Subject: Build Thread: 2Pi Towers, 6Pi Corner horns (and possibly a sub and center)
Posted by joshua43214 on Tue, 22 May 2018 02:09:38 GMT
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Greetings everyone!
This post will be mostly introduction and planning. At the time of this writing the 2Pi Towers are all but complete and in service, and the 6Pi mid-horns are in the last stages of construction.

Introduction:
Almost 20 years ago, I invested in a set of Athena Audio speakers for my home theater. They sat alongside my venerable Acoustic Research speakers which finally went to their maker about 5 years later. Acquiring a new set of high end speakers for music ended up getting put off because the cost of anything much better than the Athena's was cost prohibitive. I came across Pi Speakers 5 or so years ago, and giving them a try has been on my list of things to do ever since. Last year, one of the drivers in my surrounds packed up, I thought this was a good chance to test the Pi Speaker philosophy and built a pair of 1Pi's. These little speakers are really amazing for what they are. If you are in the market for a pair of nice monitors, I highly recommend them.
A couple of months ago another speaker and the sub from my Athena kit failed, and I decided to go ahead and build corner horns and 2Pi surrounds.

When I started planning this project, I realized I have a lot of unusual experience, and that this would make a very nice build thread. I have been working with wood since I was a little boy, and have had the pleasure of being a professional furniture maker, a semi-professional wood worker, and now a hobbyist wood worker. In more recent years, I have acquired a some machine tools, and become a fairly competent hobby machinist. I have also been blessed with almost perfect pitch and very good hand-eye coordination, which made me a passable acoustic guitar player. I returned to college after a serious back injury ended my 2nd career, and now hold degrees in Molecular Genetics and Mathematics and work in a research capacity.

My intention is to write a detailed (and lengthy) thread on constructing these speakers, and I hope that my experience will benefit (or even inspire) others to take on the challenge of speaker making. In many ways this will be a series of "pro-tips," but I would like to also cover basics like tooling and adhesives, as well as alternative methods. In my view, the best method for doing something is the method that gets the job done with the expected degree of accuracy, and the minimal amount of fuss given the tools a person owns.

I quick word on safety. I will describe some techniques in this thread that might make you cringe at first glance. Please take a moment to look closely and read my descriptions before jumping to the conclusion I am being unsafe. Rest assured, I take safety more seriously than most people do. That said, woodworking machinery is probably the most dangerous machinery I have used. My planer has a sizable dent from a sheet of plywood that climbed over the blade of my table saw and frizbee'd across the shop.

Choosing the Right Stuff:
Like many of us, I was at a quandary over which models to buy, and what options to buy. My room

is not especially big, squeezing in a pair of 3Pi's or 4Pi's along with flanking subs would require some lifestyle changes. On the other hand, my screen comes down in front of the fireplace which is flanked by open bookshelves of questionable ancestry, so I am not convinced that corner horns are the best fit either. My reasoning for going with the corner horns is they use space more efficiently, are substantially cheaper to build, and the worst case is I have to (finally) replace the open shelves with closed front shelves. After reading through many threads on this forum, I also decided that the 7Pi is too big for my space and settled on the 6Pi. I also went with the basic kit with no upgrades. I learned from the 1Pi's that Wayne really gets the best out of Eminence drivers, and I am not convinced My Denon AVR produces high enough quality signal to take advantage of the upgraded electronics.
I chose the 2Pi Towers because I want the lower extension, and they save me the trouble of building stands.
I have not decided on what to do about a center channel yet, and I am shopping around for a plate amp for a 3Pi sub which I will try to include in this thread.

Planning:

I began by modeling the speakers in CAD. I use Fusion 360, and I highly recommend it. The software is free to hobbyists, students, and small businesses. Certainly the 2Pis can be built from a napkin sketch (I did that for the 1Pi's), and even 3 or 4 Pi's can be built with little more than a simple sketch. The corner horns on the other hand have some complicated parts, and taking the time to draw them up in CAD has many benefits - some of which will come up during this thread. Most importantly, a CAD model lets you test different designs easily, test last minute design changes, take angle or radius measurements that would otherwise require some real math, and produce detailed drawings for the shop.

Once I had the major components drawn in CAD, I collected the dimensions and used MaxCut to optimize a cut list. I used MaxCut because it is free, and was the first software on a Google search that did what I needed. I am sure there are better programs out there. It does have one issue for this project - you can only give it rectangular parts. There is a script you can install into Fusion 360 that lets you place all the parts in your design onto a sheet, but you have to manually move stuff around to make it fit. It turned out that rectangular parts was fine, details later.
The 4 speakers combined have 54 major parts, and used 5 sheets of 3/4" MDF. This does not include the tweeter box for the 6Pi's and the assorted scrap needed. So I purchased a 6th sheet.

Up Next, the 2Pi Tower build.

File Attachments

1) room.jpg, downloaded 3779 times
2) Teaser.jpg, downloaded 3806 times
3) Cut_List.jpg, downloaded 3844 times
4) Pile_O_Parts.jpg, downloaded 3821 times

After completing the model, I ordered up all the little parts that would be needed. Lots of threaded inserts, #10 cap head screws, banana plugs, etc. I also decided to replace my 20year old speaker wires. I sourced all the fasteners from McMaster Carr. I use them only because they are very reliable, there are cheaper places. I sourced the wire (Belden 5000UE) and banana plugs from Blue Jean Cable, and banana jacks (Dayton Audio BPA-38G) from Parts Express.

Cutting the Parts:
Cutting large panels that are both consistent in size, and square is always a challenge. Most big box lumber yards will cut sheet goods for you. My experience is that the cuts are never very dimensionally accurate, never consistent, and usually have damage to the edge from the operator not being careful enough. The raw edge of MDF is very rough, and when it is pushed through a vertical panel saw, it rocks around on the rollers, to make matters worse, the off cut is pulled down onto the blade by gravity. If you can't transport the full sheets home, I suggest only letting the lumber yard rough cut the panels into more manageable sizes, and do all the finish cutting at home. Store MDF flat on the floor, or as vertical as possible to prevent bowing.
I stacked all my sheets on a pair of saw horses, then used pieces of scrap up elevate the top sheet for rough cutting. Label your parts! If you are like me, the rough cut parts at the end of the panel get left over-sized and easily get mistaken for a different part. Use stick on labels, blank labels and a sharpie are fine if you don't want to print them. I print my labels before I cut, and I know I am done when I run out of labels. I suggest not using pencil (it easily rubs off MDF), and never use a marker directly on the MDF (it bleeds through).
I used 3/4" (19mm) MDF, and allowed 3/8" (10mm) between parts during the roughing. This gives me about 3mm of extra to trim off.

Once all the panels are rough cut, I ripped them to final width on the table saw. I start by putting the straightest rough edge against the fence, rip slightly over-sized, then run the fresh edge along the fence for final dimension. This last fresh edge is your reference edge, mark it with an arrow as it comes off the saw. It is important (like really important) to always work from a single reference.
The tricky part is cross cutting so the panels are both consistent in length and square.
I use a framing square to set the cross cut guide. You can spend a lot of money of a precision square, but unless you need the scale to be really precise and need a ground edge on it, I suggest saving your money for better things. Google up "squaring a square with a punch." A cheap square can be made extremely accurate very easily by hand, and then abused to your heart's content with no worries. My preference is for cheap plated squares because it is easier to scrape glue off of them.

Study the image below for getting the second cut both square and consistent. The square is placed along the reference edge. The end already cut has a square drawn at the square corner (upper left). A piece of long scrap has a block of wood clamped to it, and is used as a story stick to get consistent lengths. The story stick is held to the panel with a spring clamp, and the square carefully butted up against it and used to set the cutting guide. If you are better with a circular saw than me, you can probably just use the square as a guide. If you take your time and are careful, you will probably be pleasantly surprised at how square and consistent your panels are.

Save your off cuts! You will need them later.

Laminating the Baffle:
It is the glue you can't see that is holding your parts together.
When I built my shop, one of the things that was imperative was the ability to be able to saw my own veneer, and do large laminations. I have a vacuum panel clamp big enough to laminate full sheets of MDF, and I have done quite a bit of laminating using a whole range of techniques. For this job, it was not worth the trouble of setting up the panel clamp, instead I used the tried and true screw and glue method.
There are any number of glues that can be used to laminate panels, some good and some bad. The 2 worst glues to use for this are yellow glue (Tightbond), polyurethane (Gorrilla Glue). Yellow glues have a short open time and even shorter working time. Unless you have a big panel clamp, it will be about impossible to spread the glue properly and get it clamped before the working time expires. Yellow glue is also very thick, and requires huge clamping force to get it to flow, and it will resist flowing even more once the working time has expired. Polyurethane flows well, but it expands like crazy during its cure. If you can put sufficient pressure evenly across the panels (something like a pile of cement blocks or your car), polyurethane is a better choice than yellow glue.
There are glues made specifically for laminating, and these are the best options. They flow well, are thinner so they penetrate with less pressure, and have extended working times.
My choice for this is PVA. PVA is the white glue your grade school teacher told you not to eat. When properly used, PVA is exceptionally strong, has a long working time, and flows very well. PVA resists water better than MDF does, so it is a good choice even in very humid or damp environments.

You can see the MDF fails before the glue joint when I tried to break this off cut.

There are two things pay special attention to when using screws and glue.
first, the screws will cause the material to bulge. Drill pilot holes and counter sink on the inside of the joint. Test on some scrap to determine how much counter sinking is required. Failing to do this will result in large voids where the panels got pushed apart by the bulging.
Second, use the right amount of glue. The glue needs to be spread evenly into the material, and it should be thick enough to be almost opaque. I used a large notched trowel like the type used for mortaring up tiles. The glue is spread evenly on both surfaces with the smooth edge of the trowel forcing it into the MDF, then the notched edge is swept over the glue. The last step is important, if the glue is not notched, the glue will not flow out properly.

The panels are layed up, and screwed together. When the proper amount of glue is used with the proper amount of pressure, a fine line of glue beads will form at the edge of the joint, drips mean too much glue or too much pressure. I use special screws (McFeely) that are designed for this application, but I used to use plain old drywall screws with good luck. Drywall screws are easier to strip out, so best to run the screw gun gently and tighten with a screw driver. Work from the center out, and work at a pace slow enough to let the glue flow to the outside. It is worth testing the process on some scrap, then sawing the parts in half through the screw hole for a post-mortem if you have never done this before. Two hours of dry time is enough to test a practice piece. The panels should be allowed to cure overnight.

