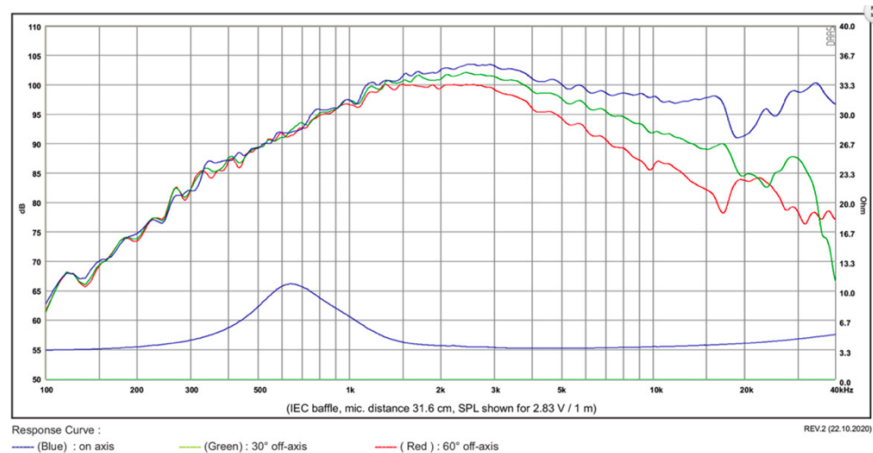
This department of speaker design separates the men from the boys. Floyd Toole's book *Sound Reproduction* chronicles Toole's 40 years of professional experience and one of his maxims is this: Flat response on-axis and lousy response off-axis is a dead-giveaway to your ears that you're listening to artificially reproduced music. On the other hand, when you get radiation pattern right, the results will impress everyone.

Radiation pattern is one of the most important and overlooked aspects of a speaker. A good radiation pattern makes a *huge* contribution to how realistic the sound is. A speaker with great response on axis and bad response off axis will inevitably sound unnatural. With a good dipole, you frequently find yourself marveling at how realistic the illusion of live sound is.

Constant Directivity is what you really want. Constant Directivity means you get flat frequency response on axis, and as you turn the speaker in any direction, the level steadily drops off axis, yet the octave to octave balance remains even. Then imaging will be great *anywhere* in the room.

The best way I know of to achieve this is with a Constant Directivity horn. Horns are much trickier to work with – they almost never have perfectly flat on-axis response, and you have resonances and complex impedance loads to deal with. However, CD horns are mathematically optimized towards this ideal radiation pattern, and the good ones achieve it.

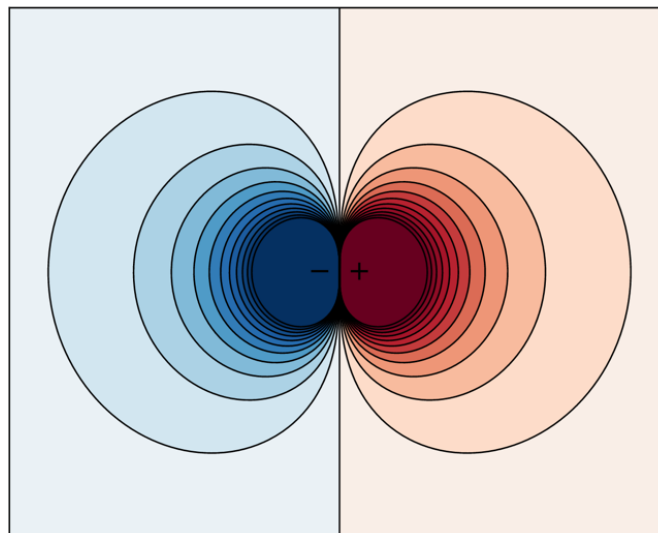
The SB Beryllium tweeter is fitted with a waveguide, which transforms a standard dome tweeter (which by definition is *never* CD) into a CD source. You see this in the factory frequency response curve:



As you see, the difference between 0 degrees in 60 degrees broadens gradually from 3dB at 2KHZ to 15dB at 15KHz in a very well-behaved family of curves. This means: When your speakers are angled towards the listening spot and you're standing next to the left speaker, you can hear the right speaker equally well, all the way across the room - and you still get a good stereo image.

