The Bitches Brew Open Baffle Live Edge Speakers

Stunning Imaging + 120dB Dynamic Range + Natural Wood Finish.
Named after Miles Davis' classic 1970 album.

I've been designing speakers for almost 40 years as a hobbyist, including a 3 year stint at Jensen's OEM automotive division, where I designed speakers professionally for Honda, Mazda, Chrysler and Acura. I've built just about every type of speaker and enclosure type that exists except electrostatics.

This system embodies the best of what I know. An "ultimate design" which also aims for simplicity and elegance. 15" 3-way system with 2x SB Acoustics 15OB350 woofers and 1x B&C 15CXN88 constant directivity horn coaxial.

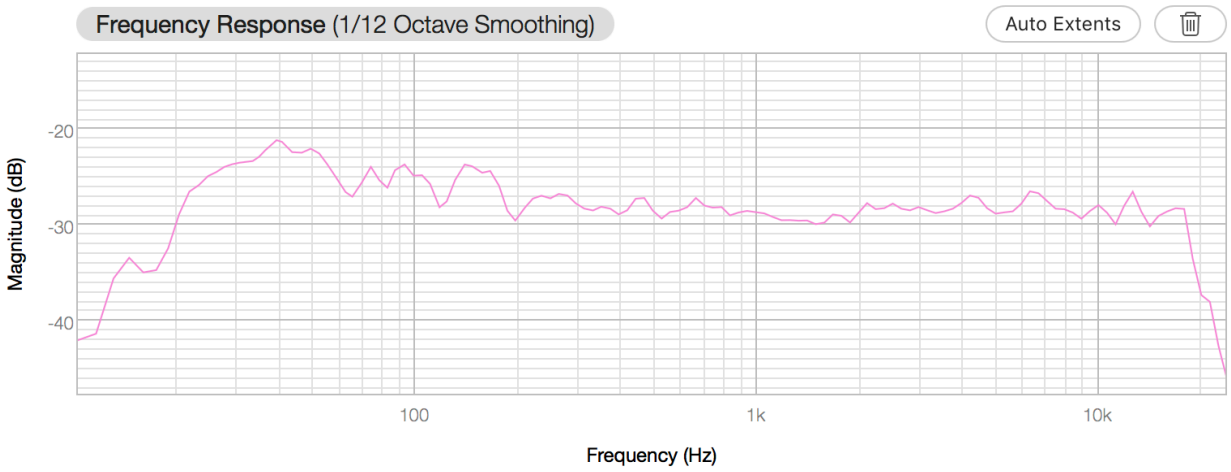
These are made from book matched slabs of spalted birch. I picked out the wood at Schroeder Hardwoods in Harvey Illinois, and Seth Cothron of @studio38designs performed the carpentry. Spalting is when fungi has grown in the wood, and in right proportions dramatically emphasizes the grain.

If you're willing to spend $25,000 to $100,000 retail you can get some pretty extraordinary speakers. Nevertheless at about $4500 including all parts and carpentry fees, these speakers perform feats no commercial speaker I've seen of can do. These put some of the most respected designs in the world to shame.

Achieving flat frequency response is of course important. But just accomplishing that is the junior varsity team. Today with modern crossover design software and DSP, anyone who can't achieve that isn't trying. What separates the men from the boys in speaker design is how many other priorities you can simultaneously achieve.

When I have friends over they are in awe at the transparency, realism, impact and imaging. They have the accuracy of a KEF or B&W, the dynamic range of a Klipsch, the impulse and phase response of a Duntech, the transparency of planars and imaging better than all of the above. Most people have never heard sound like this.

Frequency response in real room, mostly at listener positions, averaged across both speakers and 16 locations:



I chose Open Baffle because nearly all "box" designs sound… boxy. Most people have never heard a speaker that doesn't sound boxy! But once you have, it's like experiencing "real" Chinese food or Italian food for the first time. After the real thing, you'll never again be satisfied with Panda Express or Olive Garden. Same thing here: they have a huge sound stage, an open, effortless, spacious image and a palpability that must be experienced.

Open Baffle speakers have almost no radiation to the side and that gives you many interesting possibilities in room placement.