The biggest enemy of a good glue joint is dust and debris. Debris will prevent the joint from closing, and dust will simply ruin the join. The entire panel should be given a quick rub with a hard sanding block to check for anything that would prevent the joint from closing, and the edges should be lightly chamfered. I wipe my panels down with solvent before gluing. Too much pressure will force all the glue from the joint leaving it starved, and not enough pressure will mean the joint is depending on the tensile strength of the adhesive rather than the chemical bond it forms. A proper glue joint with any woodworking glue is several microns thick, and should be invisible.
My work flow for this was pick up the MDF on the way home from work, rough cut all the panels, and glue the laminations so they could cure overnight. The next day, I ripped the panels to width, and trimmed to final length. The top and bottom panels where ripped to the same width as the sides, but only 1 edge was cut square at this point.

Up Next: gluing up the panels

File Attachments

1) Get_Started.jpg, downloaded 3640 times
2) SetUp_Repeat_Crosscut.jpg, downloaded 3615 times
3) PVA_Strong.jpg, downloaded 3581 times
4) PVA_Spread.jpg, downloaded 3643 times
5) BAffle_Clamp.jpg, downloaded 3613 times

Subject: Re: Build Thread: 2Pi Towers, 6Pi Corner horns (and possibly a sub and center)
Posted by joshua43214 on Tue, 22 May 2018 15:07:05 GMT
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If this was the carcass for a cabinet, one would typically glue the 4 sides in one go, then glue on the top and bottom.
A speaker though has bracing and stuffing, both of which would be very difficult to install from the ends.
I used a somewhat unconventional method of assembly that both allowed me to keep everything square, yet still gave access for installing braces and stuffing.

My milling machine has a DRO, so I used the hole pattern feature on it to drill the mounting holes, then used a circle guide and router to cut the rabbit and cut out for the drivers. The mounting holes are deep and close to the cut out, a drill guide is a really good idea if you do not have a drill press large enough to accommodate the baffle.

I should mention that I am a huge advocate of the "file to fit, and paint to hide" school. This is the essential element to "as built" construction. I also believe that it is almost impossible to dry fit parts too many times, and large glue up should always be practiced.
Glue seems to turn into a first class lubricant at the worst possible times leaving parts that joined up perfectly hopelessly out of alignment. Making a dry run will not only ensure you really can

assemble things in your planned order, but also put clamps where you plan too. It will also ensure you have everything on hand.
My plan was as follows: glue the sides to the baffle, glue the top and bottom on, install the stuffing, install the bracing, glue in the rear panel.
My design has the front and rear panel fully captured on all 4 sides. I choose this to take advantage of the extra surface area of the doubled baffle even though it puts the raw edges of the sides to the front of the speaker. I also want the sides, top and bottom to be very slightly proud of the baffle so they can be sanded back flush.
Since the back and baffle are fully captured, it is important that the speaker carcass be glued up so the back can be installed last - in other words, the carcass cannot be allowed to twist out of shape while the glue is drying.

I began by cutting scrap to space the baffle and back. These spacers will do double duty later for attaching the bracing. I used one of the off cuts from the baffle to position the spacer, and glued them down. The pic should be pretty self explanatory. It is important that the spacers be square.

Those off cuts from the baffle proved to be extremely useful during the entire build process to lift parts off the bench for clamping. It was a happy accident for me, but I would suggest adding a few inches to the rough cut baffles for them.

I then dry assembled the parts to make sure everything fit properly.

Rollers are excellent for quickly spreading glue. Not only do they easily put down the right amount, they force it into the wood. Note this is the perfect amount of glue, it is just thick enough to be almost opaque.

I used Tightbond for the carcass. In my opinion, it is the ideal glue for this. It has a very short clamping time, and well constructed joints can be handled in about an hour.
To get everything to come together in proper alignment, I used the following order of operations:
Apply glue to the edges of the baffle and the sides. Set the baffle on the bar clamps, then place the sides. close the clamps just enough to keep the sides from tipping over, but not enough to squeeze out any glue.
Set the back into place with no glue.
Place the top and bottom panels into position, and apply mild pressure with pipe clamps.
Place bar clamps front to back over the spacers to pull the baffle against them.
Double check all is lined up, and tighten the bar clamps to close the joint between the sides and baffle.
Let sit for 5 minutes for the working time to expire, then remove the pipe clamps and pop the top and bottom off. Don't wait too long or they will get glued on.
It might sound a bit complicated, but it really is not. A single practice run showed me I had to make some adjustment to clamp placement so I could remove the pipe clamps, and it took less than 2 minutes to complete the clamping.
After about 10 minutes, the carcass can be moved out of the way to dry for an hour before the next stage.

To be Continued...

File Attachments
1) holes.jpg, downloaded 3574 times
2) Panel_Spacers.jpg, downloaded 3595 times
3) Pi2_DryFit.jpg, downloaded 3582 times
4) Proper_Amount_Glue.jpg, downloaded 3551 times
5) FR_Panel_Glue.jpg, downloaded 3571 times

Subject: Re: Build Thread: 2Pi Towers, 6Pi Corner horns (and possibly a sub and center)
Posted by joshua43214 on Tue, 22 May 2018 16:26:15 GMT
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After about an hour has passed, I removed the clamps. I scribbled pencil at the ends of the carcass and passed a large hard sanding block over them. It is important that the ends are planar and there is sufficient surface are for a good airtight glue joint. I placed one of the top panels on and made sure it did not rock. At this point, it is just possible to knock the carcass apart with a mallet if something went really wrong. If the ends are not planar but can be fixed, consider letting it dry overnight. In my case, the ends came out very well, and just some minor dressing with the sanding block gave a near perfect join.

My sanding block is a piece of MDF cut to use 1/3 of a sheet of sandpaper longwise. I use a light coat of spray adhesive to hold the sheet in place. I also have an MDF sanding block covered in heavy felt that uses 1/4 sheet of sandpaper. I only use soft block for finer grits and finishing. Leveling surfaces is best done with a hard block even though it wears out the paper faster.

Next I glued the top and bottom on.
once again, the order of operations is important.
I set the carcass face down on some scrap to keep it off the bench slightly, and applied glue to all the parts.
I set the back in place with no glue.
I placed the top and bottom, and gently clamped crosswise to bring the sides tight to the back.
I then placed pipe clamps top to bottom and lightly tightened them.
I then slightly loosened the bar clamps holding the sides against the back and slightly tightened the pipe clamps so the carcass could relax or twist as needed for the top and bottom to go on square.
Once everything was aligned, I tightened up the bar clamps, then the pipe clamps.
I removed the bar clamps, and used the port as a handle to pull the back out.
The off cuts I said to save in an earlier post are used as spacers, and clamped between the sides.

Once again, it sounds much more complicated than it is. The important thing is that the clamps go on in such a way that the carcass will take the right shape for the back to be lowered in later.

I masked off areas that glue will applied to, and use Scotch 77 spray adhesive to glue in the R13 fiberglass.
For the braces, I used 1x2 lumber. They are cut slightly overlong so the panels will all be under tension.
I gave some debate about the right material for braces. Maple is what the sound posts in violins

are made from. A sound post transmits the vibration of the front plate to the rear plate and a violin will not sound without one. So maple seemed like a poor choice for bracing if I wish for sonic deadness. MDF on the other hand has essentially no tensile strength, and only modest compression strength. I am of the opinion that MDF braces do not connect the panels to each other in any meaningful way. I think they provide reinforcement by making the panel thicker where they are installed, and the very nature of MDF will cause it to absorb vibration - this makes MDF a good choice for bracing. Plain old yellow pine has better tensile and compression strength than MDF, so it will connect the panels to each other, and is soft enough to absorb vibration. My choice was made partly because it is cheaper, and partly because it is simpler to trim pine to fit, than to get MDF braces to fit tightly without resorting to dado joints.

Once all the bracing was installed, more fiberglass was hung from them.
These are my preferred choice for inserts. I like them because they are about as hassle free as it gets, and they cannot be pulled through. California users beware though. It seems the State of California has knowledge otherwise unknown to the rest of humanity of the dangers of elemental lead used to alloy steels. I expect Nobel prizes to be awarded any day. In the mean time, better break out the Tyvek. Those of you in the rest of the world can carry on as normal.

Lastly the back was glued into place. It went right in with no issues or trimming on both speakers.

About this time, the parts from Pi Speakers arrived. One box with 6Pi parts got badly damaged (pics later), and another box showed up a day late containing a bent Alpha 10 driver.

Wayne promptly shipped a replacement Alpha 10 out while he deals with UPS, and it arrived just as I was beginning to paint. Painting ended up getting delayed by nearly a week because it was too cold on dry days, and raining on warm days.

Next up, Finishing the Towers

File Attachments

1) Flush_Ends.jpg, downloaded 3556 times
2) TopBot_Glue.jpg, downloaded 3544 times
3) BracesAndStuffing.jpg, downloaded 3536 times
4) inserts.jpg, downloaded 3387 times
5) Damaged Alpha.jpg, downloaded 3517 times

Subject: Re: Build Thread: 2Pi Towers, 6Pi Corner horns (and possibly a sub and center)
Posted by joshua43214 on Tue, 22 May 2018 16:47:08 GMT
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Here are the pics from the 6Pi parts.

Those with sensitive stomachs beware...

The Crossovers got hammered to death by one of the Compression drivers. Wayne asked me to send them back for assessment, and UPS managed to sit on them for so long they didn't get back to him til late last week.
They look even worse in person, even the resistors got bent and almost ripped off the boards.

The Delta 10 is about 1/4" out of round

and the Delta 12 is bent over 1/4" out of flat.

Wayne also asked me to send the compression driver back since it was probably the hammer that caused the problems.

All in all, it was a very sad day.
Hoping the replacements arrive before the 6Pi's are complete, the race is on

File Attachments

1) Sploded_Xover.jpg, downloaded 3510 times
2) Bent_Delta12.jpg, downloaded 3531 times
3) Bent_Delta10.jpg, downloaded 3544 times

Subject: Re: Build Thread: 2Pi Towers, 6Pi Corner horns (and possibly a sub and center)
Posted by Wayne Parham on Tue, 22 May 2018 21:03:57 GMT
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Great build thread! Keep 'em coming!

This kind of stuff is so useful for everyone on the forum.

Subject: Re: Build Thread: 2Pi Towers, 6Pi Corner horns (and possibly a sub and center)
Posted by ggnarley on Thu, 24 May 2018 02:28:17 GMT
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Josh,

Great read! I already picked up several pointers for an upcoming build.

Paul

Subject: Re: Build Thread: 2Pi Towers, 6Pi Corner horns (and possibly a sub and center)
Posted by joshua43214 on Thu, 24 May 2018 03:52:23 GMT
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Before I even began making the CAD drawings, I was worried about finishing. If the hulking monolith of the 2Pi gets a low WAF score, the 6Pi Cornerhorn gets a total fail. Fortunately, I no longer have to worry about WAF scores, but I do prefer things to look good.

