

Synergy Horn Project

September 2017 by John Hollander



Project description

This project makes a Multiple Entry Horn (MEH) similar to a Synergy Horn. The horn design is for full range home audio use. Efficiency is about 86 dB at 2.83 V rms.

Design goal

The design goal was to make a compact MEH that would be comparable with high quality home audio speakers. The design goal meant that only a single midrange driver was required to meet home volume levels, the woofers needed to perform in the 30Hz range in a small enclosure, and the tweeter needed to perform better than a compression driver used in many horn designs.

Driver Selection

After testing some tweeters in the horn model, the Tymphany XT25TG30-04 1" Dual Ring Radiator Tweeter was chosen. The horn gain allowed the tweeter to be crossed with lower than expected distortion.



The horn simulations called for a midrange that would work well from 400 Hz to 1,500 Hz. The SPL requirement needed to be above 87 dB at 2.83 V rms for flexibility in the crossover design. The GRS 4FR-8 Full-Range 4-1/2" speaker was chosen because it met the SPL requirements and could be mounted on its face without the surround hitting the cabinet while playing. The GRS also fit inside a 4 - inch diameter PVC pipe making for a simple midrange enclosure.

The woofers are a pair of Dayton Audio DCS165-4 6-1/2" Classic Subwoofers. They perform well in a smaller volume and have reasonable sensitivity.

Enclosure Design

The enclosure design is a stand mount cabinet with a 60 x 90-degree conical horn. The horn is about 6.7 inches deep. The horn is designed to maintain pattern control to 400 Hz. The internal cabinet volume is 20 liters for the woofers. The box tuning is at 38 Hz with an F3 of 36 Hz.

The enclosure is designed for all the drivers and ports to be within the horn mouth. It was found that a square opening for the tweeter performed just as well as a round transition opening.

There are chamber resonances associated with the midrange and woofer driver openings into the horn mouth. To simplify the construction the driver openings size and locations were adjusted such that only straight holes are required in the ½ inch MDF.

The woofer ports are made from 2-inch PVC pipe.

Enclosure Assembly

The enclosure assembly is straight forward except for creating the side panels for the horn. The drawings include a plan for jigs to cut out the side panels. Note that the side panels are all the same and 4 are needed.

The enclosure consists of four parts; the rectangular cabinet, midrange enclosure, the horn, and the face frame. With respect to cutting out parts here are a few tips.

- Cut the face frame pieces oversize then trim them to fit the horn mouth while overlapping the sides of the cabinet. Trim the face frame flush with the outside of the cabinet.
- Make the back panel slightly smaller to fit in the opening
- Make the top and bottom panels slightly longer (1/8") to account for any miss alignment.

Start by assembling the midrange enclosures.

- Solder on hook up wire to the GRS drivers.
- Cut 2.5 inch lengths of PVC pipe and glue to the back of the GRS drivers
- Run the wires through a wood cap and glue the cap on the back of the PVC pipe
- Rough up the side of the PVC pipe where the angle brackets will be mounted. Rough up the metal on the angle bracket. Secure the angle brackets in place with glue and a hose clamp.
- Before gluing the angle brackets, test fit the midrange enclosure, angle mounting brackets and the port PVC mounting blocks on the top horn panel. The port PVC mounting blocks may need to be trimmed.
- Mark the location of the midrange enclosure mounting studs on the horn top panel.

Assembling the horn.

- On the top and bottom horn panels, draw out the lines where the side panels attach and the location for the driver holes and ports. Drill out the holes.
- Attach the 2-inch PVC port mounting blocks with the 1.5 inches of pipe over the port holes. Flush trim the inside of the port holes to the PVC pipe inside diameter.
- Cut out and attach the woofer mounting rings. I used plywood underlayment that split. I would not use that again.
- Drill pilot holes and install studs for driver mounting. Be careful not to screw through the side of the horn mouth. Some of the inaccessible studs were not installed.
- Cut and use a 4.0 cm spacer block to make sure the tweeter opening does not become too small while assembling.
- Lay out the location of the horn top and bottom panels on the cabinet sides. I added blocks to the side panels to hold the horn panels during glue up. Dry fit the horn pieces and the side panels.
- Glue up the horn pieces. A pneumatic finish nailer is helpful to hold the pieces together. Glue and clamp the cabinet sides to the horn. Use the cabinet back piece to ensure the assembly is square. Add clamps to the horn as needed.
- Add mounting blocks for the tweeter. Flatten the mounting surface for the tweeter after the glue has dried.