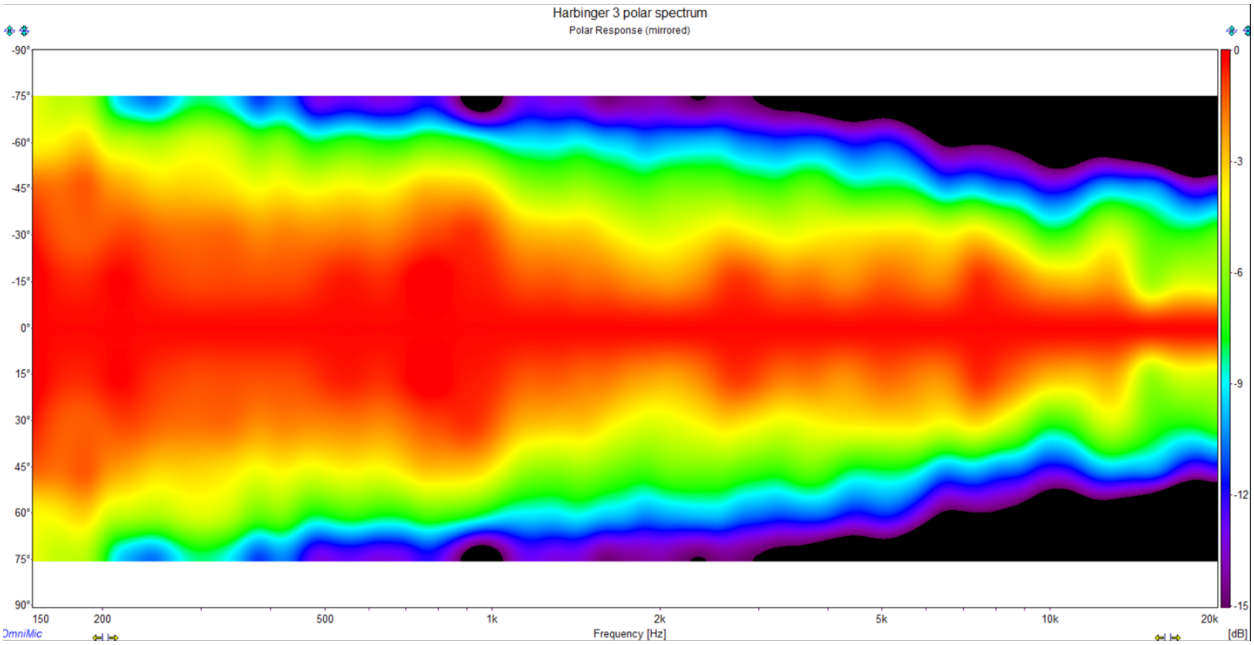
Most people have never heard a speaker that has "dynamic range to burn" - i.e. can easily exceed 120dB even if you never turn the volume above 90. Most people don't realize that even the most expensive and reputable speakers put out bucket loads of distortion at many frequencies and really don't have much dynamic range.

You probably haven't heard drums until you've heard them this way. Bill Duddleston of Legacy Audio says, "If you can see the cone moving, it's distorting." With 3 15" cone surfaces, you have to get well past 90dB before the cones move visibly. Distortion is incredibly low at any reasonable volume level so compression is negligible.

High efficiency: They'll play as loud as most people want on a flea-watt amps. My amps are 60 watts per channel (bi-amped, 4 channels total) and I can't drive them into clipping with any of my albums at any sane listening level.

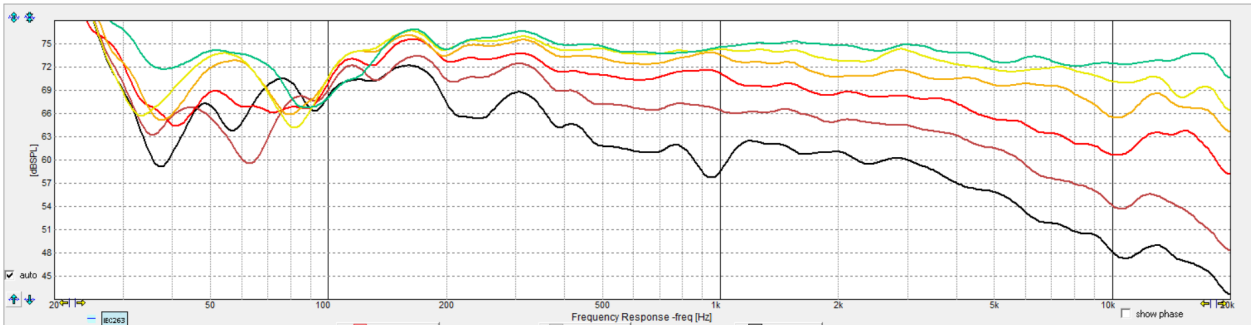
This design simultaneously prioritizes additional things:

