Coax Dipoles using the Faital 12HX230 2-Way Constant Directivity Horn

At the 2016 AXPONA audio show I was intrigued by dipoles exhibited by Spatial Audio. I thought an active design with digital crossovers would be even better.

What you see here is a triangular open back enclosure, with the sides extending the low-end cutoff to a lower frequency than you would get using only a flat baffle. Dimensions 20” wide, 36” high, 12” deep. Front panel leans back 12.5 degrees.

The Faital 12HX230 is made in Italy, cost is around $400. It’s a 12” woofer with a concentric constant directivity horn tweeter. Minimum recommended crossover frequency is 1700 Hz. Build quality is outstanding. Rated power is 500 watts program. https://tinyurl.com/12hx230

The Faital designed for PA and studio applications. This makes it a far cry from the many other designs I’ve done, which tend to resemble designs by KEF, Duntech, Thiel and Legacy Audio.

I had done little work with horns and tended to not like them. To my ear, horns almost never sound accurate; they usually sound loud, gritty and obnoxious. (I think the Klipschorns sound terrible.)

I wasn’t too sure what to expect… but these *vastly* exceeded my expectations. They sound like electrostatics – nearly equal in transparency, but they play far louder and cleaner.

But in addition to that, when positioned well in the room they image well literally *anywhere* – standing right beside one and across the room from the other; everywhere else in the room. They even sound great *behind* the speakers!

With active EQ, these can go down to about 40 Hz. They can shake a small room with very pleasing bass. If you want to go lower, or have a big room, you need a subwoofer. Above 100 Hz these easily put out 120 dB.

A friend came over and I played “Hatesong” by Porcupine Tree, which has a spectacular drum part at the end. He said he’d never heard a floor tom punch him in the chest and

sound so tangible, forceful and realistic. This design gave me a new appreciation for several things:

1) Horns and large pro woofers are incredibly clean and dynamic… so IF you can fix their inherent problems with digital EQ, you can also get the clarity and transparency of the finest domes and planar speakers. Female vocalists sound fantastic on Quad electrostatics… but electrostatics and planars cannot do justice to a real drum set – especially bass drums and toms. These, however, absolutely deliver both. They are startlingly realistic. They'll seize you by the lapels and punch you in the face. But again they have all the finesse you could ever want. You can play choirs and string quartets at a whisper and they sound velvety smooth.

2) Constant Directivity means sound level is higher on-axis, but the frequency response curve is very consistent even off-axis. Regular woofers and dome tweeters cannot do this. Thus the sound is far more consistent all around the room and there is no one sweet spot. This makes a huge difference to the overall sound, even while you *are* in the sweet spot. Inconsistency between room reflections and direct sound makes most speakers sound unnatural and unlike live music.

3) The large surface area of the woofer combined with the dipole configuration makes for a *huge* soundstage. Regular speakers sound restricted and boxy by comparison. You'll have a hard time going back to the miniature compressed sound of a regular speaker. This has nothing to do with loudness, by the way. The soundstage is huge even if you're playing quiet music in early morning while your family is sleeping.

You'll notice a tweeter on the back and an L-Pad for the rear tweeter (Eminence APT80 with 80 degree conical horn https://tinyurl.com/eminenceapt80). This adds a great deal of extra "air" in the high end.

Without it, you would still get the benefits of dipole bass and midrange but you're left with monopole treble. The rear tweeter makes a major positive difference. The L-pad lets you adjust the air to taste.

These are very efficient. Woofers, 97 dB above 100 Hz. Tweeters, 107 dB.

Digital Crossover: Combining both IIR and FIR Filters

30 years ago in Speaker Builder magazine, Gary Galo said "Compared to active crossovers, even the best passive designs are turkeys." That was true… except for one

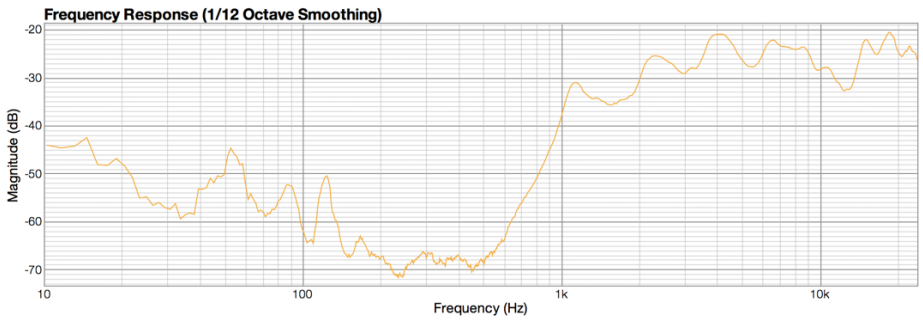
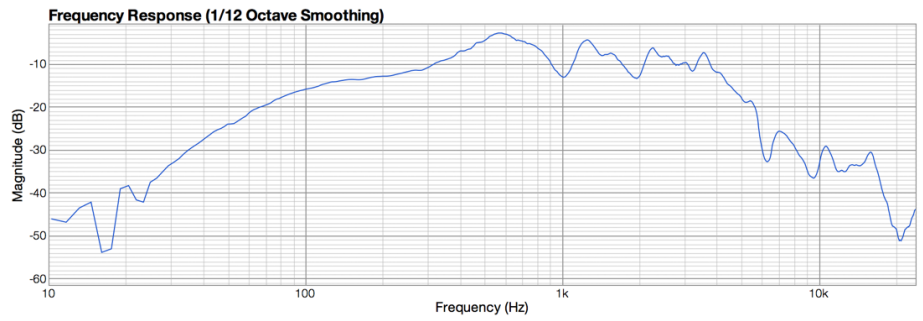
thing: Analog *active* crossovers with their cascades of opamps invariably added noise and distortion, often more than clunky passive crossovers. So even though they're much easier to work with, and biamping and triamping are vastly superior, sometimes the result still wasn't better. The pure performance of your $3000 preamp was completely thrown away once the signal reached your active crossover. Active crossovers certainly never caught on in high end circles.