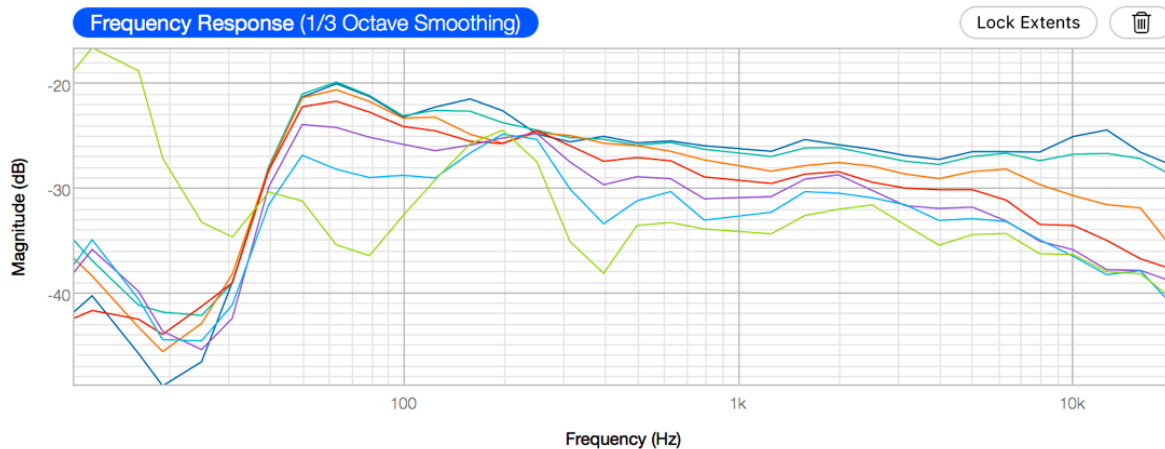
So... if you mate it with a woofer with a similar directivity pattern... but a constant directivity woofer is impossible – *unless you build a dipole*. A dipole gives a “figure 8” radiation pattern where the front and back give strong on-axis response, and the back wave progressively cancels the front wave as you move off axis.

On the side, which is top and bottom in this diagram, the front and back waves cancel out:



Therefore... if you design a dipole using a coaxial woofer where the tweeter is a Constant Directivity horn – and if you add a CD horn tweeter on the back to make back and front symmetrical – you get a true Constant Directivity response both front and back. The dipole configuration automatically makes the woofer into a Constant Directivity source.

This is what I've achieved here. This is the family of response curves at 0, 15, 30, 45, 60, 75 and 90 degrees:

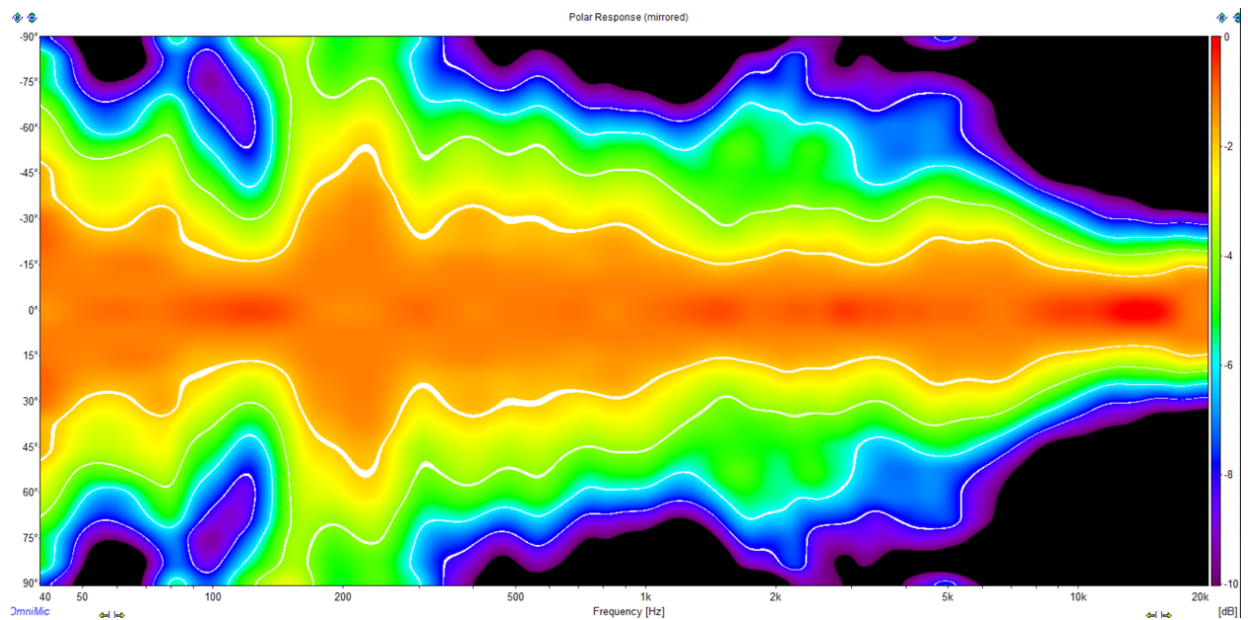


I the only other speaker measurements I've seen that can do this is another pair of 3-way dipoles I also designed (www.tinyurl.com/liveedgedipoles), which are featured in AudioXpress magazine January 2021. I wanted to accomplish something similar in a simpler 2-way design. The idea was: "If I were going to take 2-way speaker to a desert island, what kind of speaker would I want? How can I stretch the performance of a 2-way to the absolute limits?"