Constant Directivity across the entire audio spectrum. This provides amazing precise imaging everywhere in the room - even when you're literally standing right next to one speaker! You can walk all around the room and the stereo image is stable. You're not confined to one sweet spot, and in fact one of my favorite things is to invite a half dozen friends over, sit them all around the room and listen to an album together. There is not a bad seat in the house.



Most people have never heard a speaker that can do this. Constant directivity says that the speaker gives flat frequency response on axis but also as you go off axis, the level drops off evenly (and not only at the top of the woofer's and tweeter's range) so the response is still smooth everywhere else. When combined with proper speaker positioning it sounds great everywhere. At 45 degrees off axis, the level drops 6dB and at 75 degrees it drops 12dB. 90 degree side radiation is down 15dB or more.

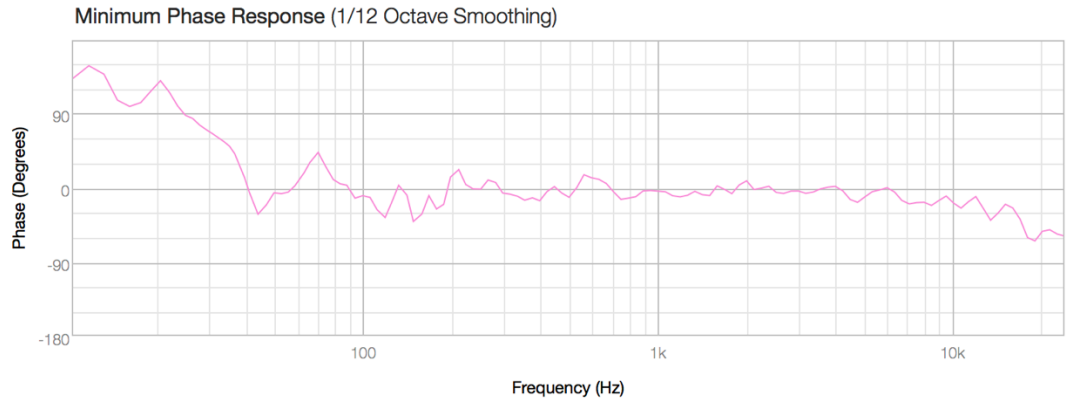
This is nearfield frequency response at 0, 15, 30, 45, 60 and 75 degrees off axis. (I don't have a good way to measure these at low frequencies, so there is odd behavior below 150Hz in the nearfield that is not present at greater distances):



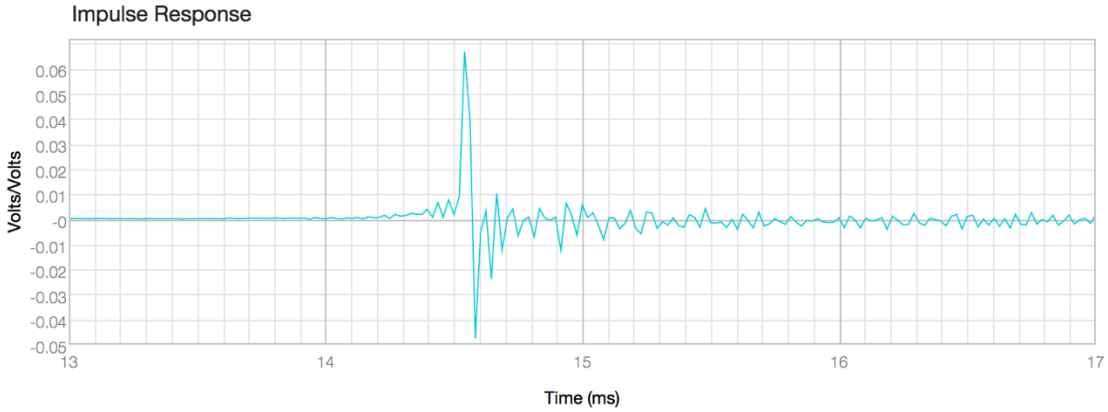
Some of the finest horn and studio monitor designs achieve constant directivity above 1000Hz, but this system achieves Constant Directivity across the entire spectrum.