This is NOT the case with digital crossovers. All the signal processing happens in the digital domain and doesn't get converted from digital to analog until the amplifier. So you don't pay that penalty because you still only have one D-A converter. You can fix as many problems as you want in the digital domain without losing the purity of your signal.

I used the MiniDSP 2x4HD, which supports both conventional "IIR" (Infinite Impluse Response) filters, as well as FIR (Finite Impulse Response). FIR allows you to separate amplitude and phase, adjusting both at will. This is impossible with IIR filters, who have inevitable phase shifts for steep filters. But FIR is harder to use. I used Eclipse Audio software to create the FIR files.

I judiciously combined both FIR and IIR in this design. This allows me to achieve nearly perfect impulse response while dealing with rather erratic driver behavior. Crossover frequency is 2000 Hz.

Tweeter EQ

Raw frequency response, Faital 12HX230 Tweeter	
Raw frequency response, Faital 12HX230 Woofer	

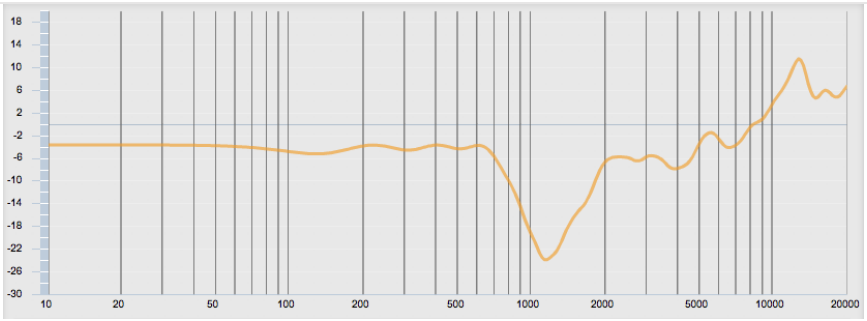
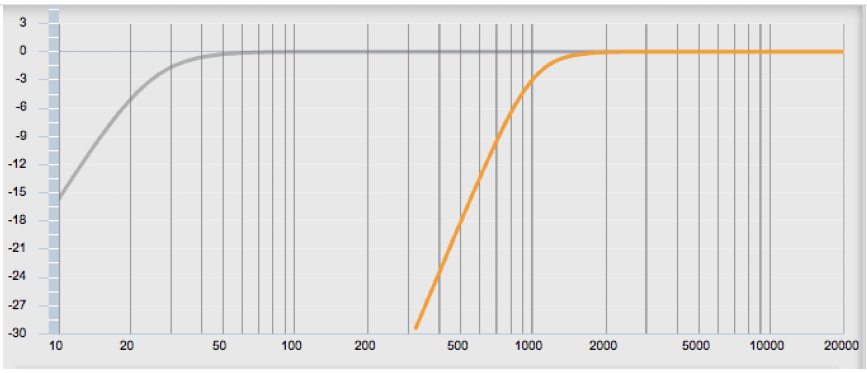
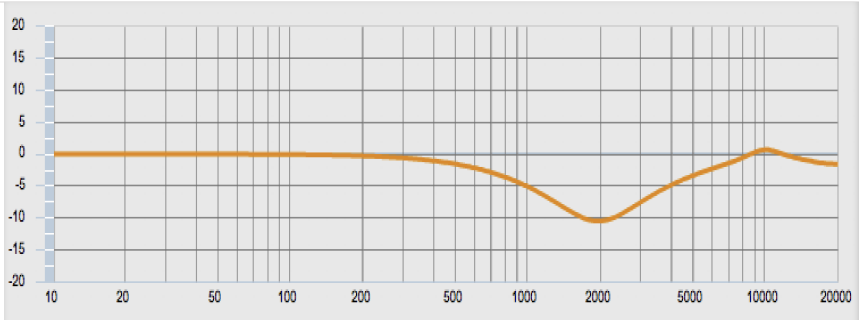
Most speaker designers flat out *ignore* impulse response, step response and phase response. Many experts claim you can't hear the difference. I insist you can. You can certainly measure them! (Consider how many things most audiophiles believe they can hear but defy measurement, like exotic speaker cables.)

Following the lead of the late John Dunlavy, I think time domain performance is very important. For the most part I don't believe you hear good phase response *as such.* I believe it manifests itself in the form of superior imaging, texture and clarity.

If you want good time domain performance, you have to make it your starting priority. So I fixed most of the drivers' problems with an FIR filter, which allows you to adjust the amplitude any way you like while obtaining flat phase response.

