
Subject: 4pi build with stands finally realized
Posted by [Roger S.](#) on Sun, 12 Sep 2021 00:19:51 GMT
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Started planning and buying parts a year ago, and now it is time to create them. I have spent some time with Sketchup to try different designs. They are made of 21mm plywood with double baffle and additional bracing. Finishing will be bare plywood with Osmo black wax. Internal measures, port dimensions and positioning of drivers are according to original spec. DE250 and JBL2226 drivers will be used. I am showing you pictures from sketchup in this first post. More pictures from the build process will be shared tomorrow.

File Attachments

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 - 2) [4pi_2.jpg](#), downloaded 1205 times
 - 3) [4pi_3.jpg](#), downloaded 1066 times
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Subject: Re: 4pi build with stands finally realized
Posted by [Roger S.](#) on Sun, 12 Sep 2021 17:53:59 GMT
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Promised some updates, and here it comes. Decided to finish the stands first. The bottom is made of two layers 21mm birch plywood, and the top is single plate. Top plate is tilted 3 degrees. I used two sheets plywood and it was just enough for speakers and stands.

File Attachments

- 1) [20210911_120551.jpg](#), downloaded 1059 times
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Subject: Re: 4pi build with stands finally realized
Posted by [Roger S.](#) on Sun, 12 Sep 2021 21:57:47 GMT
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Building the cabinet.
I wanted flushmounted driver/horn, so I used the router on the outer baffle first. Then I cut out the

holes, glued the outer front to the inner and used a copy bit to to make the same cutout on the inner front.

There was a guide bushing accessory my handheld router, so I made a template for the horn flushmounting. I think I made four versions before I was happy with the fit. The horns were slightly different in size (approximately 1 mm), so I ran them through my router table to make them 100% alike.

Parts start to come together. I twisted my mind to find a decent way to make the port opening in the baffles flush with the port construction itself. I ended up cutting out a slightly smaller port opening in the baffle, glued the port to the baffle and ran the whole construction face down on my router table with a long copying bit to follow the sides of the inner port. Port opening was finished with a roundover bit to follow the "rounded" design of the speaker and to appear as large as the horn.

I used masking tape to avoid glue spill. Experience from earlier mistakes taught me that oil or wax dont dont absorbe on those spots. You may have to sand really deep to fix it.

First sanding of top after side panel assembly. A good start. Side panels were rounded off with a roundover bit with same radius as the plywood thickness. Had to practice on several pieces to find the right router/feeding speed. It is damn easy to get burnmarks. This was done on my routertable to ensure stable feeding and guiding.

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- 1) [20210902_210903 \(1\).jpg](#), downloaded 1018 times
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 - 3) [20210904_164955.jpg](#), downloaded 992 times
 - 4) [20210906_135407.jpg](#), downloaded 1070 times
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Subject: Re: 4pi build with stands finally realized

Posted by [Wayne Parham](#) on Mon, 13 Sep 2021 14:05:04 GMT

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Wow, stunning! Excellent work! Those are going to be really great speakers!

Please keep the build pics coming. I can't wait to see them finished.

Subject: Re: 4pi build with stands finally realized

Posted by [tom-m](#) on Mon, 13 Sep 2021 21:25:31 GMT

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Yes, very nice! High quality work for sure. I love the birch plywood.

Subject: Re: 4pi build with stands finally realized
Posted by [Roger S.](#) on Mon, 13 Sep 2021 21:54:28 GMT
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More pictures. First round with Osmo black wax just applied. Nice to see the plywood layers highlighted.

I think this was after second layer black and semi matte clear hardwax. Not dry yet. The bright parts on the sides are light reflections.

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- 1) [20210910_192457.jpg](#), downloaded 902 times
 - 2) [20210910_192514.jpg](#), downloaded 158 times
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Subject: Re: 4pi build with stands finally realized
Posted by [Roger S.](#) on Mon, 13 Sep 2021 21:59:34 GMT
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Thanks alot. You barely see speakers with plywood finish. Wanted to highlight the endwood, and so far it looks ok.

Subject: Re: 4pi build with stands finally realized
Posted by [Roger S.](#) on Mon, 13 Sep 2021 22:33:58 GMT
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This is how I applied damping material. I covered all sided with classic felt damping. This layer is just 7mm thick but has good effect.

Behind the woofer below the top brace there are two layers more. One sheet with the white stuff which is very airy, and classic foam type on top. So three layers in total behind woofer. Had this laying around from earlier projects, but I believe they will give a good combined effect.