Linear phase further contributes to incredible precise and stable stereo imaging. It also delivers incredible attack and slam with percussion because the wavefront is incredibly steep with no phase inversions or delays. This is a huge key to soundstage and it enables you to resolve very fine details in recordings that were previously obscure.

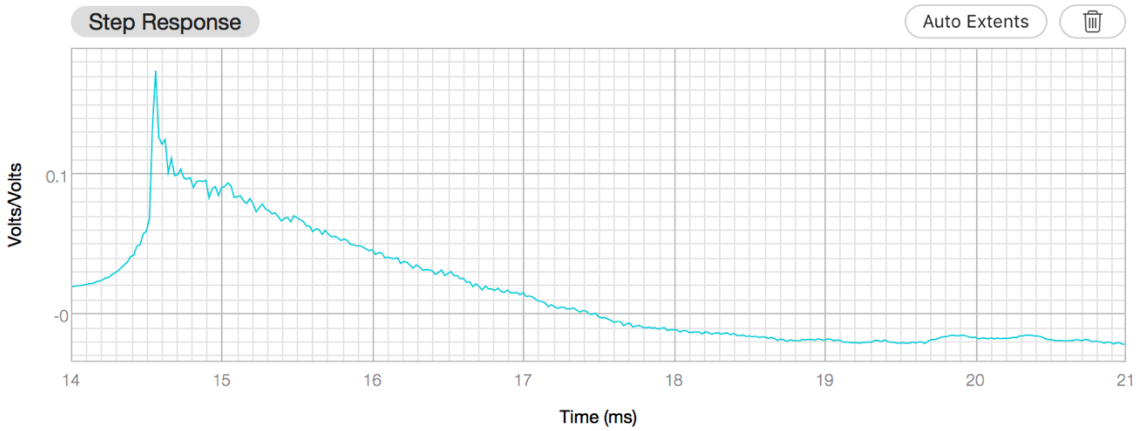
Below is phase response at listener position, averaged at 5 locations around my couch:



Below is impulse response:



Below is Step Response:



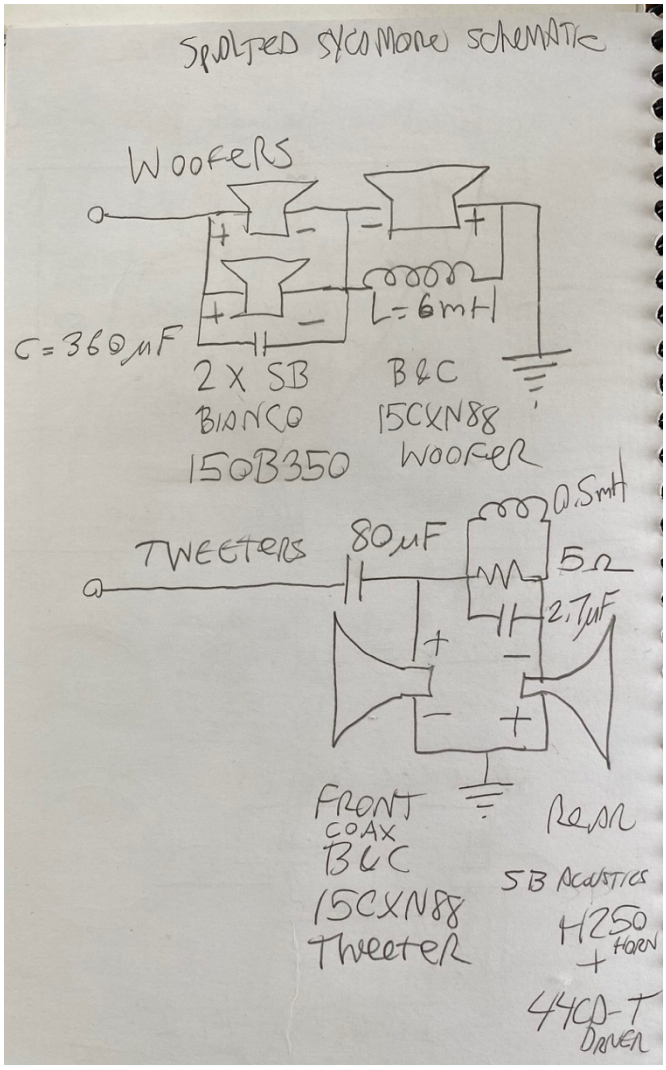
As you can see, the impulse and step responses are much better than nearly all speakers.