Assemble the face frame

- Attach the top and bottom face frame pieces, align the pieces with the horn mouth.
- Cut and fit the side face frame pieces.

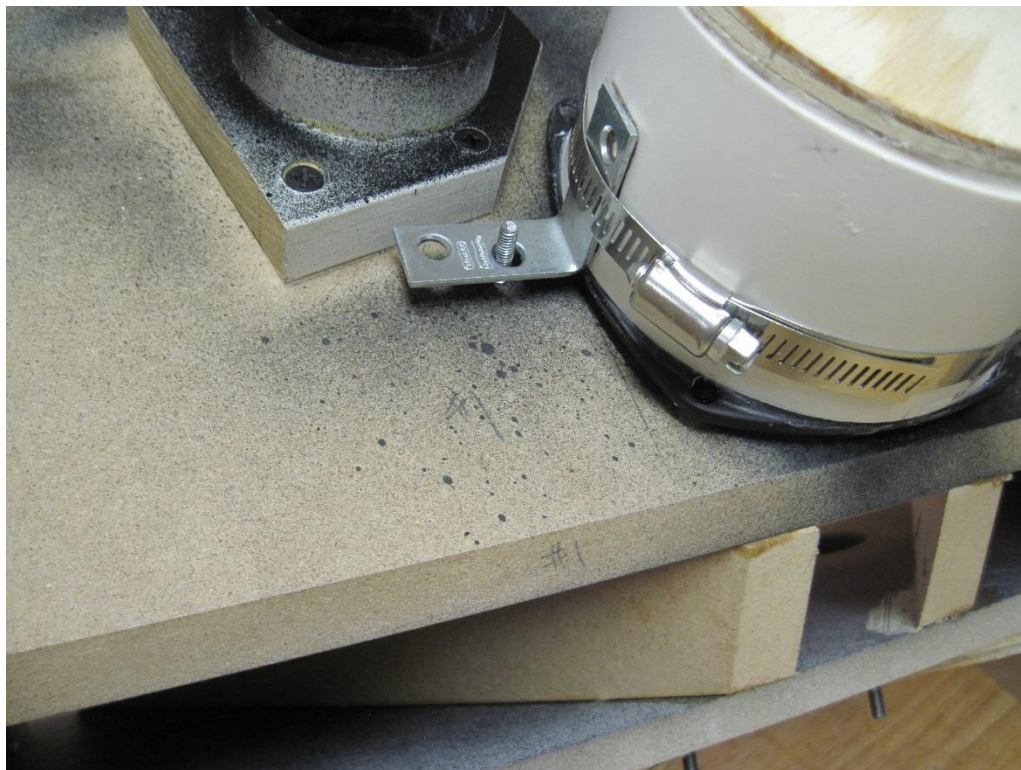
Assemble the cabinet and port

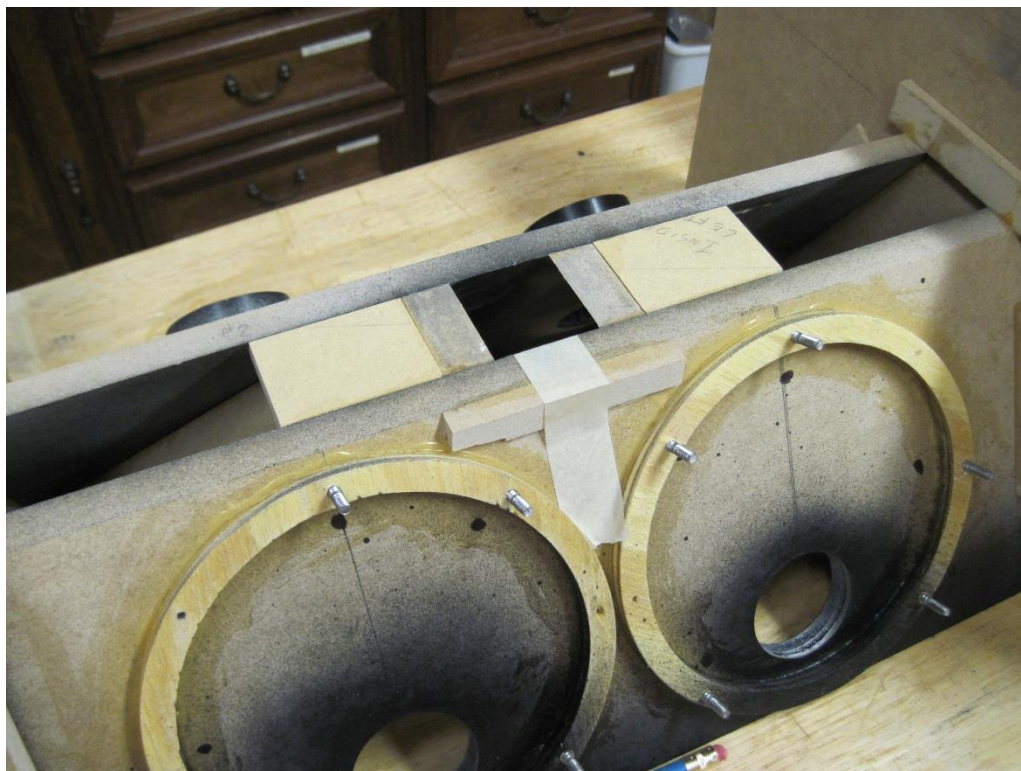
- Attach the cabinet bottom panel.
- Install the back panel mounting cleats on 3 sides
- Cut and fit the PVC ports. Grind out the back side of the horn panels to get the PVC port to fit under the cabinet back. Glue the PVC ports together and to the side cleats.
- Note the PVC ports are shorter than what is shown in the pictures. The port length is correct in the drawing. The ports had to be shortened due to the closeness of the port to the back panel.
- Glue the cabinet top panel and cleat in place.
- Layout and drill holes for the cabinet back mounting screws and binding posts.
- Apply finish to the cabinet.