You'll notice that the curves "bunch up" in the octave around 200Hz. This is because of the "U-shape" of the open baffle design I chose. The triangular side panels extend the low frequency cutoff by about an octave. If these sides were not there, the low frequency roll-off would begin at ~120Hz. With the sides, the Open Baffle cancellation begins at around 60Hz so this buys us 6dB of output at low frequencies.

The penalty for this is that the radiation pattern goes "cardiod" and reaches towards the back from about 150Hz to 300Hz. This is because the wavelengths are short enough to start to be directional but not long enough to cancel from the backside. The null points are somewhat behind the speaker instead of directly to the side.

Despite that, this system achieves constant directivity across the entire range. This is a Polar Heat Map from 50Hz – 20KHz:

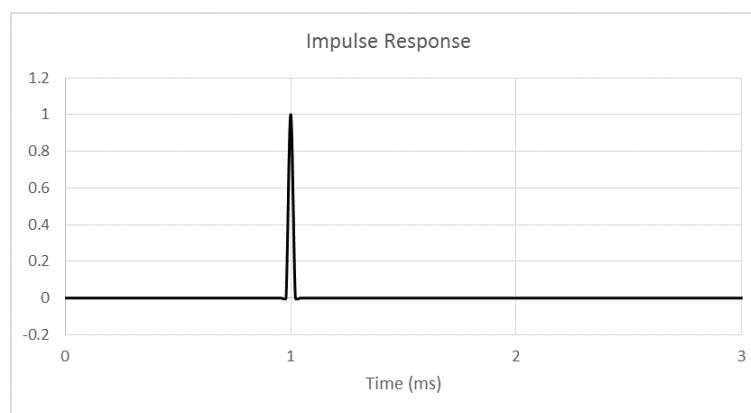


Again, other than perhaps a *huge* full range horn designed for stadiums (i.e. from Danley Sound Labs) I've never seen a speaker with such a consistent radiation pattern across the range. Most graphs like this start at 500Hz because there's no point in showing the pattern for low frequencies, because it's 360 degrees.

Meticulous Attention to TIME and PHASE

Another department that separates the men from the boys is phase response and impulses.

Impulse response is when you feed a signal into the speaker that's almost an infinitely short spike, like this:

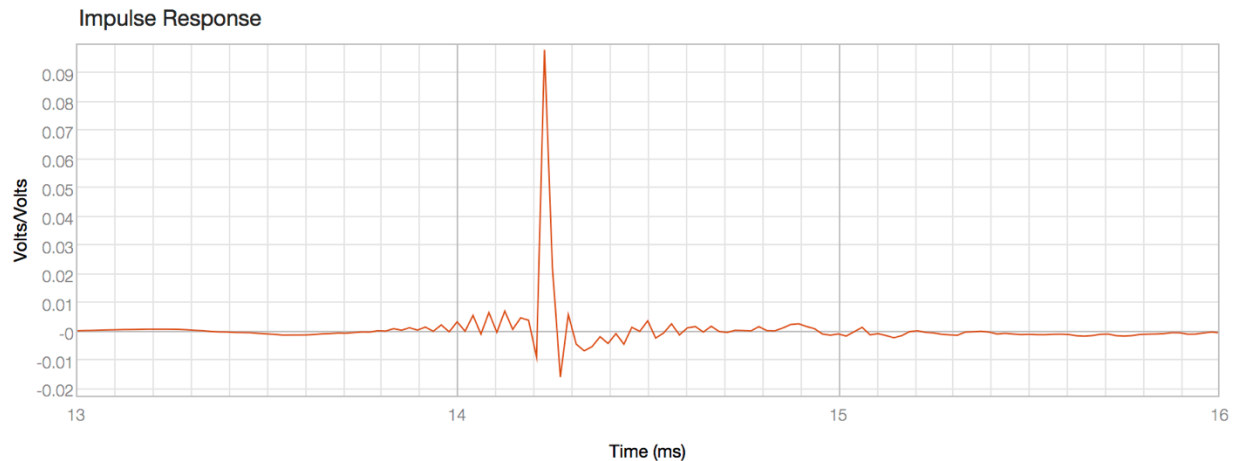


Ideally what comes out should look similar. But if you stop and think about a voice coil pushing a cone back and forth, it's not hard to imagine that the output could get pretty sloppy.

Most speakers *butcher* impulses.

Well it gets worse than that because the more woofers, tweeters and crossovers you have, the more time delays and time distortions you get.

These are precise to $1/20,000^{\text{th}}$ of a second as you see here:



This doesn't even look like an impulse response for a speaker. It looks like the impulse response of a CD player or Digital to Analog converter!