Veneering was definitely an option. I have several hundred board feet of "African Mahogany" that I let my lumber supplier talk me into a bunch of years ago. The stuff is so awful to work with I have never sold it, but I would be otherwise "free" material. After much consideration, I decided that it just has too much figure and would serve only to draw attention to the speakers. Not such a problem with the 2Pi's but I don't really want to make the 6Pi's stand out too much. I have close to a thousand board feet of White Oak, and a fuming chamber large enough to hold even the largest parts. Fumed oak is wonderful, and would match my house nicely. Fuming veneer creates an entire new set of issues because the ammonia will attack the glue if it is too thin, and veneer thick enough to fume has a major effect on construction and joinery. I am knee deep in projects already, and I need new speakers more than I need yet another showcase piece.

In the end I decided to paint the speakers, and after looking at thousands of pictures of painted speakers, I settled on black paint. What I want is for the eye to not be drawn to the speakers. Flat chalk black actually creates a negative space that the eye is drawn too. Likewise, gloss ivory black demands attention because it is so lovely. I also knew I wanted some texture to the paint. I wanted just enough eggshell to prevent reflections, but not so much it once again creates negative space. This eliminates using my spray equipment, and eliminates high texture paints like Duratex.

I started experimenting with paints the day after I began sawing up materials, and was still experimenting with paints while I was applying primer. I finally settled on Sherwin Williams satin black All Purpose latex enamel. The color is exactly what I wanted.

I will point out at this point that I am not an expert on the subject of paint. I have some knowledge on the topic, I would say I have enough knowledge to get myself in trouble, and not enough to bail myself out. The vast majority of my experience relates to finishing furniture where I used nitrocellulose lacquer or solvent based automotive lacquers in conjunction with stains or shellac.

While I do feel confident detailing my approach to painting these speakers, I urge anyone with real knowledge of painting to chime in and add their knowledge.

At this point, construction of the speaker is complete except for the cut out for the wires. I also still have not made a decision about whether to add acoustic fabric to the baffle or not. I decided at the last moment not to use the terminal cup that comes with the kit. By the time I made this decision, the primer was already on. A word of warning, the wire kit that comes with the 2Pi tower is about 3 feet too short, something I did not notice until after I had installed the binding posts. I drilled the holes for the binding posts as close to the floor as I could go and still be able to reach them on the inside through the driver hole (this is about mid-speaker). The wire is so short, you

have to put the terminals almost directly behind the driver.

Finishing:
I began by sanding the entire speaker with 80 grit paper on a hard block, paying special attention to making sure the ends are flush with the panels. I closed off the driver cut-outs with 2" painters tape. I just stretched the tape over the holes, then used a sharp knife to cut the tape around the hole and let the tape fall into the recess. I want to make sure the inside edges of the recess get filler. I removed the tape after sanding so the recess could get a coat of black.

After sanding, I wiped the speaker down with a very lightly dampened clothe and covered the entire thing with filler. I use garden variety all-purpose joint compound meant for drywall. The stuff I use is gypsum in a vinyl binder.

Do not be shy with filler. Force it into the MDF with a trowel, especially the raw edges. I let it dry overnight, then sanded it entirely off with 180 grit paper and a hard block.

Once the filler was sanded off, I sanded the corners to about a 1/16" (1.5mm) radius. The reason for doing this last is because the MDF edges are very fragile, and the corner radius will get damaged rolling the speakers around, or even by the trowel itself. Making a consistent radius by hand is not difficult, but it does require a lot of practice for most people. A round over bit in the router, followed by 220grit on a hard block is a good idea. I suggest not using a soft or contoured block since it will ruin the nice crisp transition the router should produce if adjusted properly.

I then sprayed the speakers with Rustoleum all purpose primer. I was still experimenting with paints at this point, and I knew from experience that this primer will work with about anything. I sanded the primer back with 180grit and a soft block to remove the stubble, but not enough to remove the paint.

I should make a few notes here. A paint ready surface is a much higher quality surface than a stain ready surface. Paint will reveal and magnify the smallest flaw in the surface, and the smoother the paint, the more it will magnify it. If you plan to use a gloss paint, it is very important to get a really good surface under it.

Mixing types or even brands of filler/primer/paint can lead to binding and curing issues. This is not such a problem with latex, but it can be a huge problem with polyurethanes and lacquers. If you plan to use any type of oil, urethane, or solvent based finish, I strongly suggest using filler, primer, and paint from the same brand unless there is a real expert at the counter that can attest that the products will work together.

Lastly, just because the can says "1 coat, primer and paint in one" does not mean that it will do the job in one coat. Take this statement the same way you do "gap filling" glue - it is a fictional character that only exists in science fiction. If you are not getting proper coverage, don't just roll on more paint, wait a bit and roll on another coat.

After some experimentation, I settled on a faux mo-hair roller. This produced a modest eggshell finish that looked nice on the test boards.

At this point the first of my problems emerged. The latex paint dries far too fast for the surface to fully flow out. I had some paint extender from another project a few years ago, it looks and smells like white glue. I added some to the paint, and decided I would attempt to tip off the surface after I rolled it up. Like I said, I know enough to get myself into trouble, but not enough to bail myself out. Tipping off 5 panels proved to be beyond my skills and I wound up with 3 or 4 minor sags at some of the edges. To make matters worse, the paint proved to be very slow to cure. After 5 days, it was finally hard enough to sand. It would pill up a bit, but not enough to clog the paper. I will say the paint was extremely tough, I had to use 100grit paper to cut it, 180grit would not cut through it.

I returned to Sherwin Williams where I interrupted their resident expert from his important work, and laid out the full story. He agreed the Rustoleum should not be a problem, and that the filler I used is also known to be fine. That left the extender or the weather. We had a string of days under 60 (15C), and the days it did get over 60 it rained.

I was also not satisfied with the texture, it had more texture than I really wanted (see above pic), which was why I had attempted to tip it off. After more discussion with the expert, I decided to try a flock roller, and purchased some M-1 extender.

I sanded the previous paint back enough to remove the old eggshell texture with 100grit. I probably should have done a finish sand with 180grit because some of the scratches left by the 100grit telegraphed through the next coat. My plan was to give them a final coat when they got moved to their final position as rear speakers, since I expected them to get damaged if I chose to put feet under them or add fabric. Currently they are being used as mains while the 6Pi's are being constructed.

dirty hand prints courtesy of my son

The color and texture do exactly what I want, but it also makes them difficult to photograph. After they have their final coat, I will try to get some shots of them in sunlight.

Up Next: The 6Pi's (what we are all waiting for) or a review of the 2Pi Tower sound (will depend on my mood).

Here is a teaser from the 6Pi build

File Attachments

1) Perfect_Color.jpg, downloaded 3437 times
2) Filler.jpg, downloaded 3461 times
3) Pi2_Done.jpg, downloaded 3399 times

4) Pi6_Teaser.jpg, downloaded 3412 times

Subject: Re: Build Thread: 2Pi Towers, 6Pi Corner horns (and possibly a sub and center)
Posted by joshua43214 on Mon, 11 Jun 2018 01:16:11 GMT
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So, how do they sound? Good.
How good? Very.
They sound so good that I felt compelled to take a break from working on the 6Pi's so I could deal with acoustic treatments. Flaws in my listening room suddenly became intolerable.
They sound so good I found myself using mostly well engineered music for critical listening (the audiophile rabbit hole).

My first thought when I hooked them up was "wow, that is big sound." Very reminiscent of the big speakers that where so popular in the '70s, the kind of speaker you want to play blues, rock, or soul through. Not to say they do not work just as well with orchestral music. Piano and cello are reproduced with amazing accuracy. Most impressive to me is how well they handle percussion though. They handle percussion almost as well as acoustic suspension speakers (which is even more impressive considering these do not have a Zobel circuit).

So far they have been put through three critical listening sessions with my son (who is musician of some skill and an audiophile), and we shared a relaxed listening session last week. For reference, I relied on 4 songs:
Tori Amos Pretty Good Year. This song is a good test because it has a fairly wide range of octaves, and it is difficult to produce the low piano notes, Tori's husky voice, and the backup vocals simultaneously. It also was very useful for speaker placement - the song will bring out room issues very quickly. The CD is very well produced, and has very good sound. The majority of the signal is inside the 2Pi Towers "sweet spot" and they effortlessly push the music into the room. A sub would be needed to fill out the bottom fully, but the Towers never sound like they are straining on this track.

Massive Attack Group Four. This song will test any speaker. The nice thing about Massive attack is that every bit of sound in the track is put there by hand, and it is clear when something is out of place. The music itself also hints at what is missing if your system is not able to reproduce it. The Towers idle right through the first section of the song which is a whimsical Trip Hop duet, and hammers out the second section which has a goth grunge sound to it without a sweat. It almost reproduces the transition between the sections flawlessly, but to be fair, very few systems can.

Yes Mood For a Day and Led Zeppelin Braun-Y-Aur. I chose these both because they are filled with rich harmonies, and because I had mastered both songs in my 20's so I know exactly how they should sound and feel. I also included Ana Vidovic's rendition of La Catedral.

The 2Pi Towers put the music right where it should be and fill them room with little effort. They do have all the limits that a 2-way speaker has, but the worst issues of bass-reflex are nicely minimized or absent. The most notable thing they are missing to my ear is that extra punch that sticks make when a drummer puts all their weight into the toms. Regular hard drumming and the

kick drum come through just fine. I am a huge fan of all things percussion, so I am probably more sensitive to this than most people, my son certainly did not notice til I pointed it out. This is one of those things that only horn loaded drivers are really able to reproduce, and is always a weak point with bass-reflex speakers.

The question I keep asking myself is "are they good enough?" In other words, if I was not building a set of 6Pi Cornerhorns, would I bother to upgrade them. I honestly don't know. I am hip deep in projects, and there are other things I would much rather be doing than working with MDF. On the other hand, they sound so good, they are dragging me slowly but surely down the audiophile rabbit hole of endlessly seeking improvements. If these had to be my primary speakers, I would definitely add subwoofers and high-pass them a bit. I would probably also opt for something smaller than the 3Pi Sub since space in my room is at a premium - the Towers do not need much help at the bottom end.

I have also been using them as the mains for movie watching, and they do a very impressive job at this as well. My Athena Audio sub died right about the time I ordered the 6Pi kits, so the Towers are being used also for theater. Suffice it to say that the Towers where able to turn Blade Runner 2049 into a truly immersive experience even without a sub for LFE. I do have a sub on order, and we plan to re-watch Blade Runner, and watch Baby Driver when the 6Pi's are up and running.

I do have to withhold full judgment for the moment though. I am 95% certain the two issues I am having are my room and not the speakers. I suspect the port might be tuned too high, but it is pumping right into a corner node. I placed a piece of Rockwool Safe and Sound in the corner behind the speaker (partially blocking the bookshelves), and it helped immensely. The tweeter also seems to be a tad bit loud, but once again, room treatment helped this problem as well. I know I am still having room issues because I can improve the sound by equalization. I will try to get around to building a tester for measuring the speaker tuning sometime this week (yet another project...). I did try laying the Towers on their back over a pair of chairs, and observing the excursion at different frequencies, but it was not conclusive.