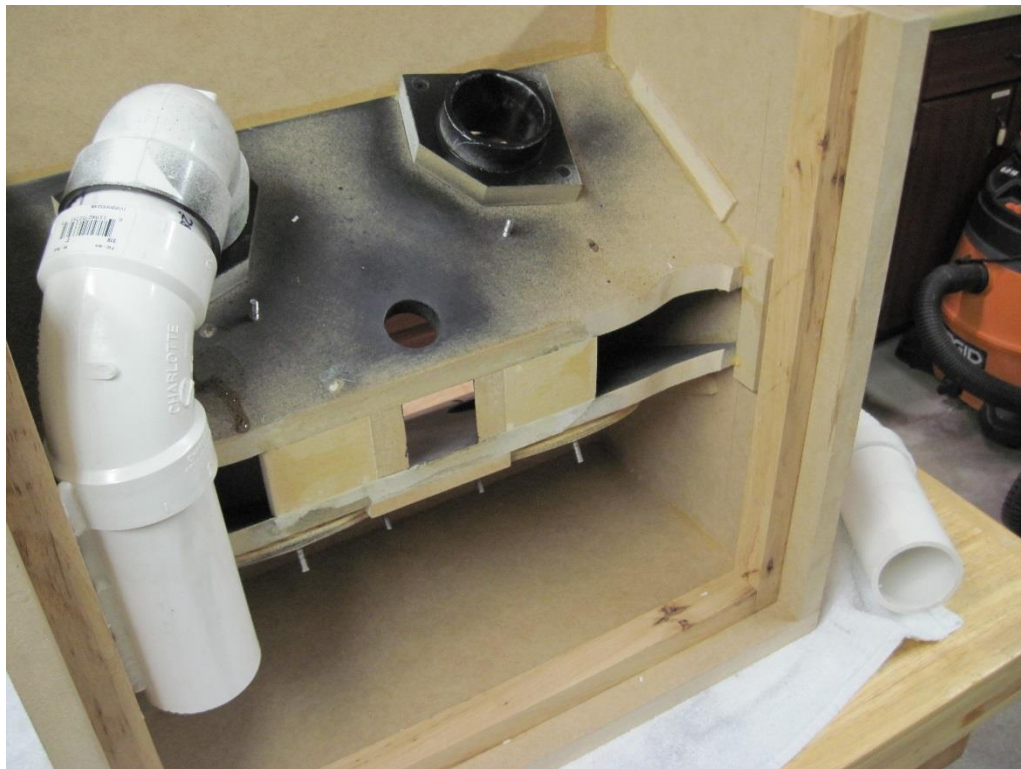
Final Assembly

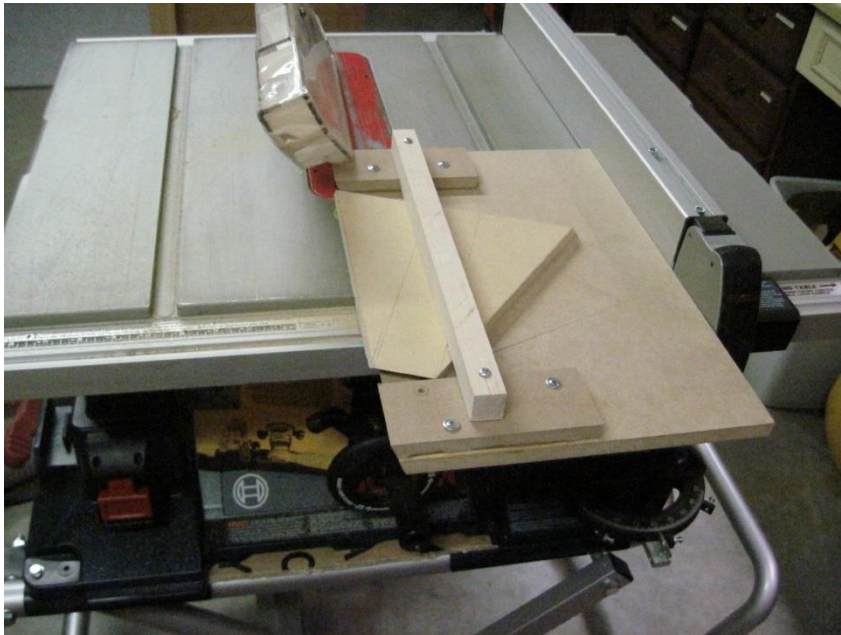
- Install woofers and midrange. I like to use a drop of wood glue on the threads to hold the nuts in place.
- Cut the tweeter flange to center the tweeter in the opening. Add foam gasket to the tweeter opening and mount the tweeter.
- Install about 1/3 lb of Acousta-Stuf insulation in the upper half of the cabinet. Use poly batting to hold the insulation in place
- Mount the crossover on the cabinet back and connect the wires.