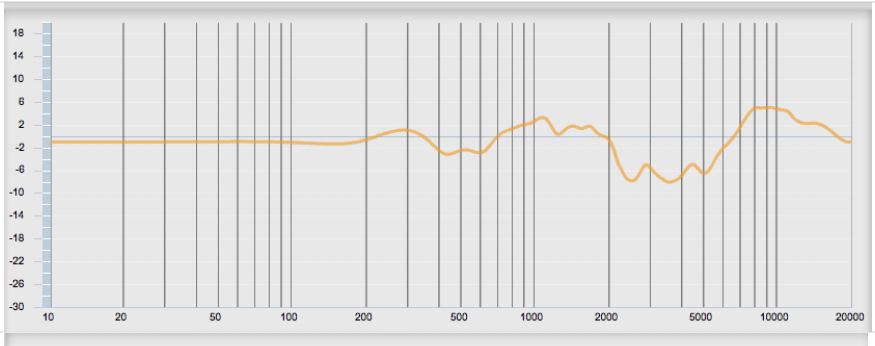
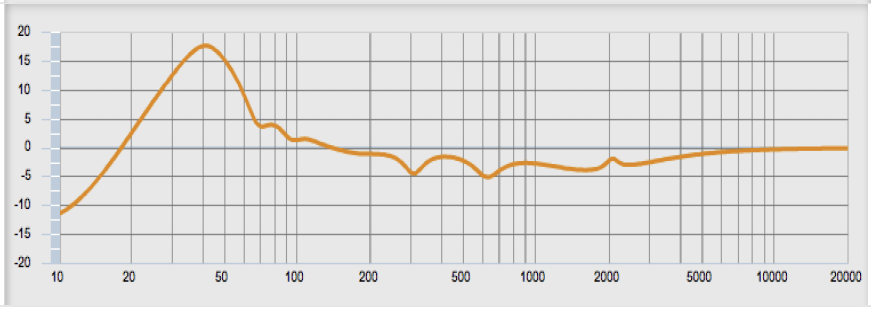
But I applied it very conservatively, combining it with standard IIR filters so I wouldn't have to use long filter lengths (which introduce errors and require expensive hardware).

The tweeter uses a combination of three filters:

The FIR filter fixes the frequency response problems of the horn tweeter, while giving you a flat phase response and excellent impulse. The dip at 1200 Hz is the first of a 2-step crossover strategy.	
This IIR 18 dB/octave high pass filter "finishes the job" of the tweeter crossover, so frequencies below 1200 Hz don't reach the tweeter. Its phase shifts kick in well below the audible range.	
The IIR filter adds final tweaks. Notice the very gentle slopes. It also pushes timing of the tweeter slightly ahead of the woofer. This evens off-axis response in the crossover region.	

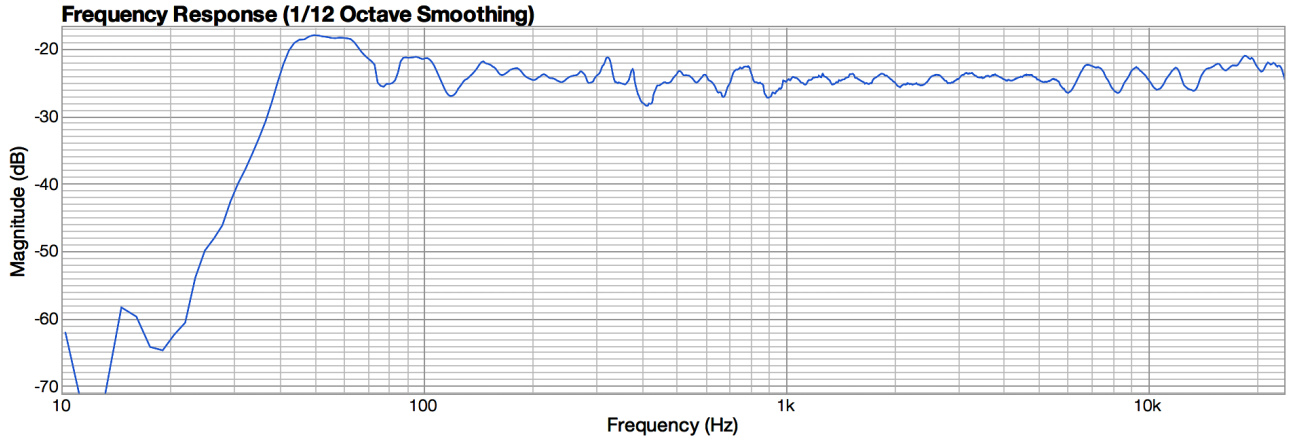
Woofer EQ

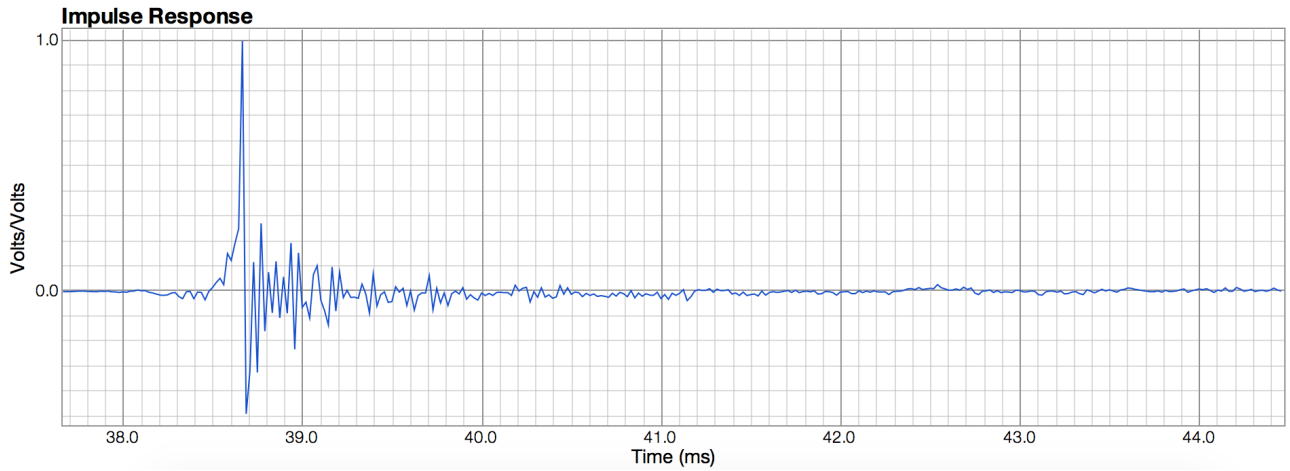
The woofer uses two filters:

This FIR filter fixes the amplitude and phase problems of the woofer in the crossover region. The DSP doesn't have enough taps to deal with low frequencies using FIR.	
This IIR filter deals with the remaining problems and applies the necessary 17dB boost at 40 Hz. This compensates for both woofer and baffle.	