Once the Cornerhorns are completed. I can move the Towers into a better position in the room and give them another critical listen. Whether I will or not is a different question. Their primary duty will be for surrounds in my theater, and for this they are already excellent. I will also want to be listening to my 6Pi's, not moving furniture around.

One other issue, the Pi logo decals are black...
sure would be nice to have them in gold (hint hint).

Up Next: The 6Pi Cornerhorn build

Subject: Re: Build Thread: 2Pi Towers, 6Pi Corner horns (and possibly a sub and center)
Posted by joshua43214 on Wed, 13 Jun 2018 03:14:48 GMT

As I write this post, the replacement drivers have arrived safe and sound, and I am still waiting on the replacement cross-overs and my 3Pi Subwoofer parts. All the major construction of the 6Pi is complete, and only a handful of small parts need to be made, and some holes drilled. I have begun painting what is ready to be painted, and I expect to spend the next week or two on painting the rest. I aggravated my back injury lifting the bass bins last Thursday, so I have been working at a slower pace since then. I have also begun work on the 3Pi Subwoofer, but can't proceed until the kit arrives. I will prolly interrupt the 6Pi build with a post or two on its construction at some point.

The vast majority of this portion of the thread will be given over to the midhorns. The Tweeter boxes and bass bins are fairly straight forward, and do not require much additional to the 2Pi Towers. This forum limits the number of images you can upload for each post, so this will also be broken up into many posts since I have many pics.

During one of my previous lives, I was a furniture maker. During this time, I spent a few years making percussion instruments. I have probably tried about every method possible for cutting and gluing tapered joints. I know from experience how difficult it can be to get a proper glue joint on something like this. Proper glue joints depend on two things: surface area, and clamping pressure. It takes very little error in the cut angle to reduce the amount of surface area below the required amount, and it is almost impossible to clamp perpendicular to the joint. I consider the horn section of this build to be a somewhat advanced project, that should be doable by anyone with moderate experience in woodworking. Mostly it requires patience and fussiness at a few key points, as well as the proper tools.

The method I used is one of the methods I worked out for making tapered drums, and it works extremely well. I decided not to make a full sized jig because it would have taken most of a day to construct and cost over $50.00 to make. If I had to do it over again, I would make the jig. The time and hassle saved would have been well worth it. A properly designed jig would allow not only the flare parts to be cut accurately, it would also act as a clamp for gluing, and allow the horn box to be fitted over the flare with no hand fitting. The design and construction of a jig like this is actually more complicated than the design and construction of the entire 6Pi, if your inclination is toward this type of work, I suggest you follow your inclination.

Wayne sells flat packs for the horn flare.

Tooling:
If you are cringing at the idea of buying tools just for this project, consider that the 6Pi costs $2700.00 + freight unfinished. Even if you spend several hundred dollars on tools, you are still coming out way ahead.

I would not even consider attempting the flare without a table saw unless I was planning on spending many hours hand fitting the joints. The flare parts are big, so the saw will need to have plenty of extensions, and a solid rip fence. The rest of the parts can be made with a circular saw if you opt to buy the flat pack.

A plunge router is a really good idea.

A decent dial caliper. If you have to chose between a cheap digital model (as in Horror Freight), and a dial, get the dial type. I have owned over a dozen dial calipers over the years, and my current daily driver is a 6" dial caliper I purchased from Shars.com, and it seems to be the perfect balance between cost and quality (cost very little, and is durable as heck). I generally work to a tolerance of 1/64" in the woodshop, which is about 0.015" (0.4mm). A dial caliper lets you measure this quickly and accurately even over rough surfaces.

A trammel. A trammel is similar to a compass. Rather than being a pair of legs, is it a long beam with points that can be moved along it. You can spend an obscene amount of money on a trammel, I made mine from some scrap oak. It pivots on a piece of 1/4" (5mm) piano wire that I pointed on the grinder, and has a pencil on the other end. I made it decades ago and it works well.

A machinists combination square. It just needs to be square, and the head needs to lock solidly. I have a Starrett (expensive), not sure what to recommend for a cheap one that does not suck. You wanted one anyway

A precision protractor. One that can be set to minutes (or even seconds) of a degree. I am lucky to own a nice Japanese universal bevel protractor, but even used they are very expensive. There are cheap copies for under $60.00 that would probably work, and digitals for even less. Just make sure the moving arm can be put against the saw blade or you will have to make repeated test cuts - digitals often have trouble with this.

A decent dial indicator with a magnetic base is also very handy to have. It takes all the guess work out of nudging the rip fence over a "touch." just plop the thing down, butt it up to the fence, and tap it over the correct amount (you measured the correct amount with your dial caliper). My daily driver is from Shars.com, I use the mid-priced black faced version. I abuse the heck out of indicators in the metal shop. These hold up very well, and are so cheap I keep a couple spares and toss them when they finally start to get sticky. I almost never use my nice Mitutoyo ones.

Lastly, is CAD software. I made a number of changes to the design during construction, one of which would have cost me a pair of horn boxes had I not double checked things in CAD first. Cad will help prevent major problems like putting a fastener where a driver goes, and make sure important things like binding posts are not an afterthought. CAD will also let you pull angles directly from the drawing without having to use any math. I have a math degree, I would take no pleasure in figuring out the cut angles for the parts. I use Fusion 360, it is free to hobbyists, and there are many very good tutorials on YouTube.

You will also need a ready stash of cash. The 2Pi Towers and 6Pi Cornerhorns needed 6 sheets of 3/4" (19mm) MDF at $28.00 a sheet. The fasteners ran about $100.00 total, the paint another $100.00. The bathtub liner used for gaskets and the like costs $8.00 a foot. Add in a roll of R15 fiberglass, 3 bottles of glue and other forgotten things. I opted to purchase binding posts from Parts Express, the 6Pi's required 4 pair binding posts and 3 pair banana plugs for each speaker. Expect to spend $100.00 to $300.00 on top of the material costs. All said, this project has cost about $1500.00 plus another $350.00ish for the sub, and I consider it a huge bargain. If you have

a spouse type thing living with you, it might be a good idea to consider squirreling some extra cash away for the project

I would also plan on 3 to 8 weeks for construction, and a week to 10 days for painting and curing. If I made these professionally, I would expect they would take about 15 hours over a 6 work day period to construct each speaker before finishing assuming I had all the jigs made up and was practiced at it.

The Midhorn:

Since the midhorn is the most complex part, I started there. Some issues came up pretty quickly, and I started a thread on the topic.
https://audioroundtable.com/forum/index.php?t=msg&th=21885&start=0&
In a perfect world, I would just make my CAD model public via the Autodesk cloud. Wayne offered me this reply when I asked about doing so:
Quote: Also, I appreciate your offer for the CAD drawings, but we already have CAD drawings and even CNC code for some of the more complex models and parts. We don't provide those drawings or G-code because we don't want to encourage third-party flat-pack builders. There have been a few unapproved businesses that have sold flat-pack kits for our models, with one of the most aggressive being just a few years back. They usually start off offering to build cabinets or flat-pack kits as a favor or limited service, but then gradually transition to a full-fledged manufacturing operation.
Everything needed to work out the design issues pertaining to the horn are in the above thread, and the plans. Reading the Whitepaper helps a bit. It is more important that both horns be identical, than they meet some theoretical ideal set of dimensions.

The horn box itself is in effect an acoustic suspension speaker - in must be sealed airtight with no leaks. There are several places that can be troublesome for this. The back, which uses a gasket to seal it, must be as flat as possible, and must be able to carry strong fasteners. The join between the sides and the angled sides must be tight and well clamped. The join between the driver mount and the horn throat must be airtight and square to the box. The driver should be square to the box, the flare should not be off center, and the mouth of the horn should be perpendicular to the bottom so it is in the same plane as the front of the bass bin.
I imagine the horn is somewhat tolerant of things being off a bit. Error does accumulate though, so I consider it best to aim for things being a perfect as I can get them.

There is a great deal of geometry in the 6Pi, some is critical, some is not. For instance, the sides of the bass bin do not need to be perfectly square to the baffle. Nor does the baffle itself need to be square to anything other than mostly square to the floor. The front of the bass bin though acts as a baffle for the midhorn, so it should be planar to the midhorn driver. Likewise, the tweeter box is entirely optional, so it's only critical geometry is that it must support the tweeter horn so it is aligned properly.

When I make drawings for anything I build, I constantly ask myself "how am I going to cut that, and how am I going to install that?" It is just part of my design process. Knowing how something will be physically cut and installed can have a huge affect on the design itself. I often makes notes in the plans on construction so that when I am working in the shop I can focus my attention on

other important things rather than trying to figure out how to put something together after I have cut all the parts.

My next several posts will go into detail the process I used to make the midhorn so that the horn throat is centered in the box and flare, the driver planar to the bass bin front and the horn mouth, both horn flares are as identical as possible, and that the flares themselves would be symmetric vertically and horizontally. The fact that the midhorns exceeded my design expectations is more a testament to being fussy at a few key points, than my tools or experience. I believe this is something anyone with moderate experience in woodworking can accomplish.

File Attachments

1) CAD_Pi6.jpg, downloaded 3131 times
2) Tools.jpg, downloaded 3108 times
3) CAD_MIdhorn.jpg, downloaded 3037 times
4) Protractor.jpg, downloaded 3067 times

Subject: Re: Build Thread: 2Pi Towers, 6Pi Corner horns (and possibly a sub and center)
Posted by johnnycamp5 on Wed, 13 Jun 2018 12:17:13 GMT
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Awesome build!

Just a couple of observations-

You had mentioned the six pi Corner horn being smaller than the seven pi.
I believe it is the other way around, with the six pi tuned to about 1/2 an octave lower.

As far as the two pi's lacking in punch.
It has been my experience that woofers (especially high sensitivity) will loosen up and break-in, improving in just that range (mid bass).
My four pi's slowly broke in, increasing in the mid bass.

Experience also tells me that amplifier topology also has a part to play in this.

I used an Adcom 555, with moderate punch.
Then a set 300 b with a bit less punch.
Now two medium size mono blocks using Kt 88 tubes, they pretty much punch you in the face.

Ymmv.

Subject: Re: Build Thread: 2Pi Towers, 6Pi Corner horns (and possibly a sub and center)
Posted by Wayne Parham on Wed, 13 Jun 2018 16:46:30 GMT

Seriously cool build thread, Josh! I've been meaning to say a few words, but I've been slammed lately. So I just read without comment. But here are the things I've been meaning to say, or at least thinking about as I read your notes:

little taller - Less than 2". So I didn't say anything when I read your post about that. They look exactly the same to the eye.

It's just the tuning required for the drivers I've chosen. Both have an alignment that is slightly overdamped, just the way I like it - Controlled. The system can't shift towards underdamped (peakyness) even when the power levels are high for extended periods.