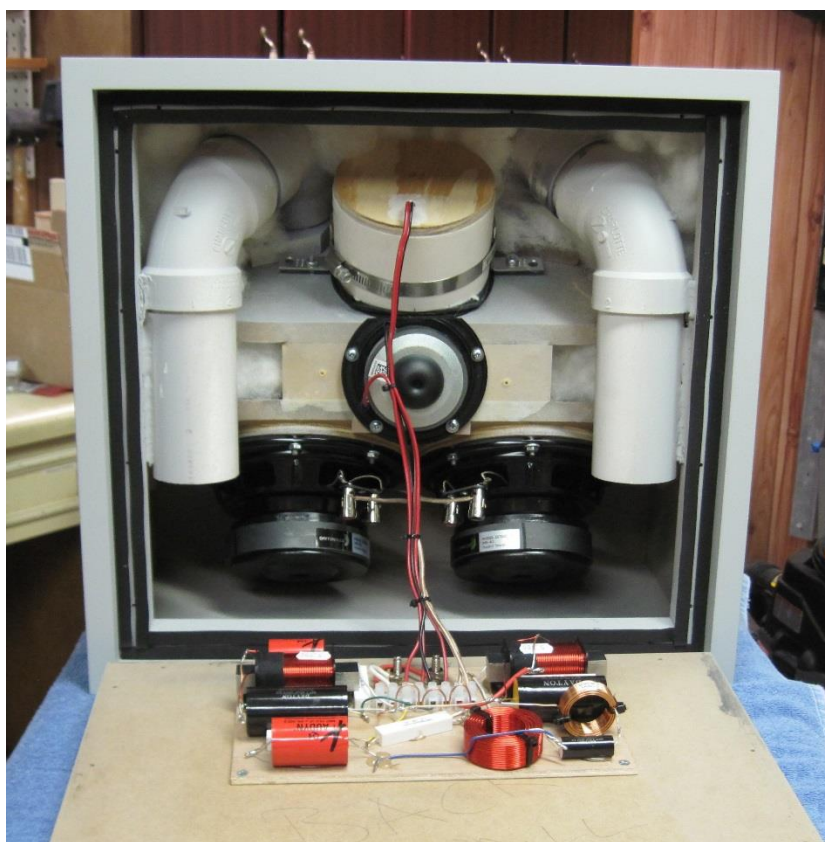
Construction pictures