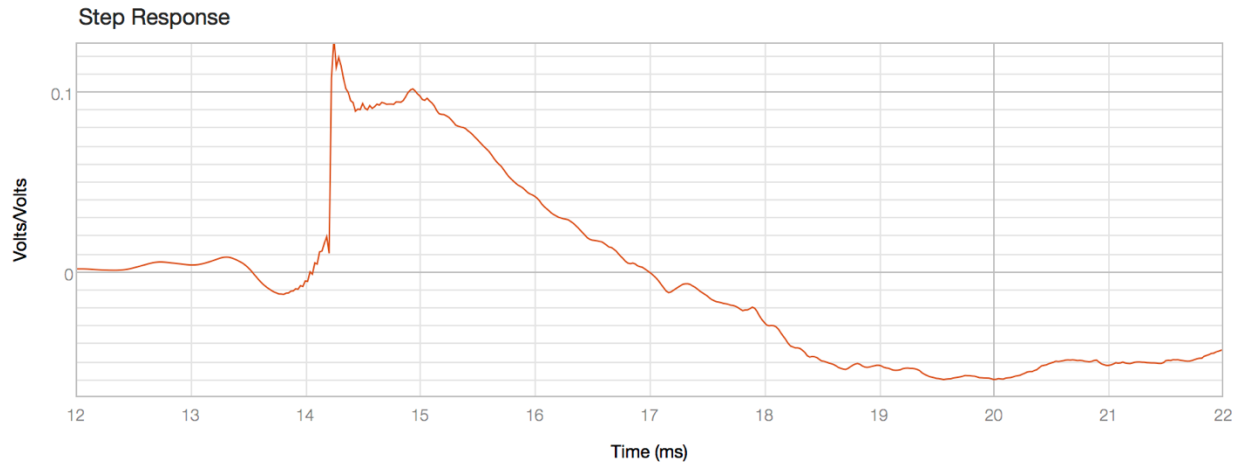
Time is *very* hard to get right. It's one of those things where you push in on one corner of the universe and another corner pops out. Most designers don't even try. (Modern DSP helps a lot.) So if you think of this in terms of stored energy, most speakers have very "cluttered" representation of detailed information. Mostly they just turn fine details into mush. Or, if you get impulse right, something else suffers.

Now... why is this important? Why should you care?

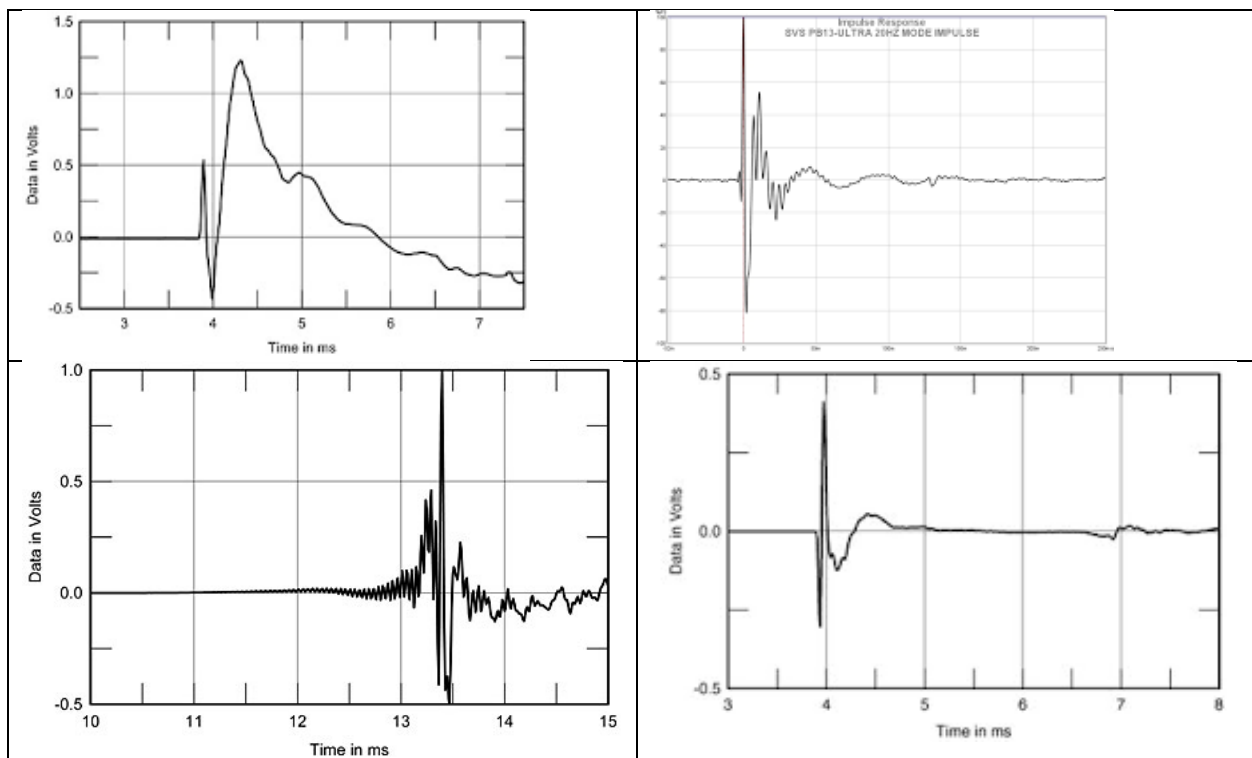
Because you can hear that. Well if you listen to things like snare drums, cowbells, cymbals, any sort of percussion whatsoever, you will find these speakers beat just about every other design you've ever heard in terms of clarity and detail. So like for example lots of jazz recordings have "ghost notes" on the snare drum. Light taps the drummer uses to add flavor.