Total System Measurements

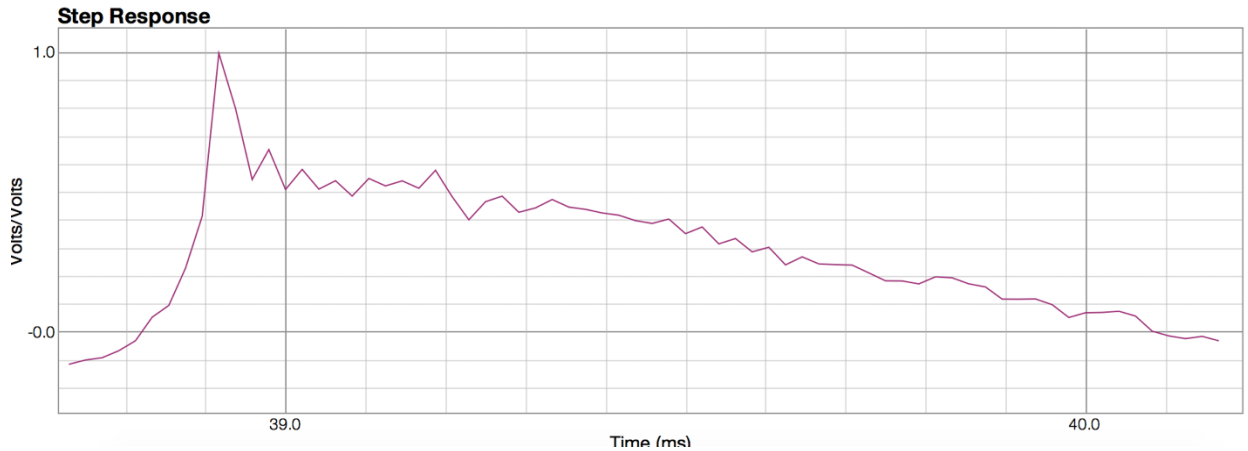
These curves were taken about 2 feet in front of the speaker in a real room. The bass peak is an artifact of the nearfield measurement but goes away at the listening position:





Impulse response as clean as you see above is almost unheard of, especially with horns. (Frequency response from horns is almost never this good either, for that matter.)

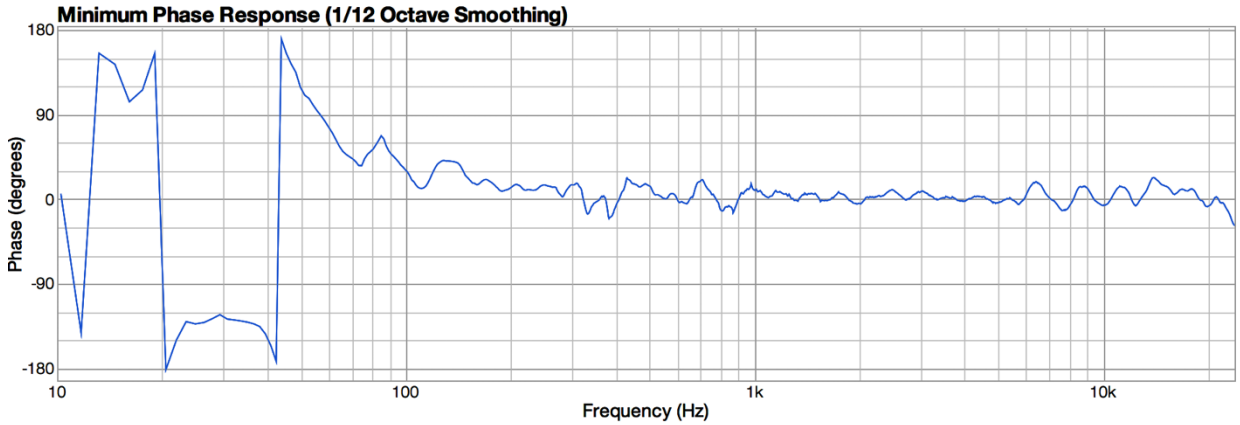
Below is step response:



Most speakers *butcher* impulse and phase response. These preserve both. Impulse and step response maintain imaging information and enable you to hear very fine details. Do the drumsticks have wooden or nylon tips? Can you hear the rattle of the snare in ghost notes on jazz recordings? Those fine taps are very delicate. Can you hear the pluck of each guitar string, or are transients smeared across time?