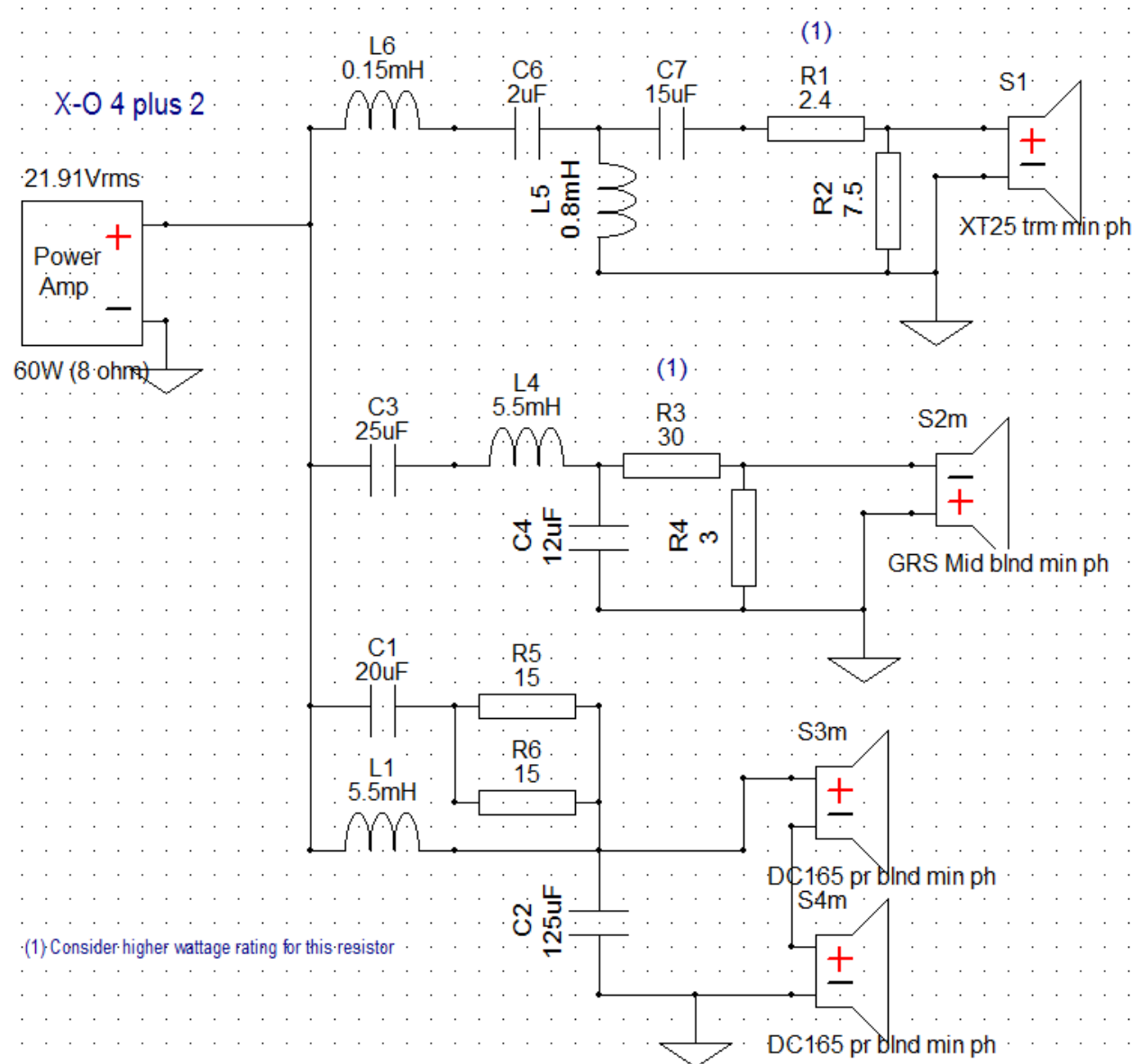