The threads in the "Models, Upgrades and Driver Characteristics" section of the FAQ talk about all that stuff in more detail so I won't belabor it in your build thread.

cornerhorns.

I'm still amazed how much damage those parts suffered. UPS does a pretty good job, but I have to make claims in about one out of every thousand shipments. So I'm hoping I'm good for two thousand shipments 'cause you had two packages damaged.

Subject: Re: Build Thread: 2Pi Towers, 6Pi Corner horns (and possibly a sub and center)
Posted by joshua43214 on Thu, 14 Jun 2018 11:51:32 GMT

@johnnycamp5
@Wayne Parham

Thanks for the feedback.

Sorry about the confusion on speaker size, I was actually referring to the size of the drivers as opposed to the cabinet. My intuition was that the 15" woofer in the 7Pi is just too big for my room. I do not need the extra sensitivity, and I already knew the 8" 1Pi can fill my room. So I resisted the "if some is good, more is better" logic. I did not know the 7Pi was physically smaller than the 6Pi, though either one has a smaller foot print than the 4Pi because they need no wall spacing or flanking subs.

Good advice on amps. I have had the nagging feeling that this might be the case as well, and my son also has the same contention. I dusted off my venerable Marantz 1030 that I purchased used as a teenager and hooked it up. It produced lovely sound for less than a minute before it started making crackling noises. I can't find my old Harman Kardon amps.

I am somewhat tempted to snag some cheap Ebay kit amps of different classes to see how they affect the performance before building something high-end (more projects...).

That is great news about the crossovers being on the way. I suppose this means I have to get back to painting.

-Josh

Subject: Re: Build Thread: 2Pi Towers, 6Pi Corner horns (and possibly a sub and center)
Posted by ggnarley on Thu, 14 Jun 2018 22:19:15 GMT
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Josh,

Thumbs up on the great posts. I have read them over a couple times and keep picking up solid build tips; not just for speakers, but carpentry/woodworking in general.

Paul

Subject: Re: Build Thread: 2Pi Towers, 6Pi Corner horns (and possibly a sub and center)
Posted by joshua43214 on Fri, 15 Jun 2018 02:30:20 GMT
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The horn flare requires the sides to be cut at a compound angle. The work must be fed through at an angle, and the blade itself must be angled. There are a number of ways to accomplish this, all have pros and cons. The number of methods shrinks rapidly when they are constrained to a high level of precision and consistency. Ideal methods will use a single set up on the saw.

Before I began cutting parts, I took the time to make sure the rip fence was parallel to the blade, and that the miter gage was square. I use the dial indicator to adjust the fence. I turn off the magnetic base, and hold the base firmly against the fence with the plunger near the gullet of one of the teeth on the blade. Zero the indicator, then move the base up the fence and check the far side of the blade. Best practice is to mark the gullet with a felt tip pen, and use the same gullet for each check. I prefer this method to using the miter gage as a mount for the indicator.
To square the miter gage, cross cut as wide a piece of scrap as you can. Tape a piece of paper to the table next to the rip fence. Hold the reference edge against the fence, and strike a line

along the edge that was cut. Flip the part over front to back, hold it against the fence and strike another line alongside the first line. The difference between the two lines is the double the error.

These two checks are the first of the critical things that I was fussy over.

Accomplishing a single set up is best done using a sled that positions the work, and once the rip fence and blade angle are set, all the cuts can be made. My sled is just a piece of MDF with 3/16" (4.5mm) brass pins spaced exactly 10" (25.4cm) apart. To get the pins "perfectly" parallel to the fence, I ripped a piece of scrap approx 2.5" (64mm) wide, and placed it ontop of the sled between the pins and the rip fence, then just ran the sled through the saw. The fresh cut edge is now the edge used against the rip fence for cutting the flare parts.

The image shows the sled on the saw. Note the larger holes are the hole pattern for the bass bin driver, so the sled does double duty as a drill guide.

The flare sides are trimmed to length. Note the work is elevated off the table saw so the tapered edge on the other end can register properly on the miter gage stop.

Three holes are drilled in each horn flare side. These holes do not need to go all the way through, but mine do. They are filled later with 5minute epoxy.
I used my mill to drill the holes. These holes need to be very accurately placed, and my mill has a DRO that makes it painless. This can be done with a compass and a trammel. I will go into details in my next post about locating the holes accurately with primitive tools, and finding the cut angles.

The flare is then placed over the pins, and the edges are ripped.
Note the large piece of MDF clamped on the left side of the blade. This is to prevent the offcut from falling onto the angled blade and getting kicked back.

The part is then reversed, and the other side ripped.

You might notice that there are no clamps holding the part to the sled. None are needed. The holes are drilled to be a tight fit, and hand pressure is more than enough to hold it down. In practice it feels no more dangerous than making any other rip cut.

Up next: Finding the angles and marking the holes.

File Attachments

1) Sled.jpg, downloaded 1694 times
2) Flare_Crosscut.jpg, downloaded 1740 times
3) Flare_Holes.jpg, downloaded 1749 times
4) Flare_Cut_1.jpg, downloaded 1706 times

5) Flare_Cut_2.jpg, downloaded 1692 times

Subject: Re: Build Thread: 2Pi Towers, 6Pi Corner horns (and possibly a sub and center)
Posted by joshua43214 on Fri, 15 Jun 2018 05:54:27 GMT
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This next part is difficult to describe in words. I will do my best, but I tend to fall into the pedantic style that science and math papers are written in, so please accept my apologies in advance if this post is a difficult read.

Many of you probably noticed the flare sides where rough cut as rectangles rather than as trapezoids. At first glance this might appear to be grossly wasteful of materials. It is, but the offcuts will be used later as bracing, mitigating some of the waste. The main reason they are cut as rectangles is so that the mouth and the throat are parallel to each other. This would be very difficult to accomplish otherwise. This ties back to my earlier post about constantly asking myself "how am I going to cut that, and how am I going to install that." Planning the cutting and assembly during the design stage is a huge benefit.

I will go ahead and describe part of the process for creating the CAD model for the flare in Fusion 360. My feeling is that most people who are willing to take on a speaker cabinet project will probably be also interested in using CAD. CAD has a bit of a learning curve. I dumped many thousands of dollars into CAD programs since the 90's, and I have found that Fusion 360 is the best all around tool for the work I do (and it is free).

I began by modeling a core that is the inside of the flare.
The image shows the core with the right side and the bottom. The base sketches for the core are visible inside the core.

To model a side, I selected a side of the core as the reference plane, then just sketched a rectangle bigger than the core and extruded it to my material thickness. The adjacent faces of the core are then used as slicing planes to split the side, and the extra parts removed.

I found that I could not get the dimensions and angles in the plans provided by Wayne to work together. I am providing the link to the thread I started again for reference.Dimensions clarifications
A pro-tip on modeling. When I drew the horn core, I began by making the base sketch for the core in the XY plane. I stopped the sketch without extruding it. While making sure the first sketch was visible, I started the base sketch for the YZ plane. By doing this, the first sketch will "auto-project" into the new sketch allowing one to constrain the intersections of the lines to be coincident. That way, when a change is made to one base drawing, it will force the other base drawing to adjust to it. Once both base drawings are completed, I returned to the first drawing and extruded it oversized. I then extruded the second drawing also oversized (ensure you are making a new body). The two 3D bodies are then used to split each other, and the offcuts removed leaving nothing but a single body.

One of the limits of Fusion 360 is that it is purely a 3D modeling program. 2D modeling is limited

to base sketches that are extruded into 3D shapes. The software is meant for producing models that are made either by 3D printing or CNC machining. As such, the tools for producing shop drawings are limited since shop drawings are 2D.
When the 3D model is imported into the tool for generating shop drawings, all the parts are projected from the cardinal directions of top/side/etc. Parts that are not planar with one of the cardinal views will appear angled or foreshortened in the drawing space. Search YouTube for tutorials on creating custom views (it is very simple), and select the appropriate view when creating the shop drawing for the horn parts.

The angle that is needed for the saw blade is referenced to the bottom face of the flare, and is measured along the line perpendicular to the cut edge. There is no reliable way to create this reference in the shop drawing space.

I found the simplest method to get this angle was to sketch a line on the inside face of the right side perpendicular to the cut, and use that line to create a new plane at a 90 degree angle. I then split the part with the plane, and copied the new part to a new model space, and used "undo" to remove all the edits (don't forget to break the link to the old model). The new part was exported to the drawing space as its own file, and my angle measurements taken from there. The angles for the mouth and throat can be taken from the main drawing.

Where to place the three holes for the pins will depend on your tooling. The digital read out on my mill resolves to 0.0001" (0.0024mm), so I just put them where they looked ok. All of the dimensions of the horn work together, so it is important to cut and measure as accurately as possible. Your dial indicator will scribe marks very accurately up to its capacity, but making marks 12" or so inches from the edge are problematic.

Here is my suggestion for making the layout. This assumes you acquired a machinist combination square that does not suck. It is a really good idea (like really good) to go through all the horn parts and mark all 4 edges on both faces right/left/top/bottom/inside/outside, and to group them as horn #1 and #2.
Cut the mouth and throat angles, cut the parts as close as you can measure. Reading glasses make nice magnifiers when using precision rulers (I think I forgot to include a 24" machinist scale in the tooling list). Strike a line perpendicular to the mouth bisecting the part. The 12" scale that comes with the combination square can be used to place the hole closest to the throat. Use a dial caliper to scribe a line parallel to the mouth that passes through point A in the pic below. Set the trammel to 10" (check and double check this, get fussy). Strike an arc across the part with the point near the throat and the center. Use the dial caliper to scribe the points closest to the mouth (distance H). Those of you without a flag on the Moon will have to use whatever metric dimensions are standard on tools in your location.

Lightly center punch, and drill with a drill press. I like to use a center point in the drill press to locate the part, then swap in the drill bit. It takes a bit of extra time to swap out the drill before each hole, but there is only 12 holes to drill. Following any method similar to this reduces you to making one questionable measurement (the 10 distance for the trammel), but this distance is only measured 1 time. Even if it is off a bit, the horns will be identical to each other.

An argument for cutting the mouth and throat angle first, as opposed to leaving them square and trimming them later: If the mouth and throat are left square, it will be more difficult to align the top to the sides. Trimming later requires sanding a substantial amount of MDF away, and it will be difficult to ensure the entire face of the flare is flat because of its size. Cutting the angles first does require an extra machine set up, and leaves you referencing from a sharp and fragile edge, but saves time and increases accuracy at the same time.

Use a precision protractor to set the table saw blade. It is vitally important that the protractor be perpendicular to the blade when the measurement is made. I use the miter gage to hold it square. Put a light at the back of the saw, and see how much light leaks between the blade and the protractor. Slide the protractor over, and then back to the blade to double check. This is a point to get fussy over.