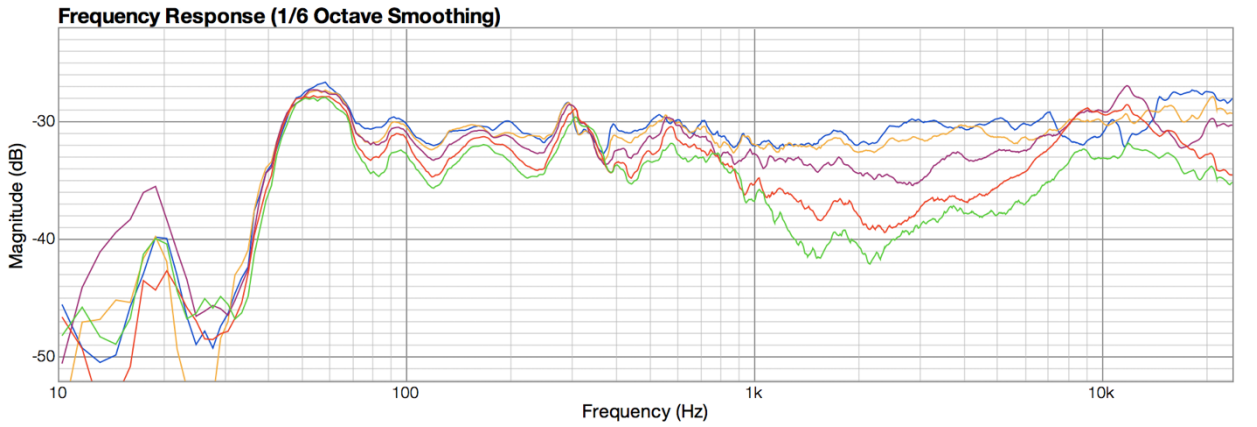
Phase Response

99% of speakers have multiple phase rotations and polarity reversals. These have virtually flat phase response from 50 Hz to 20 KHz. Low frequency phase shift is an inevitable consequence of the 40 Hz roll off.



Even Off Axis Response

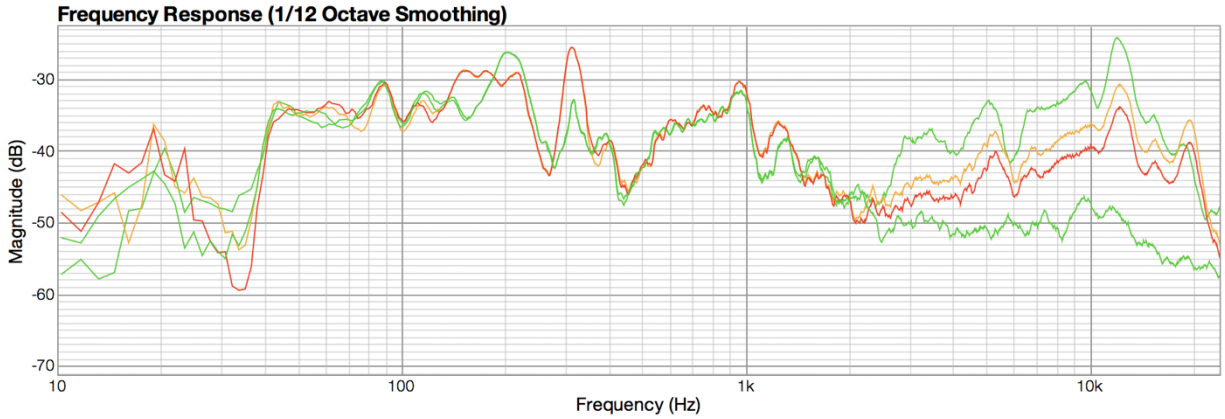
One of the reasons these sound so good everywhere in the room is that frequency response is extremely consistent whether you're on axis or off. Below: 0, 15, 30, 45 and 75 degrees off axis. The wide dispersion above 8 KHz is the total opposite of most speakers and lends to airy, spacious sound.



Blend between woofer and tweeter is absolutely seamless. You can stand right next to one speaker and clearly hear the other speaker across the room and the imaging is stable everywhere in the room. These speakers are better in this respect than 99% of all other speakers I have heard. The only other system I've done that competes as well in the "imaging all over the room" department is a Shaded Array with 12 drivers.

Frequency response measurements on the rear side

I spent zero time obsessing about making the rear response; my focus was the front side. The rear just needs to be "good enough." The curves below show the back side of the speaker with the L-pad at various settings from minimum to full throttle:



So… how do they sound?

These absolutely excel on percussion. I'd be hard pressed to name any speaker with a better sounding drum sound than these. But they also sound fantastic with orchestras and choirs. Heavy metal is crunchy and assertive; string quartets retain perfect delicacy.

One of the first things I noticed about these speakers came when I was playing a quiet classical solo guitar album. I noticed how *big* the guitar sounded, like the notes were giant drops of water rolling out of the speakers. I switched back to a set of acoustic suspension bookshelf speakers with 8" woofers and the same guitar sounded thin and boxy. The difference was startling.

You would normally think of 12” woofers, horns and dipoles as strutting their stuff with big bands, or heavy metal or ZZ Top, but even a simple solo guitar is night and day. The dipole creates an incredibly natural presence in the room that sounds like live music.

Most people have never heard a speaker with both the transparency and accuracy of a Quad electrostatic or a Duntech or Thiel or Vandersteen… yet has the dynamic range and authority of a Klipsch, Cerwin-Vega or JBL.

Without a subwoofer, these will play as loud as you want in a smallish room. They produce all but the bottom octave of bass (which most recordings have very little of). With appropriate subwoofer, they will play as loud as any sane person can stand, even in a large room. Without distortion.

A good acid test for a speaker is what you hear when you’re standing down the hall or in the next room. The Faital Dipoles come a lot closer to sounding like real musicians are playing down the hall than any other system I’ve had. (I’ve built ribbons, shaded arrays, acoustic suspension, bass reflex, horns, bandpass, just about everything, these beat them all.)

All drivers have a characteristic sonic signature that stays with you no matter how you try to EQ them. It has a lot to do with the materials used. A cone tweeter sounds like paper no matter what you do to the EQ. A metal dome tweeter sounds metallic no matter what.