Specifications -6dB at 19Hz - 19KHz; sensitivity 100 dB, power handling 500 watts per channel; +/-2dB at listener position from 200Hz to 15KHz; +/-45 degree constant directivity; phase +/- 30

degrees from 80Hz to 15KHz. Sensitivity is 100dB 2.83V/1 meter. Power handling is about 500 watts. Impedance 4 ohms.

Most dipole / Open Baffle designs are mounted on a flat board and the dipole cancellation effect kicks in below about 80Hz. That means by 20 Hz you've lost 12dB (-6dB / octave). I added "wings" on this design to counteract some of this cancellation. The top woofer, crossed at 110Hz, operates in dipole mode across its entire range.

Then the bottom two woofers have "cancellation prevention" from the cabinet sides which extends the middle woofer down to about 55Hz before rolloff begins, and 35Hz for the bottom woofer before rolloff begins. This adds significant bass extension while still maintaining the overall dipole sound distribution pattern.



The side wings, then, actually function as a short transmission line, with resonances between 150-250 Hz. By crossing it over at 100Hz I avoid peaks in the upper bass. The low end resonant frequency of the system is about 26Hz.

This is the schematic to the left.

I thought about tri-amping these, which you certainly can do, but I felt it was considerably simpler to use a 2-way MiniDSP 2x4HD (a fantastic product) and bi-amp them, with a very simple 6dB/octave PASSIVE series crossover between the subwoofers and the mid-woofer. It is series instead of parallel because a series crossover has much cleaner interactions with impedance peaks of the woofers.

This however does not create a true 6dB crossover, because the mid woofer is acoustically rolling off at 24dB per octave below 80Hz. So the phase of the mid woofer has to be reversed to prevent cancellation, which you can see on the schematic.

In order to preserve linear phase, I used Eclipse Finite Impulse Response filter software to create a phase inversion "max phase" filter at 110Hz. This is loaded into the MiniDSP FIR function. I also used the FIR filters to linearize the phase of the B&C 15CXN88 woofers at the 1100Hz upper crossover frequency, and linearize the phase of the B&C 15CXN88 horn tweeters at the

1100Hz upper crossover frequency.

I have really come to love professional coaxial horns with constant directivity. I used Radian 8" coaxial in my article in AudioXpress and they sound fantastic. A word or two about horns is in order.

I used to hate horns. The first time I heard Klipschorns I thought they had thick, congested bass, ragged midrange, and spitty highs. Yes, I did hear the dynamic range and power, but I couldn't get past the offensive harsh sound of the horns.

But remember.... that was the 1980's. Many PA systems still sound that way. But horns in the hands of a really good practitioner do NOT sound that way. They sound marvelous. They're not harsh, and in fact they have much lower distortion than domes and cones. But they are difficult to tame.

Horns almost always have a downward tilt in the treble (especially Constant Directivity horns) and they almost always have more dips and peaks than domes. Domes are very well behaved while horns need TLC. You have to coax the best performance out of them.

If you do that, which is best done with Digital Signal Processing, you get extraordinary dynamic range, high efficiency, and constant directivity. This achieves feats of stereo imaging that conventional speakers in principle cannot match.