Added some extra damping on one side as per Waynes description. A sheet with fiberglass will be added under the top brace as recommended.

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Subject: Re: 4pi build with stands finally realized
Posted by [grindstone](#) on Tue, 14 Sep 2021 03:09:08 GMT
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Good box. Thanks for posting. Nice work.

Subject: Re: 4pi build with stands finally realized
Posted by [Roger S.](#) on Tue, 14 Sep 2021 09:15:03 GMT
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Horn mounting. Tight fit, and flush. Made two extra holes on the sides of the horn just to be sure. The horn itself is damped too.

Filter install. Just enough place for the filter. Speakon 4 pole installed on bottom. I modified the filter for bi-amping to have the option. With four wires in it is also possible to test active crossover and dsp if/when I get the urge.

2 inches fiberglass insulation mounted under top brace.

Speakers had to be bolted to the stands before filter/woofer install. Four bolts with rubber gasket between stand and speaker.

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Subject: Re: 4pi build with stands finally realized
Posted by [Roger S.](#) on Tue, 14 Sep 2021 11:03:23 GMT
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Final results.

Woofers installed. I have one question regarding the woofers. These are 2226H which I bought used, and I believe they are original and imported from USA. But the cone and dustcap has a

brown colour, and all the others I see on pictures are grey/charcoal. So are they reconed with non o.e.m. cones, or is it an early production? I hope some of you guys can chime in on this.

Happy with the speakon solution on the bottom. Makes the rear a lot cleaner.

Had to make some grilles too. Wanted a more factory finish, and I thought my wife would find them less intrusive too. This is our main living room so I wanted them to look as nice as possible. The grille is made as small as possible. The frame is not going inside the woofer gasket and allows for 8mm excursion before it touches the fabric. They are now hanging on the woofer gasket, but I have ordered small neodym magnets. These will be glued to the grille frame and sticks to the bolt heads for the woofer.

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- 1) [20210912_153955.jpg](#), downloaded 807 times
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 - 4) [20210914_112346.jpg](#), downloaded 806 times
 - 5) [20210914_112246.jpg](#), downloaded 791 times
 - 6) [20210914_112504.jpg](#), downloaded 788 times
 - 7) [20210914_112522.jpg](#), downloaded 785 times
 - 8) [20210914_112536.jpg](#), downloaded 785 times
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Subject: Re: 4pi build with stands finally realized
Posted by [Roger S.](#) on Tue, 14 Sep 2021 12:04:51 GMT
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Will try to do a soundcheck today, but work is calling, and I will be away 14 days. You see the rest of my system in the background. The 4pi's will be matched to the 21" subwoofers in the corner. They are Precision Devices PD2150 tuned to 18Hz, driven by a bridged Crown K2. I have used this setup for years now, and its a really fun combo. They are not flanking subs as they are positioned now, but I am going to try that when I come home. I have another K2 used for midbass duty on my former fully active setup, and a Crown Ct-4150. The plan is to run the woofer with the K2, and tweeter with 2 channels from the Ct-4150 as this has 10db better S/N ratio and it sounds really smooth. Proper gain matching between the amps will of course be done. I have a minidsp Studio as preamp with Dirac. This is connected to minidsp 10x10HD, which will be used as dac for a while. Listening impressions and measurements will be posted when I find the time. The build started three weeks ago, and a lot of hours are spent. I am really looking forward to hear them, but from what I see from the measurements, reviews and thorough documentation from Wayne, I am pretty confident they sound nice. Small adjustments in tonal balance can easily be done with dsp. Properly integrated drivers and good power response like in the 4pi is what I look for in a speaker. Poor engineering can not be fixed by dsp/room correction

as some tend to believe. Tonal balance is easy.

Many thanks to Wayne and other builders for design and inspiration, and I hope this build will inspire others too.

I will be back with more when I have done some testing :)

Subject: Re: 4pi build with stands finally realized

Posted by [Rusty](#) on Tue, 14 Sep 2021 14:18:58 GMT

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Whew!! Stunning craftsmanship. Your work reminds me of Troels Gravesen, the Danish speaker builder. When you get all that dialed in, you'll have a system that would cost many multiples of what you put into your excellent DIY work. And sound even better.

Subject: Re: 4pi build with stands finally realized

Posted by [Roger S.](#) on Tue, 14 Sep 2021 15:55:53 GMT

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Thanks for the kind words. It is really satisfying to make a plan and see it come alive. The result is just what I hoped it would be so far. D.i.y is way more rewarding than just buying and swapping out stuff.