This woofer has a percussive, snappy signature sound of a dense pressed paper cone. It gives outstanding “pluck” on guitars and steep wavefront on drums. The tweeter diaphragm is a very firm, high density plastic and adds very little color to the sound. These are extremely transparent. With high dynamic range recordings you can hear *everything.*

By the way, I put professional speaker stand mounts on the bottom so I could use these in professional sound reinforcement applications. Matched to a subwoofer, these easily filled a room of 200 people with music – with far higher fidelity than you could ever get in any normal PA system.

Perry Marshall
Chicago IL USA
December 2019

DSP Files

I have uploaded a ZIP file of my DSP configuration files at: https://tinyurl.com/dipoledsp. You will need to unzip these and load the .XML file into the DSP.

Important notes:

1) These will ONLY work for a MiniDSP 2x4HD. Implementation in any other DSP requires your own files.
2) These are based on actual measurements for *my* drivers. If you want to base these on the drivers you buy (you should), you need to make your own measurements and convert them to a .bin file using a program such as Eclipse Audio FIR designer https://eclipseaudio.com/ and upload them to the DSP software.
3) In the ZIP file, you'll find four files: faital_dipole_15sept2019.xml; faitalpro_woofer_FIR_correction_20nov2018.bin; faitalpro_right_tweeter_fir_correction.bin; faitalpro_left_tweeter_fir_correction.bin. Ideally you should replace these .bin files with your own. If you do not, then you really should measure the speakers and adjust EQ and tweak any remaining problems. Inevitably your drivers will have different idiosyncrasies than mine. You can probably fix the mismatches. But you will not have matched Left-Right pairs or optimal EQ unless you do this. Achieving accuracy via step #2 above is by far preferable. Maybe you'll find either my left or right tweeter files are closer to the drivers you bought, but they will NOT match exactly. Use these at your discretion and *I cannot support you or answer questions about this.* You are completely on your own. Keep in mind that using FIR DSP is a job for advanced builders. There is plenty of help available on the MiniDSP user forum for tasks like this.
4) You will have to adjust levels of the drivers, and perhaps even the time delay between them, to your situation.

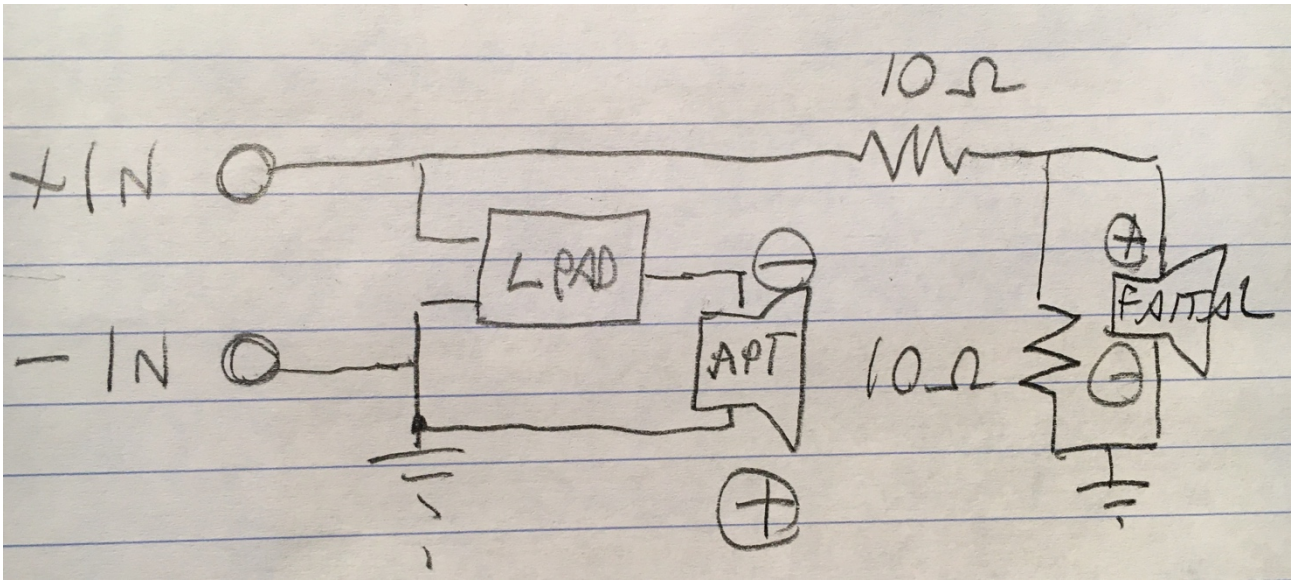
Schematic

The woofer is wired to the woofer amp directly. The front tweeters have resistors to reduce output and there is an L-pad for the rear tweeter.

The reason for the resistors is that these tweeters are so sensitive (107dB+) that just about every amplifier I connect them too has too much internal noise (hiss) for home use. There is no downside to throwing away 15 dB of efficiency, especially since I'm using these at home. If you are using these for bands or clubs then you should skip the resistors entirely. For pro use you should also add a 20 uF capacitor for protection.

- Drivers are in parallel, with front tweeter normal polarity and back tweeter reverse polarity
- A 10 ohm 25 watt resistor is in parallel with the Faital tweeter
- Another 10 ohm 25 watt resistor is in series with the Faital tweeter. This cuts sensitivity down to around 95 dB, roughly matching the woofer.
- The rear tweeter is attenuated only by the L-pad.
- The impedance of the entire circuit is about 6 ohms.