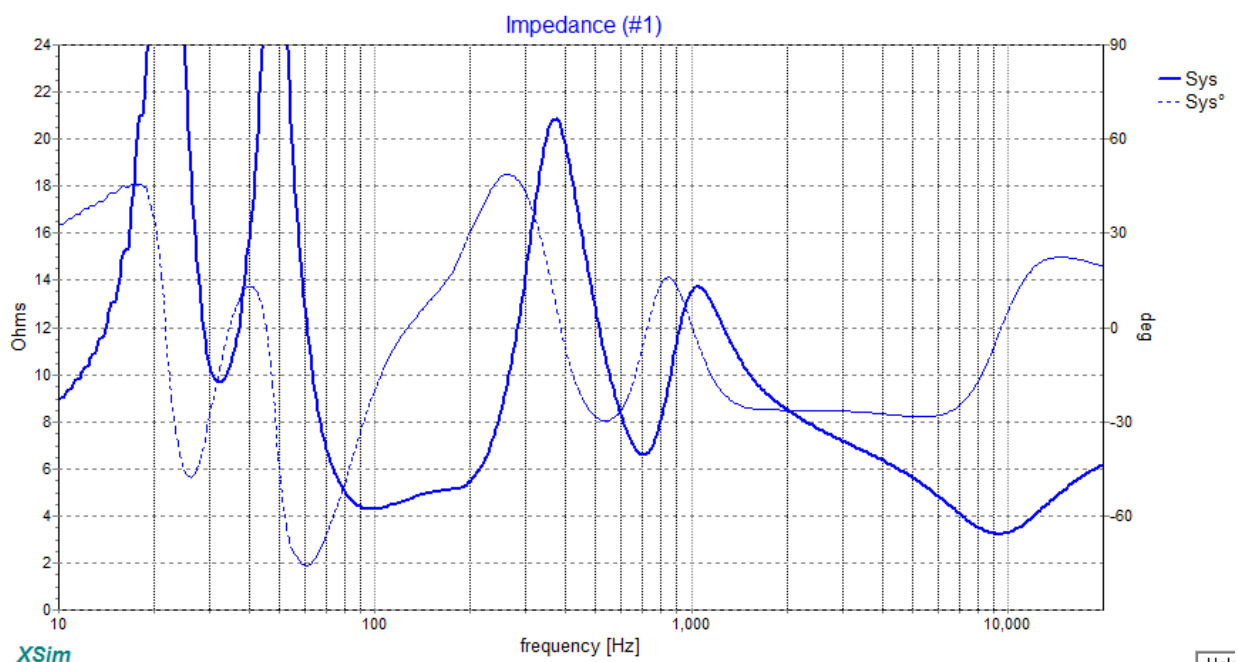
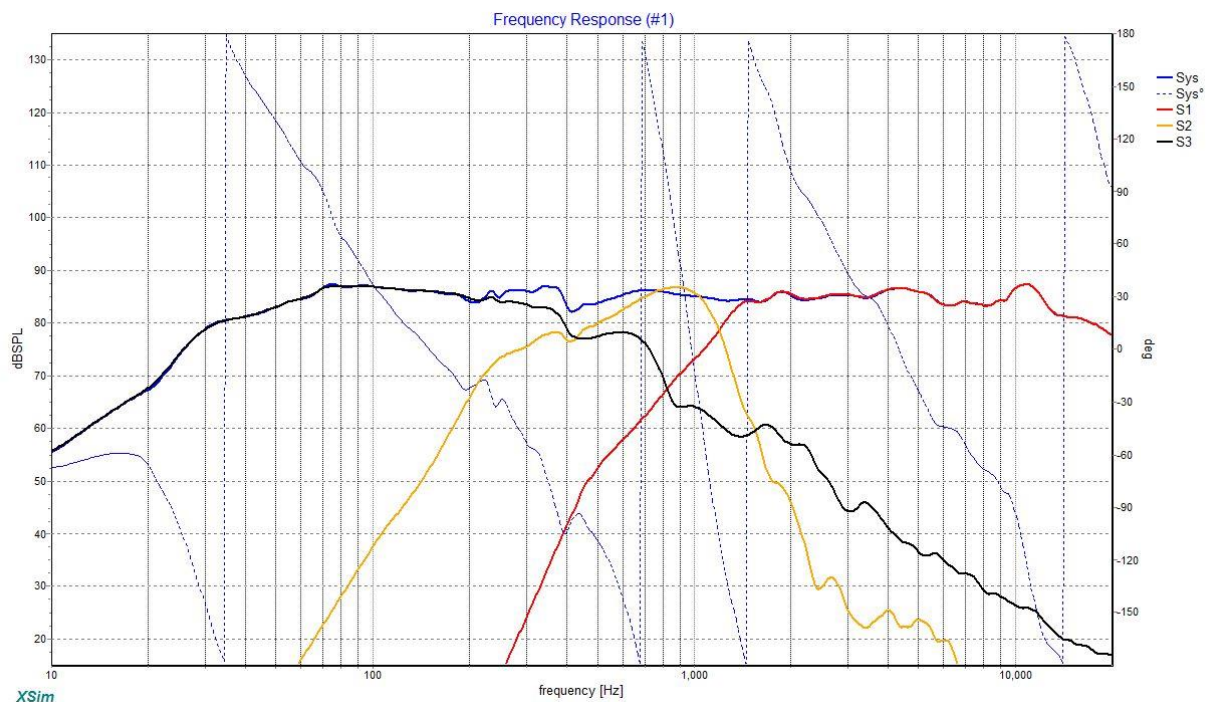