This is my plan for "flanking" subs. I can squeeze the electronics in the middle. Looks way better, and allows me to cross the subs a bit higher too.

File Attachments

1) [Stue hifi nytt oppsett.jpg](#), downloaded 748 times

Subject: Re: 4pi build with stands finally realized

Posted by [Wayne Parham](#) on Tue, 14 Sep 2021 16:56:54 GMT

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Those speakers look great, and I'll bet your setup sounds great too.

As for the 2226H drivers - you said they were used and asked if they looked like they had original cones - it's really impossible to say. They are dark grey when new, with black surrounds and black adhesive around the dust cap. But depending on how much sunlight exposure they've had, I've seen 'em get nearly white and sometimes sort of brown. They usually just get lighter and lighter grey.

The thing is, I've also seen non-OEM cones that looked nearly original. Some are decent and some are terrible. You just can't know without measuring them. The good news is that even if the cone isn't original, you can always have them re-done with OEM parts and expect them to be 100% good as new.

I'm crossing my fingers for you that measurements prove them to be OEM cones. The place to watch is 500-1000Hz. An OEM cone will measure the same as what you see posted on the website.

Subject: Re: 4pi build with stands finally realized
Posted by [alexg](#) on Sat, 18 Sep 2021 18:08:50 GMT
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Speakers look awesome. I hope you are enjoying them.

How did you handle corners on your recessed horns?

Thanks,
Alex

Subject: Re: 4pi build with stands finally realized
Posted by [Barryso](#) on Sun, 19 Sep 2021 14:05:13 GMT
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Those are superb. Just a fantastic build.

Enjoy them!

Subject: Re: 4pi build with stands finally realized
Posted by [Roger S.](#) on Fri, 01 Oct 2021 09:01:57 GMT
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Finally back from work today. I recessed the horns by making a template like this:

There was a follower/guidebushing accessory for my handheld router. I made the straight lines in the template first using the router, and stopped before the arc started. Next I drew an arc for the corners by hand. I made it slightly too tight, and opened it up by using a dremel and sanding paper. I guess there are several ways to do this depending on what tools you have available, and it is time consuming for sure. The horns may be slightly different in size, and it may be easier to sand off the corners on the horn itself for the final adjustment:)

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1) [20210911_123025.jpg](#), downloaded 633 times

Subject: Re: 4pi build with stands finally realized
Posted by [Roger S.](#) on Fri, 01 Oct 2021 09:21:56 GMT
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I was not sure if the woofers were original or reconed, so I took some raw measurements of the JBL 2226H. I did not find raw measurements on this site, but found several on the net. I think they look quite similar, but would like Wayne or others to have a look for peace of mind. I bought them used, and the seller was kind enough to provide impedance measurements on request (free air) before I bought them. REW measurements are done at 1m on axis.

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- 1) [20211001_095119.jpg](#), downloaded 670 times
 - 2) [20211001_095245.jpg](#), downloaded 661 times
 - 3) [JBL 2226H raw.jpg](#), downloaded 535 times
 - 4) [JBL 2226H raw_2.jpg](#), downloaded 630 times
 - 5) [JBL 2226H raw_3.jpg](#), downloaded 622 times
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Subject: Re: 4pi build with stands finally realized
Posted by [Wayne Parham](#) on Fri, 01 Oct 2021 13:38:31 GMT
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It's hard to say from your response chart, because it looks like a mix of on-axis and off-axis, e.g. power response. Were you measuring indoors, perhaps?

If so, measure outdoors or setup your equipment for a pseudo-anechoic measurement. Place the microphone directly on-axis around two or three feet away from the cone. Do this on a baffle or in a cabinet so reflections from the rear of the cone don't interfere with the sound emanating from the front of the cone.

To be honest, I'm worried about that notch at 1.3kHz because I see a lot of substandard cones get weird in that area. The aftermarket cones don't do well above 1kHz. But before we get worried about that, let's make sure you have good measurements because a lot of other things can cause that dip too. Could be self-interference from reflections or from the back-wave or both.

If you measure outdoors, or if you use gating to create a pseudo anechoic chart, what you should expect to see on-axis is rising response between 800Hz and 1.6kHz, and rolloff above that. On-axis, there's with a sharp dip around 2.6kHz. When you go far off-axis, at 45°, response starts to fall above 500Hz. It's down 3dB around 800-1000Hz and 6dB around 1.2kHz. Above that, it falls off rapidly, punctuated by a sharp dip around 1.3kHz.