Combining IIR and FIR filters to get the optimum crossover

IIR filters are the standard Digital Signal Processing feature in the MiniDSP units. FIR (which stands for Finite Impulse Response) requires special software. IIR is "minimum phase" which means that anything you do to alter the shape of a frequency response curve also has a non-negotiable phase penalty. FIR allows you to handle time and frequency separately, but it's harder to do.

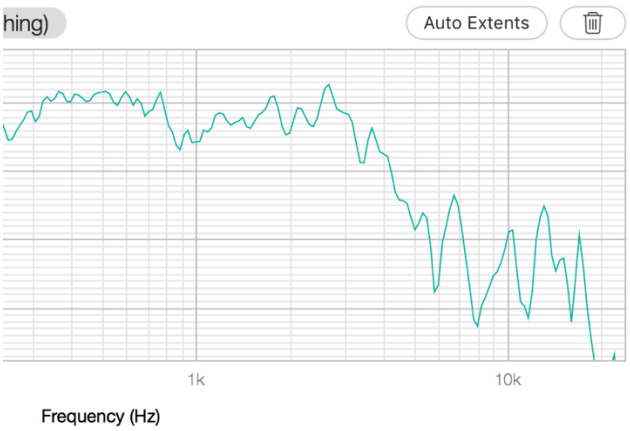
In this design I did all of the crossover and major response shaping with IIR filters and then added FIR to solve minor frequency response and phase issues.

The tweeters have 80uF capacitors to prevent damage. They roll off below 300Hz so they do not effectively factor into the crossover design. The woofer 6dB series crossover has a very high quality, low DCR inductor (<0.6 ohm).

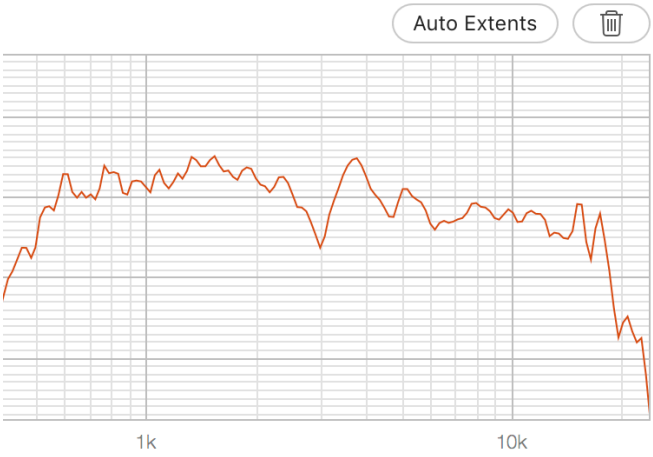
About the B&C woofer & horn

The B&C 15CXN88 coaxial is a 15" paper cone woofer + 3" titanium compression constant directivity tweeter in coaxial configuration. My measurements are actually better than the published factory specs:

B&C 15CXN88 raw woofer SPL in the upper crossover region:



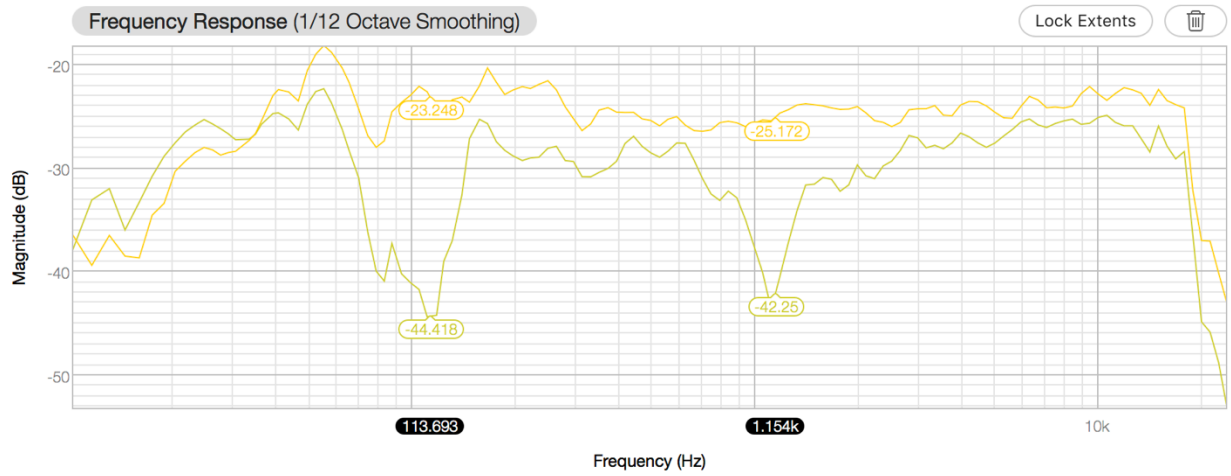
B&C 15CXN88 raw tweeter SPL:



As you might expect, I EQ'd the tweeters with the MiniDSP and the Eclipse FIR software to obtain flat response both on and off axis.

I chose the SB Acoustics Bianco 15OB350 woofers for their high Q of 0.7 and 40Hz resonance as they are designed for Open Baffles. In this design they have a final resonance of about 26Hz. With about 10dB of EQ boost they easily reach down to 20Hz.

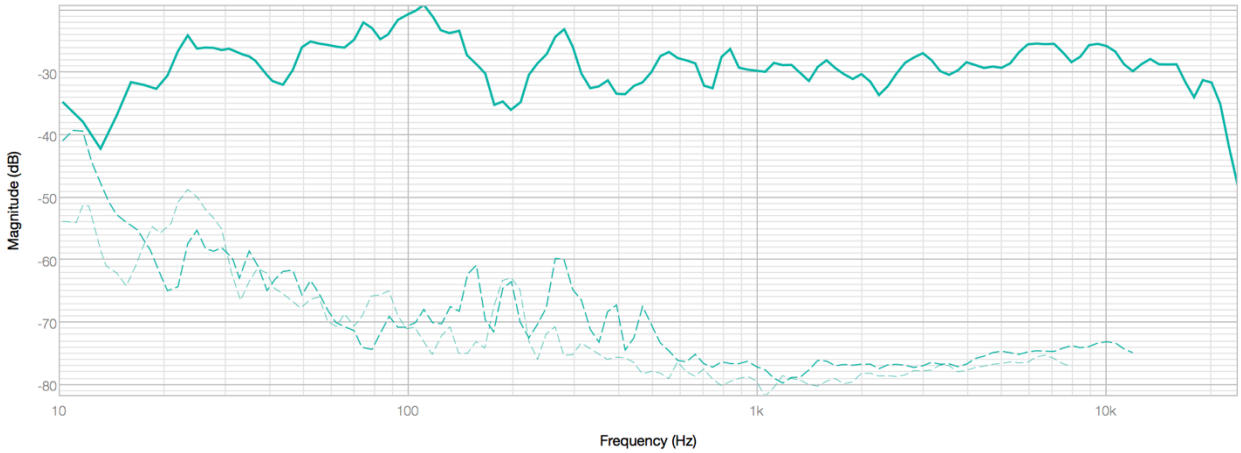
Below you see a response curve (front side) with the mid-woofer wired out of phase, so you can see a null at the 110Hz & 1100Hz crossover frequencies.



In Open Baffle designs I've always felt that having an OB woofer firing on both sides, but tweeter firing on only one side, never sounds quite right. So I added a SB Acoustics H250 horn and 44CD-T driver on the back. Photo:

I added a small passive notch filter to flatten the response around 4Khz which you can see in the schematic.

Rear response curve:



MiniDSP configuration files: https://tinyurl.com/bitchesbrewdsp (Note: These will ONLY work on the MiniDSP 2x4HD and they are based on measurements of my drivers in my room. Use at your own discretion; all modifications are up to you.)

With 100dB sensitivity for the woofers and 106dB for the tweeters, one of the most important things is selecting amps with low noise! I use Adcom GFA2535s with the input levels turned down about halfway which brings the noise down to below audibility.

These particularly excel with percussion, strings, plucked instruments, horns and aggressive bass lines, including electronic music. There is no music style that these do not excel at, from Bruckner and Stravinsky to Rush and Porcupine Tree. The resolution is incredible. You hear everything and the stereo image is huge. It fills the room and has a palpable sense of space.