Crossover Design

The crossover was designed for flat frequency response with a minimum number of components. The crossover points were determined as a result of the high frequency roll off of the midrange and woofer

performance in the horn. The tweeter to mid crossover is at 1,300 Hz. The mid to woofer crossover is at 400 Hz. The slopes are Linkwitz Riley 4th order. In the woofer circuit two 15 ohm resistors are wired in parallel for increased power handling.





Products used

295-198	Dayton Audio DCS165-4 6-1/2" Classic Subwoofer 4 Ohm	4
292-434	GRS 4FR-8 Full-Range 4-1/2" Speaker Pioneer Type A11EC80-02F 8 Ohm	2
264-1016	Peerless by Tymphany XT25TG30-04 1" Dual Ring Radiator Tweeter	2
004-30	Dayton Audio DNR-30 30 Ohm 10W Precision Audio Grade Resistor	2
004-3	Dayton Audio DNR-3.0 3 Ohm 10W Precision Audio Grade Resistor	2
004-2.4	Dayton Audio DNR-2.4 2.4 Ohm 10W Precision Audio Grade Resistor	2
004-7.6	Dayton Audio DNR-7.5 7.5 Ohm 10W Precision Audio Grade Resistor	2
016-15	15 Ohm 10W Resistor Wire Wound 5% Tolerance	4
027-214	Dayton Audio PMPC-2.0 2.0uF 250V Precision Audio Capacitor	2
027-162	Audyn Cap Q4 12uF 400V MKP Foil Capacitor	2
	Audyn Cap Q4 15uF 400V MKP Metalized Polypropylene Foil Crossover	
027-119	Capacitor	2
027-436	Dayton Audio DMPC-20 20uF 250V Polypropylene Capacitor	2
027-438	Dayton Audio DMPC-25 25uF 250V Polypropylene Capacitor	2
027-362	125uF 100V Electrolytic Non-Polarized Crossover Capacitor	4
257-022	Dayton Audio 0.15mH 20 AWG Air Core Inductor Crossover Coil	2
257-822	Dayton Audio 0.80mH 18 AWG Perfect Layer Inductor Crossover Coil	2
266-570	ERSE 5.5mH 18 AWG I Core Inductor Crossover Coil	4

Tips and tricks

Play with the speaker toe-in to get the imaging correct

Conclusion

At first it seemed like a lot of work for minimal benefit. Now I'm sold on the inherent clarity of the Synergy MEH horn. The clarity is likely because of the lower midrange distortion or the controlled directivity in the room.