The sound of those taps is extremely delicate but if handled right you can hear the entire body of the drum vibrate. The shell, the snares, the head, everything. You hear the impulse resonate through the body and hardware and wires. You can hear the sound of the stick on the drumhead. You can instantly tell whether the drummer is using a regular stick or a wooden bundle stick on a ride cymbal. You might even be able to tell whether the stick has a wooden or plastic tip. These speakers preserve those extremely delicate textures.

The Live Edge Beryllium Dipoles are optimized for percussion. The sound is free of grit and "aluminum dome hardness" – Beryllium has a shimmery liquid signature sound. You can hear the space around instruments. You can hear the silence between the pulses.

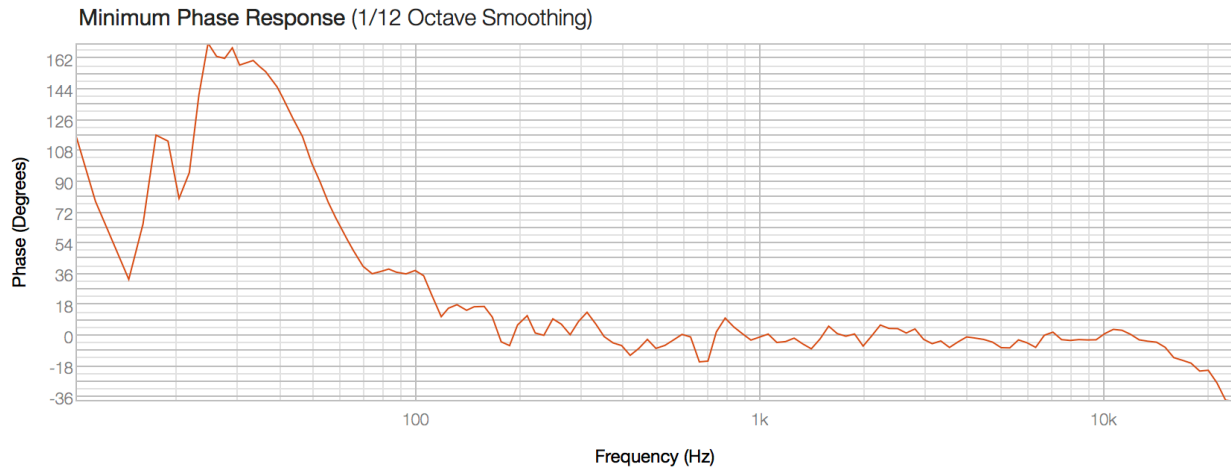


Above is the “step response” which is what the speaker does when the voltage goes from 0 to 1 and stays there. These decay very nicely. Compare to below, a collection of very typical impulse responses from real speakers that you buy in stores:

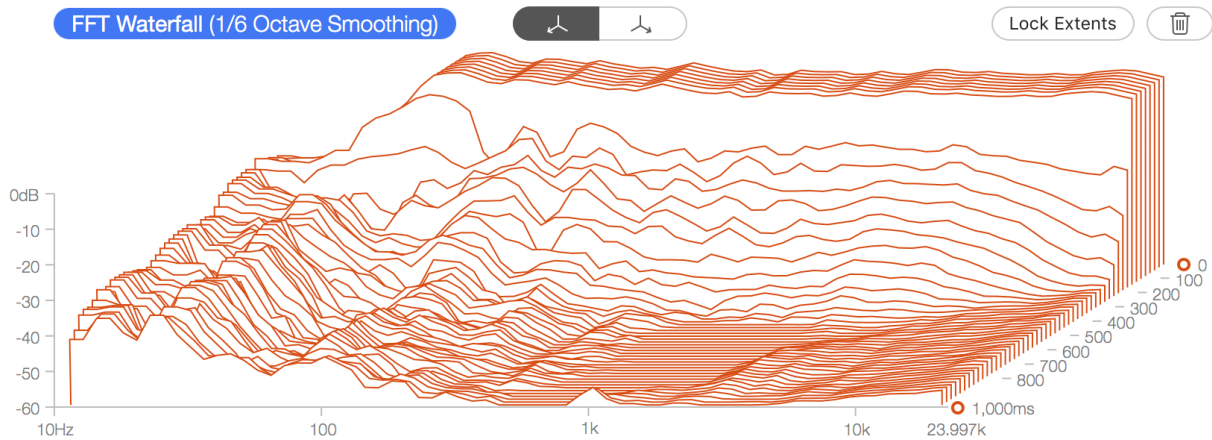


Woofer fires forwards... midrange fires backwards... tweeter fires forwards.... None of them arrive at your ears at the same time. All the above speakers are expensive, respected designs reviewed in international audio magazines. Not hacks.