The JBL spec sheet shows what you can expect to see from the raw driver:

Subject: Re: 4pi build with stands finally realized
Posted by [Roger S.](#) on Sun, 03 Oct 2021 17:18:00 GMT
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Measurements are done indoors and in the 4pi box. I am using a diy turntable for off axis measurements. Some pillows on the floor helps, but with gated measurements or with frequency dependent windowing in REW it seems quite reliable in the midrange and up. I know outdoor measurements are preferred, but a lot of hassle.

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 - 2) [20210930_140502.jpg](#), downloaded 597 times
 - 3) [20210930_141012.jpg](#), downloaded 602 times
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Subject: Re: 4pi build with stands finally realized
Posted by [Roger S.](#) on Sun, 03 Oct 2021 18:05:23 GMT
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Made some measurements of the woofer before and after crossover. I got less noise when I laid the speakers on the floor. Called the guy who sold the woofers, and he insisted they were originals. He put his pride in this and said he had newer sold drivers with aftermarket recone kits. Made three measurements, with and without crossover on 0,25m, 0,5m and 0,75m distance. Averaged the three measurements for each case. It is smoothed 1/12 and has not got the resolution you get outdoors, but the general shape and location of the dips/peaks are consistent. Standing measurements show more or less the same. It is more useful to show the effect of the XO.

Took measurements with my turntable going from -45 to +45 degrees, and with 5ms gating to

remove most reflections from midrange and up. Horizontal power response looks good to me, and I think this correlates with what one is hearing if listening at distance in a reflective room as mine. There is a problem with flutter echo in my room and I had to pull down the area from 1,3k to 3k with eq to get it balanced to my taste. This has been the case with almost every speaker I have had in this room.

File Attachments

- 1) [JBL 2226H raw vs filtered.jpg](#), downloaded 490 times
 - 2) [4pi power response.JPG](#), downloaded 573 times
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Subject: Re: 4pi build with stands finally realized
Posted by [Roger S.](#) on Sun, 03 Oct 2021 18:47:21 GMT

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I have now spent some time listening, and the treble impresses me the most compared to my former setup with a Fane 60x50 tractrix horn. The horn has no honk as promised, and treble is airy and smooth. Good low level detail. After finetuning the eq notch around 1,3-3k I have no listening fatigue at all. With 500watt on the woofer, and 125watt for the horn, I had had no problem playing stupid loud either. Speakers are toed in in front of my listening position. I guess I listen closer to the 10 degree axis now, and imaging is really good. Integration with subwoofer was easy. Added +3db low shelf on the woofer to straighten the response a bit deeper, then added 80 Hz 4th order LR to the 4pi and 73 Hz 36db LR to the subwoofer. I tend to run the subs 4-6 db hot, so the effective xo for the sub will go up a bit. Timealigned the two, and transition is really good. The last test I did was testing the port tuning. I disconnected one wire from the amp, attached an amperemeter and used the tone generator in REW to find the frequency with the impedance dip/highest current draw. I was surprised it was down at 35 Hz as the internal dimensions are exactly as described. Port dimensions and length are the same. I guess the damping material I added on top and sides behind the port is to blame. It is close enough to the port to extend the effective length. Will probably try to remove some of it later to rise the tuning. I am going to use subwoofers anyway, and the effect at 80Hz is minimal anyway.

It has been a lot of work, but I am now a happy owner of 4pi's, and it is time to relax and listen to music. Hope this build will inspire others too;)

Subject: Re: 4pi build with stands finally realized
Posted by [Wayne Parham](#) on Sun, 03 Oct 2021 19:14:13 GMT

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Your measurements look good, congratulations! I feel better about that 2226H cone now, because the measurements appear in line with what I expect from the OEM.

As for box tuning at 35Hz, that's not bad at all. The expected Helmholtz frequency is 37Hz - and that's what I've measured on several occasions - but even if you have some slight differences in your box or damping material that shifts it down to 35Hz, that's not too bad.

The truth is the 2226 will perform very well in cabinets from 2ft3 to 5ft3 with Helmholtz frequencies between 35Hz and 40Hz. I've found that the thing that matters more than the box tuning - provided it's in that range - is the positions of the driver and port in the cabinet and its size and shape because of internal standing waves. We don't want a pressure node to line up with the port or driver in the lower midrange 'cause that will give noticeable midrange aberrations.

I can see from your response curve that your loudspeaker system is free of any such aberrations and it is working as designed.