At this point, you should have horn sides that are cut to size on all 4 edges, and tops/bottoms that are cut only at the appropriate angle at the mouth and throat.
The flare top and bottom are identical, so I will only talk about the top from this point forward.
Using a framing square (you did Google up how to square a square, didn't you?), bisect the inside face of the top using the mouth as the reference, and taking care the square is referenced on the edge and not on the bevel. Cut some scrap exactly 4.5" as spacers for the horn throat. Use a compass to draw a 4.5" circle near the throat on the bisecting line. Very carefully measure out from the bisecting line the distance to the outside edge of the side, and set the trammel to this distance. Use the trammel to repeat these marks to all the tops and bottoms. Doing this will ensure the horns are identical even if your measurement is slightly off.

Mark a line on the outside of the top that will be directly over the center line of the sides.

Clamp the spacer using the compass circle to get it aligned. If you took your time and where very careful, the throat will be laid out exactly over the center of the mouth.
Dry assemble the horn. It took some playing around to figure out how to hold everything together. Get the whole horn lined up. With some patience, you will find that it will come together properly.
Carefully drill a hole for a 1/4" (5mm) dowel near the throat. Trim a piece of dowel, sand it enough that it can be lightly tapped in with a mallet, and then re-align everything (it will have shifted when you drilled). repeat until you have a pair of dowels on each glue joint (8 total). Plan to spend some quality time doing this.
Line the drill up carefully, there is a strong optical illusion that will lead you astray.
Once all the dowels are in, drill holes for #10 screw threads. Dismantle the horn and drill out the screw holes in the top to clear the threads. Counter sink the holes on the inside of the joint.
Dry fit the parts again using screws and dowels. Tighten the screws just enough to pull it together. inspect closely for gaps or poor fitting. If all went well, you should see no issues. If the joints are not well fitting, you will have to clean them up by hand with a sanding block.

Apply glue and screw it all together. Measure corner to corner at the mouth to make sure the assembly is square. Yellow glue is a good choice with this. If the glue joint is not tight, use epoxy. Do not use polyurethane glue on a poor fitting joint. Polyurethane glues are very weak on joints with gaps, and they are highly porous because of how the expand.

Make sure you remove the 4.5" spacer before it gets glued in place. After about 40 minutes, clean

up the glue with a chisel.

Remove the screws and trim the top and bottom flush with a handsaw.

Congratulations, you just built something awesome.
Many years ago I subscribed to Fine Woodworking Magazine (when it was still a mag for professionals). Every month they would feature a "Master Class" where some master craftsman would make something awesome. One month, the feature was about making a feed trough. Is it essentially the same thing as this horn flare only about 3 times the size. Everyone was amazed at how difficult the project was. It turns out that there was a class of woodworkers similar to coopers who did this type of work. It is difficult enough that specialists existed at one time for doing it.

Up Next: The Horn box

File Attachments

1) Horn_Core.jpg, downloaded 1701 times
2) FlareCutAngle.jpg, downloaded 1721 times
3) Hole_Layout.jpg, downloaded 1703 times
4) Horn_Glue.jpg, downloaded 1700 times
5) Horn_Glue_2.jpg, downloaded 1718 times

Subject: Re: Build Thread: 2Pi Towers, 6Pi Corner horns (and possibly a sub and center)
Posted by joshua43214 on Sat, 14 Jul 2018 18:10:38 GMT
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Hello everyone, please accept my apologies for the long delay on continuing this thread.
Along the way to finishing the project several things happened that took away my time on one hand, and took the wind out of my sails on the other. I continued to have issues with the paint, I will go into detail later, but I found it extremely hard to continue to muster enthusiasm for a project I was already getting tired of knowing that I was going to have real issues with the final finish in the end. My experience with the 3Pi Subwoofer only put me off more (more later).
On a more positive note, I was able to sneak a nice trip to the Painted Rocks area of the Upper Peninsula, and took a horizontal transfer where I work. I have the same title and description, but I am taking over a brand new lab and all that entails. The new position also came with a nice pay raise, and very real opportunity for further advancement. I don't recall if I mentioned it already, but I hold degrees in Molecular Genetics and Mathematics, and work in a semi-academic research capacity. The down side is a lot of hours until I can get everything working as it should, and by then we will have 2 post-docs I will have to nurse along

Also, if you could hear my 6Pi Cornerhorns, I am sure you would also prefer to relax and enjoy the music rather than write a build thread...

That said...
We interrupt this 6Pi build thread to knock out a 3Pi Subwoofer...

The 3Pi Subwoofer is truly a weekend project, and is quite a simple build. If you are looking for a good project to get your feet wet, this, or the 1Pi speakers are an excellent choice.

After a brief email exchange with Wayne over what plate amp to chose, I settled on the Dayton Audio SPA250 from Parts Express. The Eminence JOB12 that the Pi3 Sub is built around is a serious beast, and I was worried about pairing a 250W amp with a 400W driver. There is a huge price jump when you cross the 250W threshold, and I did not want to spend a ton of money on an amp whose primary purpose will be LFE (the 6Pi's do not need a sub). I suppose I should be clear that Wayne did not utter even a breath of approval for this particular amp, he just assured me that the wattage would be more than adequate. Those of you have sought Wayne's advice on anything not sold by Pi Speakers will know that getting him to voice an opinion is like trying to pull teeth from a rooster (for good reason imo).

I still took the time to model the sub in Fusion 360, which saved me from a major issue. The port tube runs nearly the entire depth of the enclosure, and it would have hit the plate amp. I had to move the plate to the upper half of the back to avoid this.

I used "as built" construction for the entire project, and only a handful of critical dimensions are cut before assembly. The 3Pi Sub is really big which makes cutting square edges a bit of a challenge.

When I cut the parts for the 6Pi bass bin, I made a special square to use as a router guide to cut all the parts to identical length, I repurposed this square for squaring up the baffle and rear panel. I know I have not yet written that part of the 6Pi build, I will hopefully get it posted before too long. It is not a complicated thing, just some scrap MDF glued together with 2 edges parallel and both square to a third edge.

I had the store I purchased the MDF from rough cut the parts - the 3Pi Sub needs almost an entire sheet of MDF. I laminated the baffle the same way already described for the 2Pi's. I took extra care to make sure I did not put the clamping screws where it would cause havoc with any of the cut outs. After the baffle dried, I cut two edges parallel on the baffle, the back, and both sides using the table saw. I then cut one edge square on only the baffle and the back with the above mentioned jig. I then cut the last edge by putting the freshly cut squared edge to the rip fence that had been left undisturbed from cutting the edges parallel. The remaining edges on the sides are left rough cut.

A word of caution here. Rip fences are for ripping, and this last cut is a cross cut. Cross cutting with a table saw is extremely dangerous. The parts are large enough, and the baffle heavy enough to mitigate some of the danger though. Unless you have had enough things go sideways on the table saw so that you know what to avoid, I suggest taking the extra time to trim the last edge with a router or circular saw.

Once the baffle and back where cut, I used the all the same methods to cut the driver and port holes as above. I used a jig saw to cut the plate amp hole.
I then glued up the baffle, back, sides, and bottom in one go. I just used my eyes and fingers to get all the overhangs even. There is no need for super accuracy here. A box this size will have to be very out of square before it is noticeable, and it will have no effect on the sound at all.

After 45 minutes, I removed the clamps, cut 2 pieces of scrap to support the port tube, and used epoxy to glue the tube into place.

Note the piece of steel scrap used a weight to "clamp" the port to the braces.

I then cut 1x2 pieces to size as braces. All of these are spring fit, and require no clamping. To get the short piece that spans the middle in, I used clamps to flex the longer cross braces back so I could fit the shorter brace in without scrapping off all the glue.

I then glued the top on and left it to dry overnight.

The next day, I used a handsaw to trim the port tube back, and flushed all the edges with a router. At this point I just moved the sub into the house and put it into service.

Note the mechanics creeper it is sitting on. This thing is heavy enough to hurt your back, and moving it around is not fun. I wanted it up front with the 2Pi Towers until the 6Pi's are done when I plan to move it behind the couch.

My plan at this point was still to remove the 2Pi's for another coat of paint after the 6Pi's where done. Painting the sub now would mean I could not generate dust in the shop during the process. So it seemed best to bring it in and enjoy it while waiting for the 6Pi's to be completed.

I am not sure how to review this sub, since it is being driven by an inexpensive Dayton Audio amp. I did find I had to turn the gain down til it was almost off before it would match up with the 2Pi Towers, and I wound up low-passing it at about 120Hz. It will operate above that frequency, but it produced some distortion that I attribute to the amp. Once it was set up though, wow...

Angels descended and shed white light upon my listening room. All was good and Josh was happy until the amp packed up after less than 10 days and started making funny noises all its own. I have trouble describing how frustrated I was about this. I put the kind person from Parts Express on speaker phone, and he agreed to do an RMA right way. At this time, I am still waiting for the replacement. What little enthusiasm I had to play with MDF in my spare time only to have paint issues rapidly diminished. A camping trip with my wonderful (and at this point suffering) girl friend was in order to restore my perspective.

Wayne highly recommends pairing his first four Pi box speakers with flanking subs. I can't speak for the 3Pi or 4Pi, but it does truly miraculous things to the 2Pi Tower, which sounds very respectable all on its own. if you are debating the addition of a sub, do it. The 3Pi Subwoofer does things for cello and piano that is nothing short of amazing, not to mention drums and deep vocals. My only issue is the size, two of them side by side would be bigger than my already too big coffee table.

Up next, the continuing saga of the 6Pi Cornerhorns.

-Josh

File Attachments
1) Sub_Glue_1.jpg, downloaded 1428 times
2) Sub_Port.jpg, downloaded 1466 times
3) Sub_Bracing.jpg, downloaded 1448 times
4) Sub_Glue_2.jpg, downloaded 1443 times
5) Sub_assembled.jpg, downloaded 1433 times

Subject: Re: Build Thread: 2Pi Towers, 6Pi Corner horns (and possibly a sub and center)
Posted by joshua43214 on Sat, 14 Jul 2018 19:45:07 GMT
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The horn box is a bit more challenging than it looks at first glance. Clamping the 45degree sides will be very difficult. The method I detail below was not my first choice, but it worked quite well and was of minimal hassle. The best method in my opinion would be to rabbit grooves in the top and bottom that are a snug fit for the sides. This would allow clamping the angled portion without having to worry about everything getting pushed out of alignment. If you opt to get the parts CNC cut, I highly suggest this as a method. Setting up a router guide/jig as way more hassle than the method I used, but if your work style goes in this direction, follow your urges.

It is really important that the miter joint in the sides be cut perfectly square to the top and bottom edges. If this joint is not square, a joint somewhere in the box will not close fully. If this happens, just spread some 5 minute epoxy on the inside of the joint to seal it. The Midhorn is the heart of the 6Pi, it is important that the box be fully sealed and airtight. Taking the time to get all the joints perfect will pay off in the end.