The benefit to this is that because your ears use time information to locate the direction of sound, you get a 3-dimensional sound stage and you can hear the spatial cues of a grand piano or drum set.

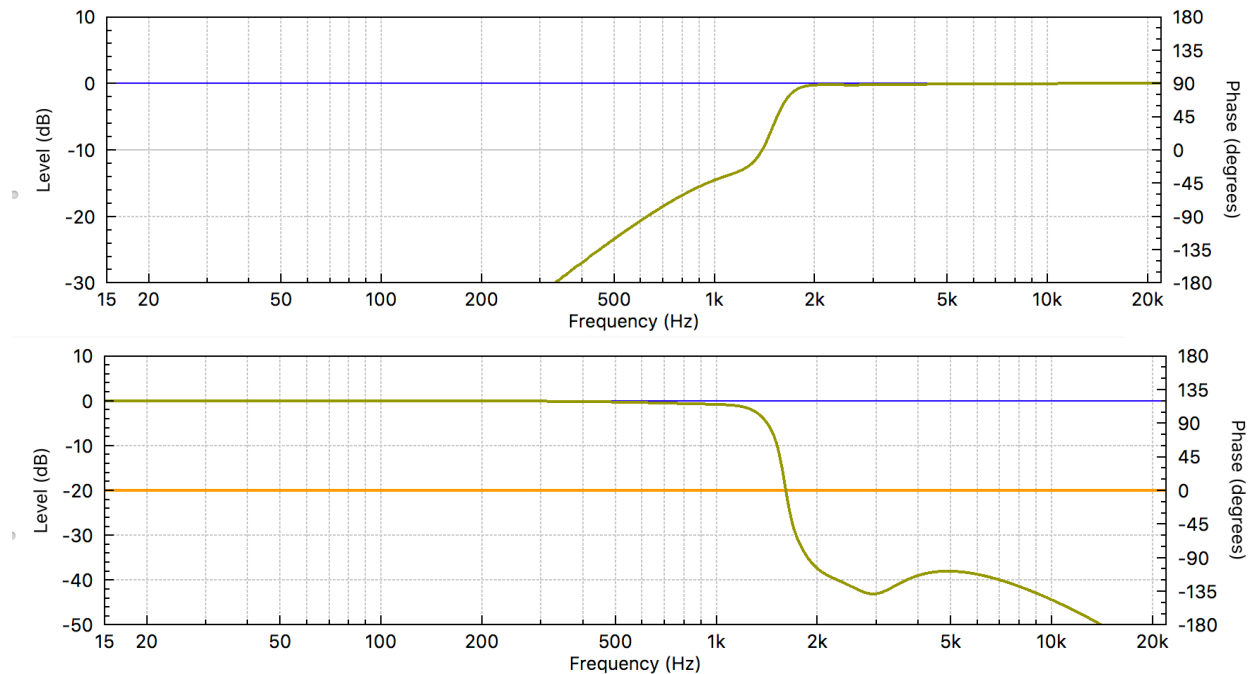


To get great impulse and step response, you have to have good phase response. Above is the phase response of the Live Edge Beryllium Dipoles. As you can see it's +/- 15 degrees across most of the band.



Notice above how clean the waterfall plot is. You can see, these things don't ring and resonate. That's why they're so transparent. You are going to hear things in your recordings you never knew were there. Especially *texture* and *space*.

The only reason this time accuracy is possible is, I used a Finite Impulse Response filter to generate the crossover. Instead of using a steep slope filter which is common (and hard to implement) I designed a target that has a very steep slope right at 1500Hz and 12dB per octave beyond that. That is much easier to pull off:



The steep slope right near the crossover point minimizes interference between the driver and cancellations that would create lobing. The woofer is attenuated more steeply to prevent lobing below axis.

The filter is a combination of Infinite Impulse Response from the MiniDSP and Finite Impulse Response filters built with Eclipse Audio FIR software. You can download my DSP configuration files here:

<https://tinyurl.com/berylliumdipoledsp>. These are based on measurements of my drivers and will ONLY work on the MiniDSP 2x4HD.