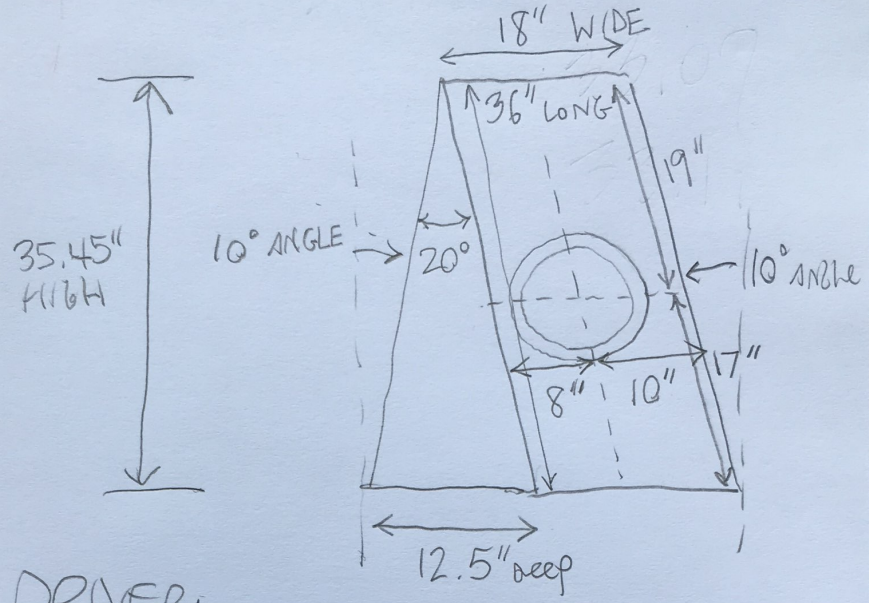
This is the schematic for the tweeters:



Physical Plans

NOTE: Below are the sketches I gave to a carpenter and these will have to suffice. I can't support hobbyists who have further detailed questions; this info should be more than sufficient to figure out the design.

DIPOLE 12" COAX



DRIVER:

FAITAL PRO 12HX230

CUTOUT DIAMETER 11.1 INCH

OUTER FLANGE DIAMETER 12.44 INCH

FLANGE THICKNESS 0.47 INCH

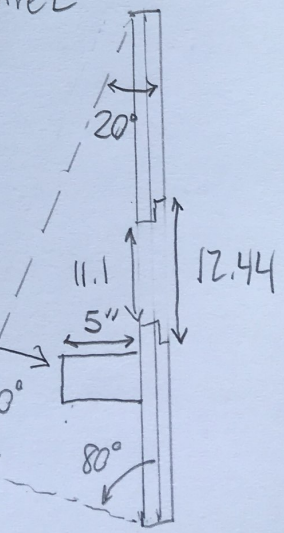
MOUNTED OFF-CENTER, LEFT/RIGHT SYMMETRICAL

OPEN BACK - NO REAR PANEL

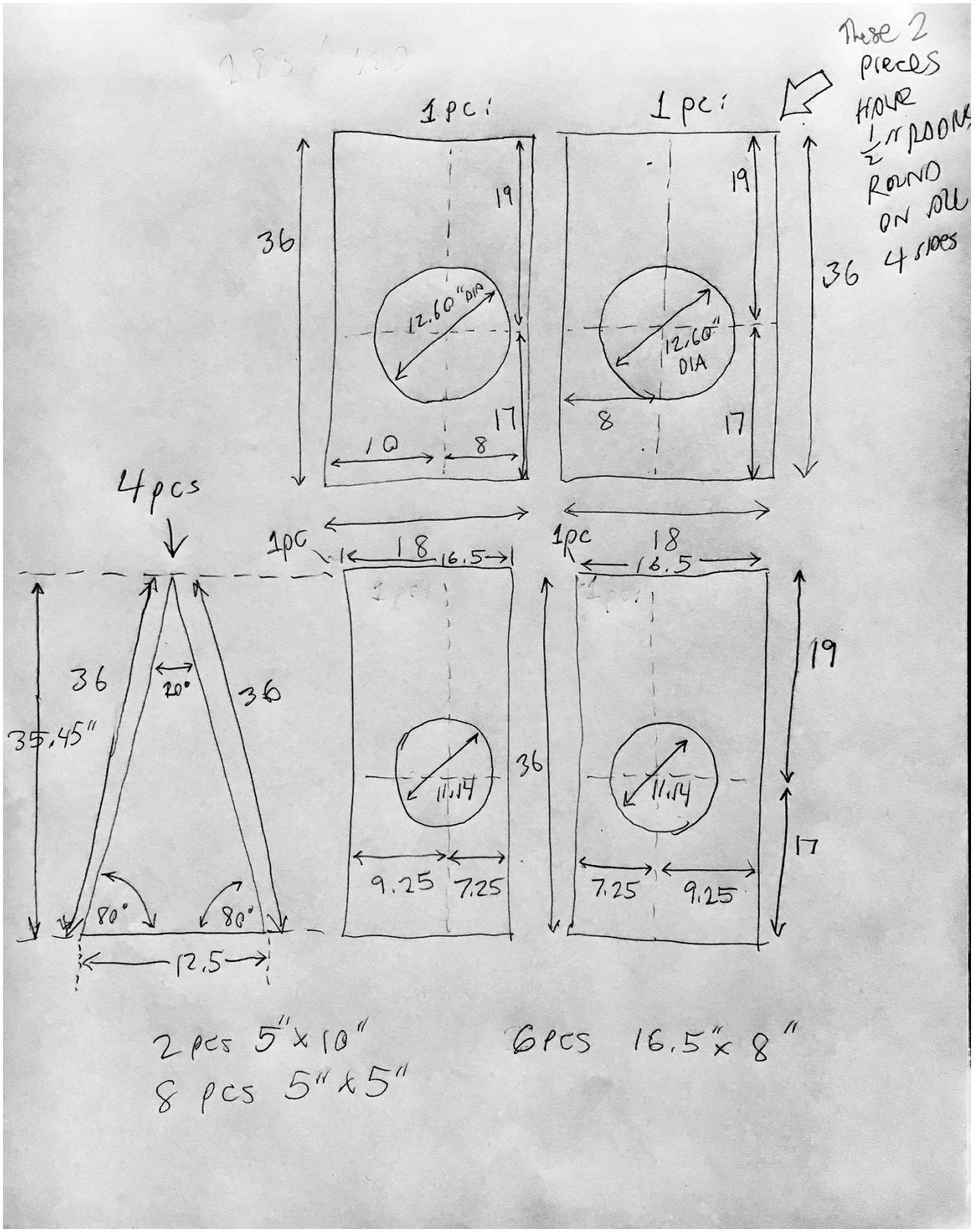
1.5" THICK FRONT PANEL

VENEER DOWN CENTER

BLACK EDGES & SIDES



BLOCK OF WOOD WITH NEEWER 1.4" SPEAKER STAND MOUNTING BRACKET ATTACHED TO BOTTOM (BUY ON AMAZON)

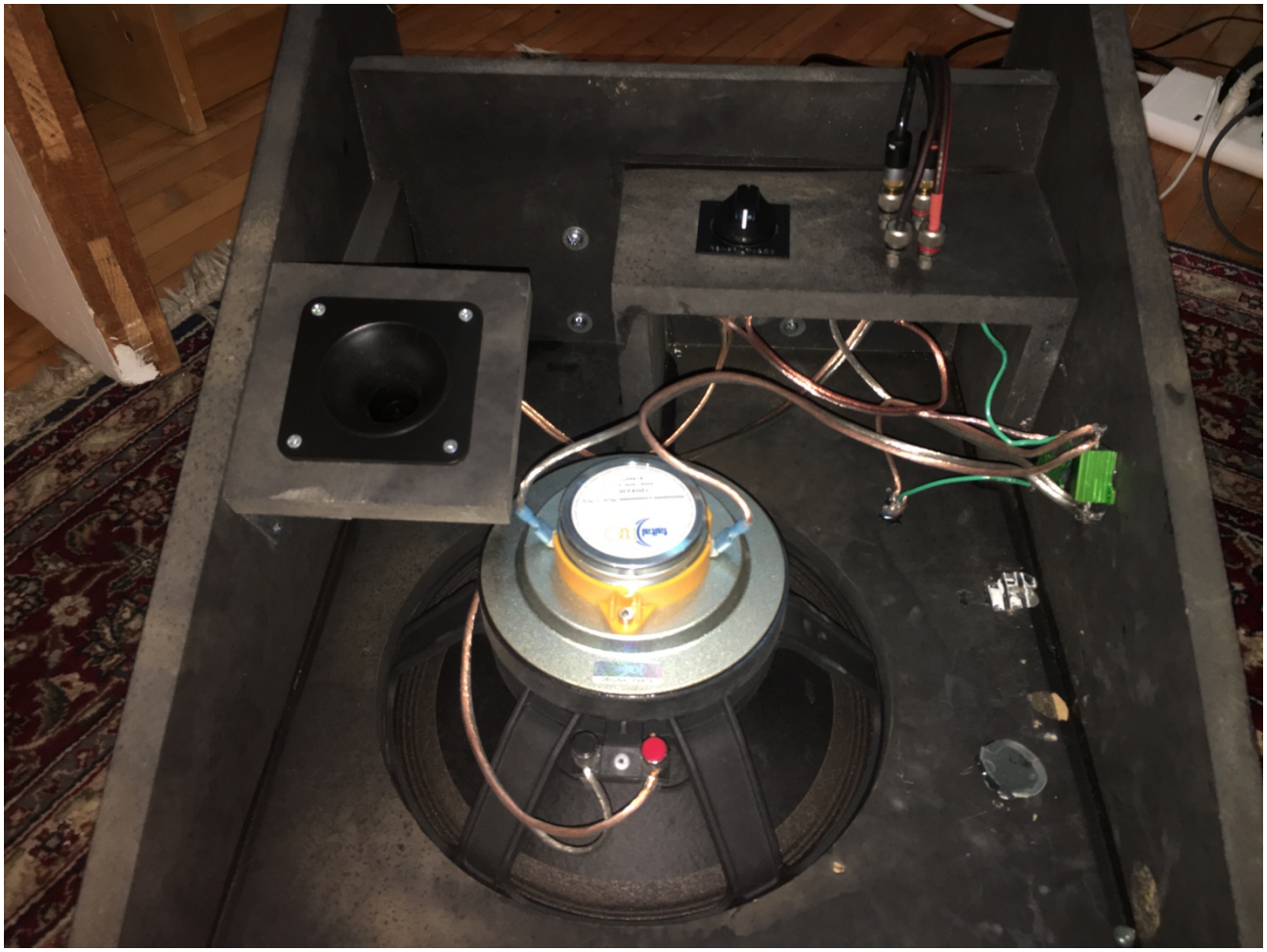


2 pcs 5" x 10"

8 pcs 5" x 5"

6 pcs 16.5" x 8"

Close up pictures of the back



I have included the above picture so you can see how the back panel is assembled. The structural members are parallel to the front panel. Notice there are three square braces along the bottom panel for stability.

As you see on the next page, there is a Neewer 1.4” diameter speaker stand mount on the bottom panel. When placed on stands, the front panel is perfectly vertical, not tilted back.