I also made a design change at this point. In my original design, the rear portion of the sides entrapped the front - the assembly method I visualized would have been easier that way. I decided that I preferred the front portion to entrap the rear so less end grain would be visible. My parts had already been rough cut, so I played with the parts to convince myself that I could still make it work. Prudence being the better part of valor, I stopped everything and changed the design in Fusion 360. What looked to be fine on the bench, turned out to not work. After some fiddling, I was able to find a way to use the parts I had already cut. In the end, I settled on using the venerable screw and glue method for getting the sides to close up at the miter. After some experimentation, I found that 5/8" #6 screws (3.3mm x 16mm) worked well.

The back is screwed onto the box, and in my design, I am mounting the crossovers in a box that will attach to the back cover on the midhorn. The back is one of the major weak points in the design - this is a large area that needs to be sealed, and it is made from a material that does not take screws well at all. Poorly executed, the rear cover will degrade the sound. I opted to glue 1x2 pine to the inside of the box to carry the threaded inserts for attaching the rear cover.

I began by ripping a 45degree angle on one edge of the pine, then ripped a 45 degree miter on the rear portion of the side. I carefully marked the position of the pine, clamped a guide along the line, then glued the pine to the sides
Note the severe angle of the spring clamps. This angle has to be steep enough to force the glue joint to close at the feathered edge. The guide prevents any slippage.

Once the glue dried, I ripped the 45degree angle on the back edge. After carefully squaring the miter gauge (a good time to get really fussy), I trimmed all the sides to length.

Next, I carefully marked out the inside width of the box on the top and bottom using the trammel. I used the sides to mark out their lengths, and glued pine corner braces in place.

note the scrap clamped along the layout lines. This ensure the pencil line is not lost when the glue squeezes out over it.

I clamped a fence to the drill press table, and drilled the holes for the miter joint screws

I did not pre-drill the sides for the threaded portion. Instead it assembled and disassembled the parts repeatedly while cleaning up the holes with a counter sink between each assembly. You will not be able to tighten these little screws enough to crush the parts together, so it is important that it get cleaned up well.

It was immediately apparent during dry assembling the box, that it would take too much time for Tight Bond glue, so I opted for old fashioned Elmer's White Glue.

I chamfered the edges of the sides where they meet the braces. Not doing this might prevent the sides from drawing up to the bracing if any residual glue remains.

I began the assembly by gluing the miter. I tightened the screws just enough to begin cloing the joint, but not enough to make it rigid.

I then put the sides on, followed by the top.

Clamping order is important here. I flushed all the front edges and lightly clamped vertically just at the front. I then clamped the cross wise to pull the side panels up against the braces. Next, I tightened the screws at the miter to draw that shut, and added a vertical clamp over the miter. I only have one clamp large enough to draw the rear side up to the braces that is still light enough to not be unwieldy. So I used this clamp with a piece of scrap to pull the rear sides up to the braces, followed by a vertical clamp to hold it in place. The horizontal clamp is then removed since it will draw the box out of square. Lastly, I measured corner to corner and clamped diagonally to square up the mouth of the box. The mouth needs to be as square as possible. Mine only required a little bit of coercion to square it up.

Next, More midhorn building

File Attachments

1) Box_Side2_Brace.jpg, downloaded 1406 times
2) Box_Side_Drilling.jpg, downloaded 1248 times
3) Box_Top_Braces.jpg, downloaded 1424 times

4) Box_Miter_Glue.jpg, downloaded 1379 times
5) Box_Glue_Up.jpg, downloaded 1370 times

Subject: Re: Build Thread: 2Pi Towers, 6Pi Corner horns (and possibly a sub and center)
Posted by joshua43214 on Sat, 14 Jul 2018 20:09:40 GMT
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I trimmed the extra material off the horn flares, and sanded the joints flush.
The flare was then inverted over the mouth of the box, and the long edges marked out for trimming

I used one of the supports for the bass bin as a sled to run the flare through the table saw. I first made a cut that I was sure would be ok, then tapped the fence over as much as I dared and cut to the line.

Fitting the long edge is just a matter of sanding until it fits, while being extra careful to sand to the line, and to keep the edges parallel.

Once the flare is close to fitting, extra care should be taken to not split the box. MDF is a very weak material in tension, and you will split it with almost no effort. Patience is the key, it does not take any special talent or skill. Just check it often, wear a glove, and think happy thoughts.

The human eye is remarkably adept at spotting regular shapes and shadow lines. Measure over and over as you go to make sure the top and bottom edges are the same width, and they are not tapered.

Trust your eyes. If it looks like this when you sight down the edge, you have done very well.

Next: Finishing up the flare

File Attachments
1) Flare_to_Box_Layout.jpg, downloaded 1369 times
2) Flare_Rip.jpg, downloaded 1340 times
3) Sight_Line.jpg, downloaded 1346 times
4) Flare_Sanding.jpg, downloaded 1347 times

Subject: Re: Build Thread: 2Pi Towers, 6Pi Corner horns (and possibly a sub and center)

Fitting the short edge is much the same as the long edge with a couple differences. Trimming of the bulk is not easily done on the table saw. I trimmed it off with a handsaw. unlike sanding blocks, handsaws to require a bit of skill to use well. Just stay inside your comfort zone and use whatever tool you feel most comfortable with.

Before I marked out the cut line, I spent some time fussing about getting the flare even in the box. I used a dial caliper and levered the flare with a chisel until I had less than 0.005" (.127mm) difference. All of my earlier fussing was so I could make this particular measurement well. If the box or the flare are not square and flush at the fronts, then getting this alignment will be difficult. The more out of alignment this is, the more the flare will be aimed off axis, and the more the driver will be out of vertical. How much does this really matter? Hardly any if there is only one speaker. The point is not that the horn and driver must be in some perfect plane, it is that the pair should be as identical as one can make them.

One again, just sand to the line, think happy thoughts, and check often. When fitted, the flare should fall in with minimal friction. Just enough to prevent it from free falling, but not so tight that it produces a starved glue joint.

This next image is actually out of order, but the operation can be done at this stage. Sorry, it is the hazard of writing a build thread after the project is completed.
I used a fly cutter on the mill to trim the throat of the horn flat. This can also be done using straight edges and rulers, which is the method I used for flattening the back of the box. Still it is a cool pic with a scary tool

Once the flare was fitted. I glued it in place and used some spring clamps to keep the joint tight. It is important to work quickly doing this, Tight Bond grabs and starts to set very rapidly. Make sure you have a mallet and an assortment of scrap for beating the flare into place.

Before I glued the flare in place, I very carefully marked the center of each side of the throat. After assembly, I test fitted the driver support after marking out the center of it.
I think this is about as good as it gets, the driver support is less than 0.010" (.254mm) out of alignent, and that only on one edge. The other horn came out the same.

This is more or less how all 4 corners on both horns came out after flush sanding.

Next: Even more Horn work

File Attachments

1) flare_aligning_1.jpg, downloaded 1350 times
2) Flare_Fycut.jpg, downloaded 1332 times
3) Horn_Perfect_Fit.jpg, downloaded 1337 times

4) Horn_Fitup.jpg, downloaded 1315 times

Subject: Re: Build Thread: 2Pi Towers, 6Pi Corner horns (and possibly a sub and center)
Posted by joshua43214 on Sun, 15 Jul 2018 22:19:20 GMT
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Once the glue dried, I used a router to flush trim the sides only. The front I sanded just enough to remove the glue, and the back I left untrimmed. The back takes a gasket, delaying trimming as long as possible delays any damage it might receive during construction.

I had saved all the offcuts from the horn to be used as internal bracing. I fitted one brace by trial and error using the bandsaw and a sanding block. Once the brace is close to being a good fit to the taper, one can hold the brace in place against one side, and scribe a line with a pencil laid flat on the other side. Then it is just a simple matter of trimming the edge parallel to the pencil line until it fits properly.
The fitted brace is then used as an angle guide for cutting the remaining braces, by taping the blanks to the fitted brace and running them past the blade.

Done wrong, this can be a very dangerous operation. Note the wide part of the guide is closer to the blade. If the tape fails and the part being cut slips, the taper will cause it to move away from the blade. If the taper is run the opposite way, the part will wedge between the blade and fence causing a kick back.

The braces are then trimmed to length. Note the stop block is making contact with the taper, not the end.

Each horn has a total of 6 braces, 4 for the longs sides, and 3 for the short sides.

As uniform as these horns came out, they are not perfectly alike. Because of this, I chose to use 5 minute epoxy to glue the braces in. Un-adulterated epoxy is very hard and brittle, so not suited for this application because it might crack from the vibration of the driver. The stuff sold in hobby stores to the model airplane crowd is the right stuff, or the general purpose epoxy sold at the big box hardware stores. People often have trouble measuring epoxy, especially when it comes in tubes because the hardener and the resin have very different viscosities. Follow the directions, if it says equal volumes, do not use a scale. I invert the bottle for a few minutes, and use it in 2 line increments. I make a puddle of hardener (it is thicker) on some brown craft paper, then add the resin directly on top.

The reaction that epoxies undergo is exothermic, and generates heat. If you over mix it, all you are doing is adding energy to the reaction causing it to react even faster. Just mix it until it takes on a whitish color and use it. Once it starts to get stringy, stop even if it means you have to scrape it back off your parts. I had to mix 3 batches to get all the braces in.

I then cut out the fiberglass stuffing. Nothing fancy here, I just went at by eye with a utility knife.

Took me all of 10 minutes.

The stuffing needs to go in before the driver mount. I also made sure the bracing would not interfere with the driver mounting screws. This is something that can be done in cad, but I just transferred the positions from the mount itself.

Up Next: Even more Horn building...

File Attachments

1) Horn_Bracing.jpg, downloaded 1172 times
2) Horn_Bace_Trim.jpg, downloaded 1155 times
3) Epoxy _And_Stirer.jpg, downloaded 1171 times
4) Fiberglass_Stuffing.jpg, downloaded 1116 times
5) Stuffed_Horn.jpg, downloaded 1138 times

Subject: Re: Build Thread: 2Pi Towers, 6Pi Corner horns (and possibly a sub and center)
Posted by joshua43214 on Sun, 15 Jul 2018 22:53:06 GMT
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The driver mount should be just a smidge shorter than the box sides otherwise there will be no room for any glue and it will be difficult to put in. I cut mine when I cut the sides, then sanded one edge back until it fit right.

I test fitted the mount, and scribed the throat opening. The holes for the driver mounting screws are laid out from the scribed line. Once again, I took the easy way out and drilled the holes and made the cut out on the mill.

Note I stayed very far from the line. This extra material is important later.