Tweeter on the Back

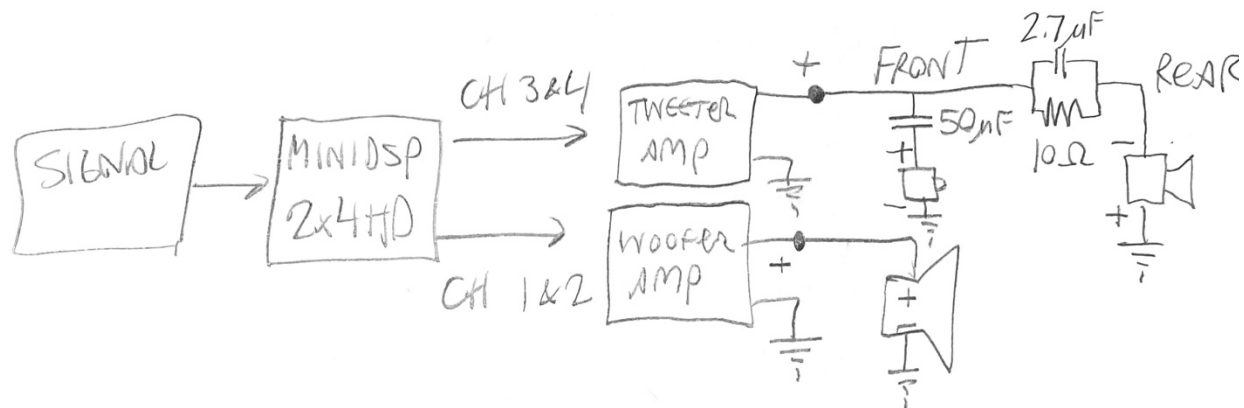
I found that adding a rear tweeter is a significant enhancement because then the dipole radiation extends to both extremes.

You design the speaker for radiation pattern, dipole Constant Directivity pattern across the entire range... then you fix frequency response problems with Digital Signal Processing.

This gives you an amazing speaker that gives you imaging and sound staging that are **physically impossible** for cones and domes to achieve.

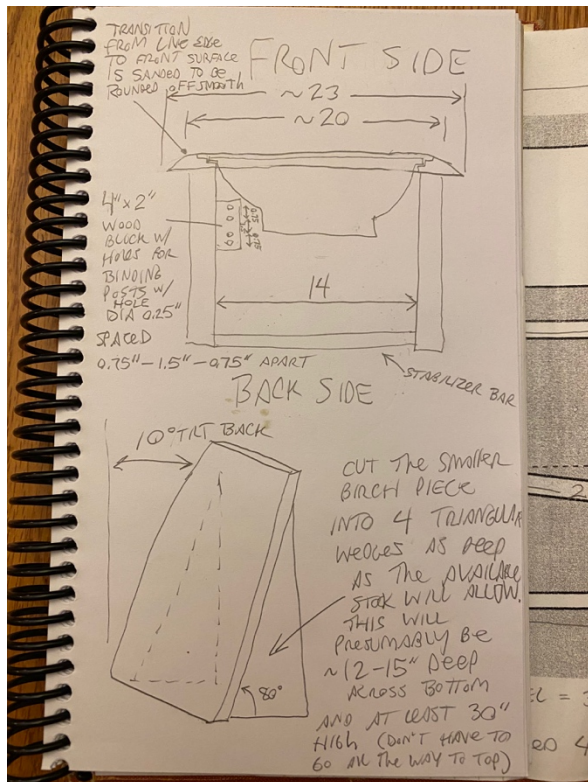
With the Live Edge Dipoles, you can walk all over the room – even stand on the far side of the left or right speaker, and you still clearly hear the other speaker across the room and the imaging is still stable. **There is no one “sweet spot.”** Music sounds fantastic anywhere you go in the room. You can walk around and *behind* the speakers and they still sound great!

The rear tweeter is a PRV WG175PH. Below is the system diagram and schematic – only three passive components and we achieve good frequency response on front AND back.



The tweeter is the SB Acoustics SATORI TW29BNWG-4. The woofer is a Lavoce WAN153.00. I chose it because of its solid midrange performance and meticulous design. My choice of driver prioritized midrange over deep bass. The 50 uF capacitor only serves to protect an expensive tweeter from mishaps; it does not play a roll in the crossover per se. The cap you choose should be a high quality film unit. I also like the fact that this speaker is lightweight with a neo magnet; each speaker weighs only 39 pounds.

Below are the sketches I sent to Seth which he used to build the cabinets. The final dimensions were 21" wide 36" high. Inside width between side panels is 14.5 inches. Woofer center is 16" from floor. Tweeter center is 28.5" from floor.



Dynamic Range to Burn

Bill Duddlestone of Legacy Audio says: “If you can see the cone moving, it’s distorting.” You can see this cone moving when you’re playing loud music with lots of bass. But at normal levels the cone barely moves at all. It’s never possible to see the midrange cone moving.

There is something entirely different about a speaker that has “dynamic range to burn.” The music is effortless, powerful and unrestricted at all volume levels.

These can play *really* loud and effortless above 60Hz. If you’re not feeding them low bass, these will absolutely rock the house. (The woofers are rated at 1000W program. The tweeters are not that robust, but they do have over 100 dB sensitivity near the crossover range. So these things can play LOUD.

You may not care about playing “loud” music (I don’t), but let me tell you, even at normal levels these devastate typical monitors with 6.5” or 8” woofers, which sound small, compressed and anemic by comparison. Most speakers have a lot more distortion than you think they do.

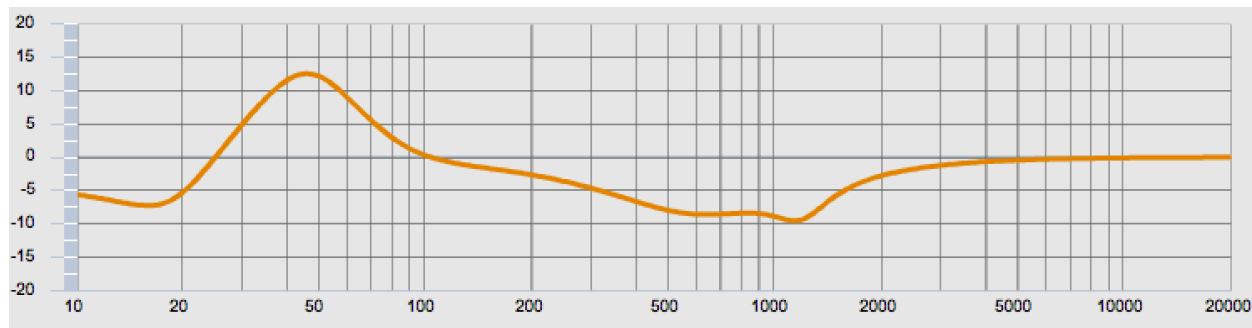


There is just something effortless and unrestricted about a system that doesn’t reach into distortion at any sane level. The impact of drums, the clarity and definition of complex musical passages is incredible. You’ll never go back to a low efficiency speaker.

These combine the finesse and imaging of electrostatics and planars, with the accuracy of KEFs, the time response of Vandersteens, and the punch and drive of a Klipsch Heresy or La Scala.

The only area where you can push these hard and get a little complaint is in the low bass. Below is my DSP EQ curve.

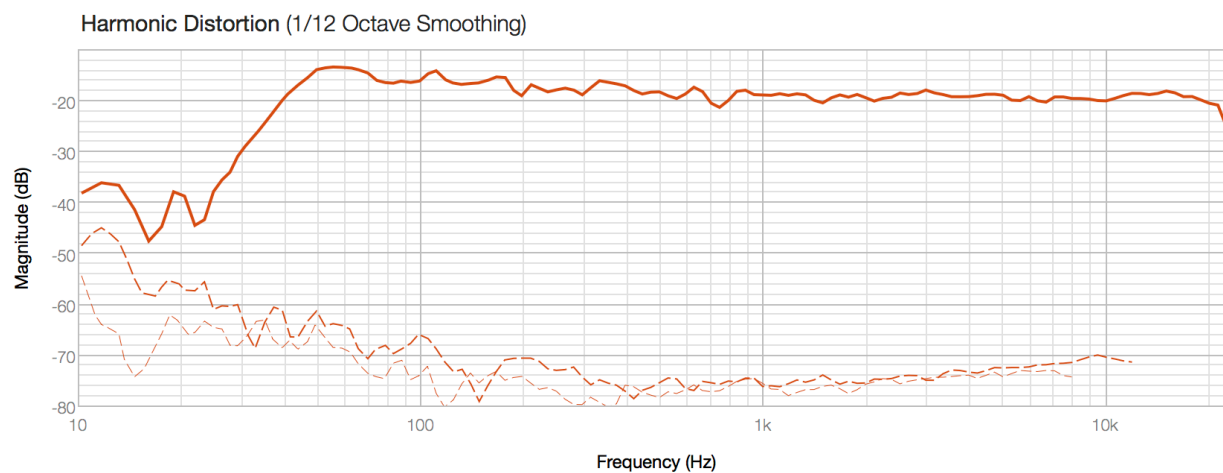
You can see a 12dB boost at 45Hz. So if you push these *really* hard in the bass range, especially with some types of kick drums, you’ll get a bit of complaint at high volumes. They won’t bottom, but the trained ear can pick up on the strain. Again, that’s only *loud* music with lots of low bass.



Make no mistake, these produce more than enough bass for most audiophiles. They will hold their own just fine with standard systems with 10" and 12" woofers. But they cut off sharply below 40Hz That means if you're a bass head, you should pair them with a subwoofer.

With the right sub, they're easily suitable for 200watt amps and if you cross them over at 60 Hz no sane level of input will drive them into distortion.

Distortion is very low as well:



In this measurement, distortion is below 0.5% (down 50dB) across the entire range of the speaker.



Enjoy!

Perry Marshall

Left: Photo of the speakers before grills were stretched over the grill hoops. Seth used a CNC machine to flush mount the grille frames around the drivers.

Conclusion

These are among of the most transparent, accurate, holographic-imaging systems you will ever hear. They'll hold their own easily with high-end brands like Wilson, YG Acoustics, Focal, KEF, B&W and Magnepan.

None of these companies offer a Constant Directivity design, so they arguably do more things right than any single model these companies makes.

I've provided DSP files with a link above. You can get in touch with Seth Cothron if you want cabinets like these – I'm sure the two of you can work something out.