I managed to remember to install the inserts before I glued in the mount. Forgetting this would be a disaster since they cannot be installed later. I also lightly moistened each hole, and added a touch of Gorilla Glue, having these unscrew would also be a disaster.
After gluing in the driver mount, I glued 3/4" (19mm) square pine strips to the top and bottom of the box at the back. These strips will hold the inserts for the back cover. I also glued in some 3/4" (19mm) braces along the driver mount to top/bottom joint. I then taped some brown construction paper inside the assembly to prevent sawdust from getting down into the stuffing.

Using one of the bass bin supports as a sled, I ran the whole assembly through the table saw to trim the excess off the back.

This is when having a dial caliper and dial indicator come in really handy.
I measure how much material is remaining.

Then use the dial indicator to bump the fence over a few thousandths short of the target distance.

I then placed the assembly mouth down on the table saw, and found the lowest point on the back. I scribed this height all the way around the box, and clamped straight pieces of scrape to the box along the line. Then it is just a matter of sanding and checking with a straight edge until the back of the box is flat. It is not so important that the back be parallel to the front, what is important is the back is flat. A gasket is only as good as the surface it seals. The rear cover will flex a bit, and a rubber gasket will compress a bit, but not enough to make up for very much error.

Up next: yet again another post on the horn...

File Attachments

1) Driver_Mount.jpg, downloaded 1124 times
2) Box_trim_1.jpg, downloaded 1134 times
3) Box_Caliper_Measure.jpg, downloaded 1125 times
4) Fence_Indicator_Adjust.jpg, downloaded 1114 times
5) Box_Back_Flattening.jpg, downloaded 1129 times

Subject: Re: Build Thread: 2Pi Towers, 6Pi Corner horns (and possibly a sub and center)
Posted by joshua43214 on Sun, 15 Jul 2018 23:24:37 GMT
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Dealing with the throat of the flare is something I spent quite a bit of time thinking about. I read about every paper published for free on horn theory, and learned a huge amount in the process. It seemed self-evident that having sharp edges where sound entered the horn would not be a good thing. This turned out to be a subject that others have done some research on. In the end, I decided to be guided by a whitepaper by Charles E. Hughes for Peavey called "The Quadratic Throat Waveguide." Reading this paper alongside Wayne's own whitepaper on horn theory will probably all one needs to know about horns in general unless you want to take the deep dive into it.

In short, the paper contends that the transition from the backside of the horn, to the inside of the horn should be a circular arc, whose edges are tangent to the back and side faces. The paper goes onto contend that the corners where the sides meet the top/bottom of the horn should be a parabolic profile whose origin is relative to the width of the side at any given point. The first part is simple enough, and can be done easily with a compass, the second part requires real working knowledge of calculus, and implementing will be a nightmare. Fortunately, we are making a 6Pi Cornerhorn, not a Peavey horn. My other research showed that above a certain size diffractions inside of horn become inaudible even when measurable, and that standing waves inside the horn

are a far bigger issue. The 6Pi midhorn is just over that threshold for size.

I honestly do not know how much of a difference this will make verses just eyeballing a radius, but it make me sleep better, which makes my girl friend happy, and a happy girl friend makes me happy

Returning to Fusion 360, I exported the midhorn core to a new design, and created a model just for the arcs.

I then created a shop drawing from the new model and printed it out.
I trimmed a piece of scrap to be equal to the distance from the front of the driver mount to the tangent line of the arc, and scribed the lines where the arc should end on the inside of the flare. The extra material I left in the cutout makes it easier to support the block for marking.

To keep everything nicely consistent, I taped scrap to my sanding block so that it would approximate the arc. techinically, this will form an involute, but they are very similar in shape.

I then glued the paper to some scrap, cut off the excess paper, and used it to check my progress as I went.

This was another unfun job, but it went faster than I expected.

Next Up: the back cover and starting the crossover boxes

File Attachments

1) Flare_CAD_Radius.jpg, downloaded 1095 times
2) Flare_Throat_check.jpg, downloaded 1101 times
3) Flare_Tangent_Marking.jpg, downloaded 1089 times
4) Horn_Flare_Finished.jpg, downloaded 1098 times
5) Sanding_arc_block.jpg, downloaded 1080 times

Subject: Re: Build Thread: 2Pi Towers, 6Pi Corner horns (and possibly a sub and center)
Posted by joshua43214 on Mon, 16 Jul 2018 00:06:04 GMT
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I spent some time trying to figure where to put the crossovers. I know it is common to put them in

a box, and set them on the floor next to the speakers. I am not the neatest person in the world, and this sort of thing just creates more mess in my world. I did want ready access to them, so putting them inside the bass bin seemed a bad option. After experimenting in CAD for a while, I settled on putting them in boxes, and mounting the boxes on the back of the midhorn. The pros of this are the crossovers are easily accessible, the box can be used to brace the back panel eliminating the need for a rubber ball behind the driver, and the crossovers are near the drivers making for a clean set up. The cons are that if I need to unplug the midhorn for testing, I will have to remove the box, and the fasteners are pretty expensive.

Because the box bolts to the back of the midhorn, the box is the same size as the back.
I focused heavily on ensuring the front of the box and flare where as square as I could make them, this came at the expense of squareness at the rear cover. Both of them are very slightly out of square.

I began by ripping the backs for the midhorn and crossover box to fit their individual horns. I then taped the back cover and crossover back together, and cross cut them to fit the midhorn. I used layers of tape on the miter gauge to adjust the angle as I cut them. This is much simpler than adjusting the miter gauge, and just as accurate in this case.

I then marked out and drilled the 4 holes for mounting the box through both parts. The holes in the horn back gets drilled over sized later to take the 1/4" threaded inserts. After separating the parts, I drill the holes for the binding posts.

I have a rolling cart that I use for my drum sander that turned out to be just the right height to put under my drill press for drilling the mounting holes for the back cover. This was easier than attaching an oversized table to the drill press. I also have a bench top drill press that would have worked nicely by turning the head around.
I drilled first just one hole that is a tightish fit on the 10-32 screws I used.

I removed the back, swapped in the correct drill for the insert, and drilled again. I installed the insert, and screwed the back on with one screw. This screw will keep the back correctly positioned as I drill the remaining holes.

I went one hole at a time, first drilling for the screw, then the insert. A bit of a time consuming operation, but it ensures all the holes are well placed.

The crossover box is straightforward with sides 2.5' (64mm) tall. I cut the sides to fit the back cover. The cover was not so far out of square that it affected the corner joints of the box sides.
I was sure I had taken pics of them, but I seem to have misplaced them. So instead I offer a pic of the parts when I was painting the edges that are hidden. As a bonus they include a sneak preview of the tweeter boxes.

This concludes the construction of the midhorns.

Up Next: The Tweeter boxes.

File Attachments

1) Backs_Crosscutting.jpg, downloaded 1083 times
2) Box_Holes.jpg, downloaded 1067 times
3) Back_Hole_1.jpg, downloaded 1086 times
4) Back_Hole_2.jpg, downloaded 1059 times
5) Back_Sneak.jpg, downloaded 1075 times

Subject: Re: Build Thread: 2Pi Towers, 6Pi Corner horns (and possibly a sub and center)
Posted by joshua43214 on Mon, 16 Jul 2018 00:37:14 GMT
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I designed and discarded a number of tweeter enclosures. The problem is that the horn itself is simply ugly and utilitarian, and putting an enclosure around it just makes it that much more obvious you are hiding something.

In the end, I just decided to embrace its ugliness, and wrap it in a box that looks like it is serving some puropose.

The tweeter boxes are "as built." I began by marking out the dimensions of the top. I used a piece of scrap that I ripped to be parallel to set the angle of the miter gauge. The scrap is held against the rip fence, and the miter gauge is adjusted until the other edge lays on the pencil line.

The fence is then moved out of the way, and the tops are cut to the line.

The driver is large enough that a relief is needed in the top. I cut the relief with a dado. A bit of trial and error was able to locate the position of the material so the relief would be centered.
The pic below has all the details. A stop is clamped the to the fence with a large C clamp. A piece of scrap is clamped above the work to prevent it from shifting upward when the dado head is raised. The work itself is held in place with a bar clamp. A large piece of scrap is clamped at the front of the saw as a last safety device should the worst occur, and it will prevent the work from hitting me in the face as I kneel to raise the blade.

After the cut is made on both sides, the fence is moved over about 3/4" (19mm) and the operation repeated.

Once the angles are cut, the top itself is then used to set the blade angle for cutting the sides.

The bottom is little more than a brace to keep the front end of the sides positioned, and the back is just a cap. After glue up, I used the horn to scribe the radius at the front, and sanded the taper with a long hard sanding block and 80 grit sandpaper.

File Attachments

1) Tweeter_CAD_Model.jpg, downloaded 1036 times
2) Tweeter_Cut_1.jpg, downloaded 1027 times
3) Tweeter_Dado.jpg, downloaded 1041 times
4) Tweeter_Blade_angle.jpg, downloaded 1040 times
5) Tweeter_Radius.jpg, downloaded 1021 times

Subject: Re: Build Thread: 2Pi Towers, 6Pi Corner horns (and possibly a sub and center)
Posted by joshua43214 on Mon, 16 Jul 2018 00:47:52 GMT
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This forum has a 5 image limit, so here are some bonus pics for the tweeter.

It is clear the mold was not up to temperature when the horns where cast, but A mold that size would take a while to warm up and add to the cost greatly.
It is a good idea to dress the area where the driver mounts, since it is anything but flat or smooth.

Here is an image of the completed tweeter showing the rope caulk wrapping, and rubber glued to the bottom to prevent it from moving around.

File Attachments

1) 20180525_111917.jpg, downloaded 1020 times
2) 20180525_122109.jpg, downloaded 987 times
3) 20180527_142848.jpg, downloaded 1021 times
4) 20180701_145031.jpg, downloaded 1017 times
5) 20180701_155314.jpg, downloaded 1016 times

Subject: Re: Build Thread: 2Pi Towers, 6Pi Corner horns (and possibly a sub and center)
Posted by Wayne Parham on Mon, 16 Jul 2018 14:50:11 GMT
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Very cool looking tweeter enclosure!

As an aside, the compression driver has a gasket that provides seal even with some of the casting marks on the mount. The casting marks simply press into the gasket. Still, it doesn't hurt to take those down with sandpaper as long as one isn't too aggressive.

Earlier versions of the horn had an aluminum throat mount that was machined from billet. The current H390C wood horn still has this mount. It has an O-Ring immediately outside the throat.

But I found this was extreme overkill. The gasket on the front of the compression driver works very well.

Another example of something similar: Some people press modeling clay into the slight separation between compression driver and throat mount. They think the tiny gap might be a problem, like a larger discontinuity would be. But it's acoustically too small - Small compared to wavelength. It's kind of like how you can't see the mesh of a screen door. A better analogy would be a large tire rolling over a small crack which passes without disturbance. There are no anomalies that can be detected from the tiny gap between compression driver exit and horn throat entrance; There are no measurable differences made when using the modeling clay. So while it doesn't hurt, it doesn't help either.