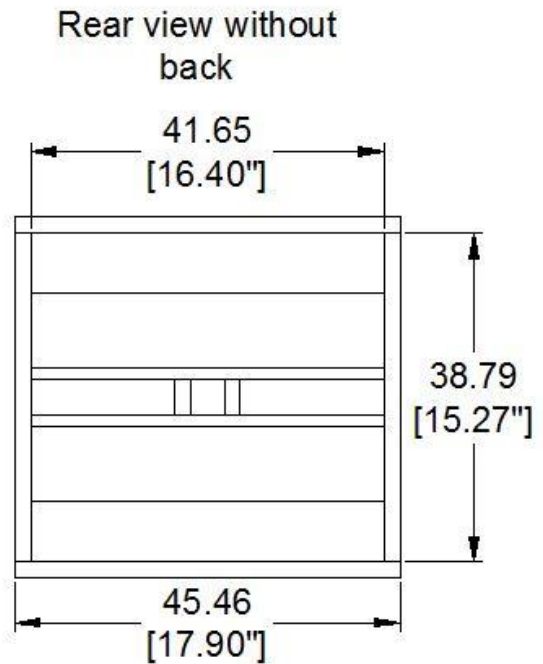
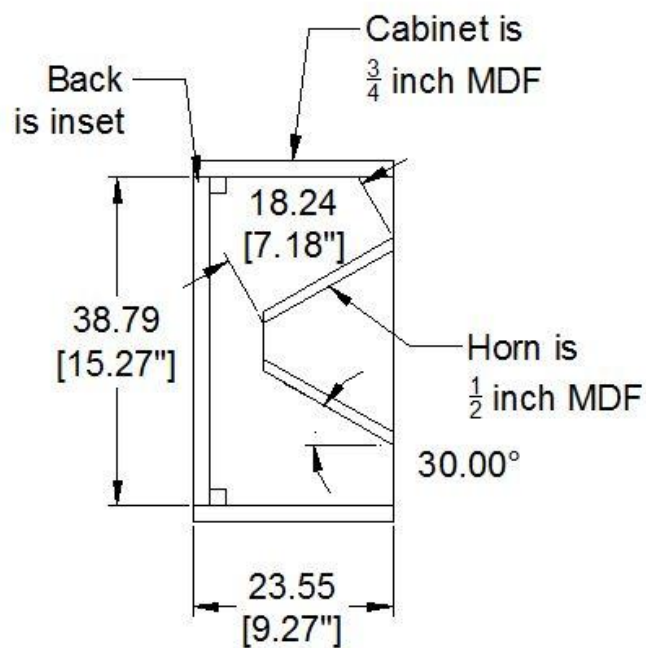
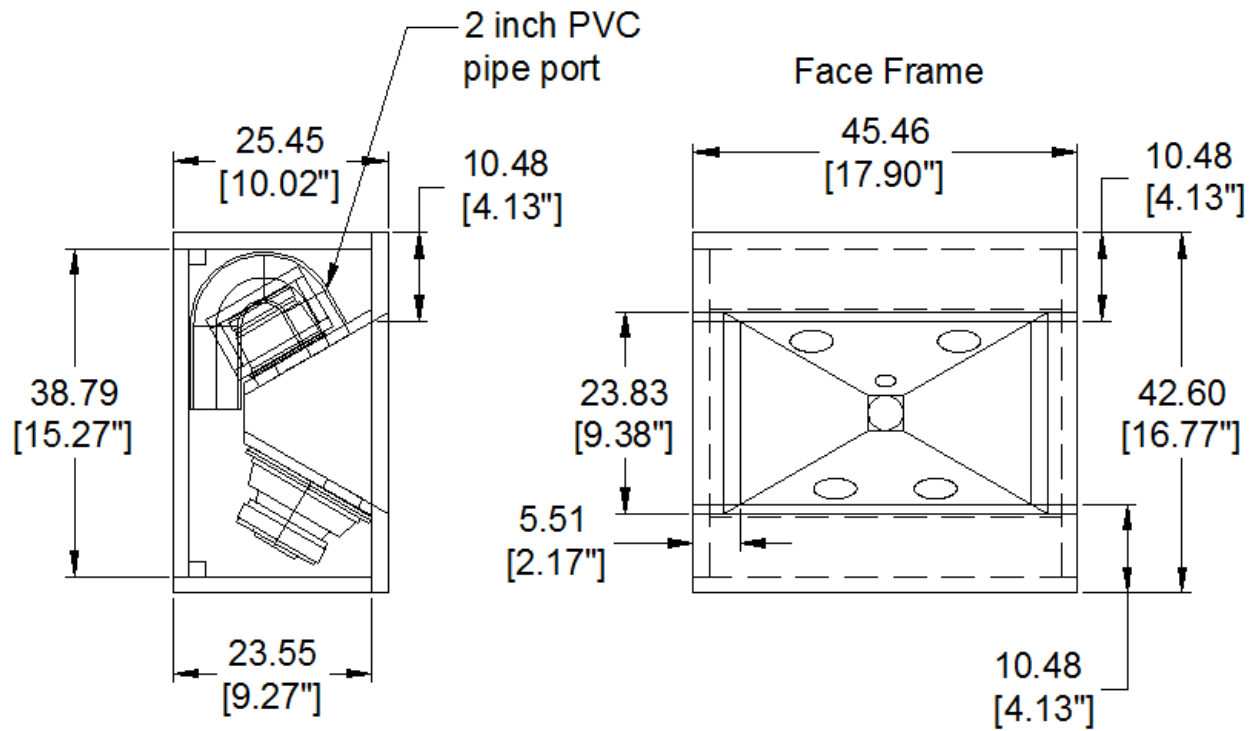
There is the potential for even better designs that optimize the midrange horn response.

A kit to alleviate the head scratching woodworking cuts would also be a benefit to future builders.

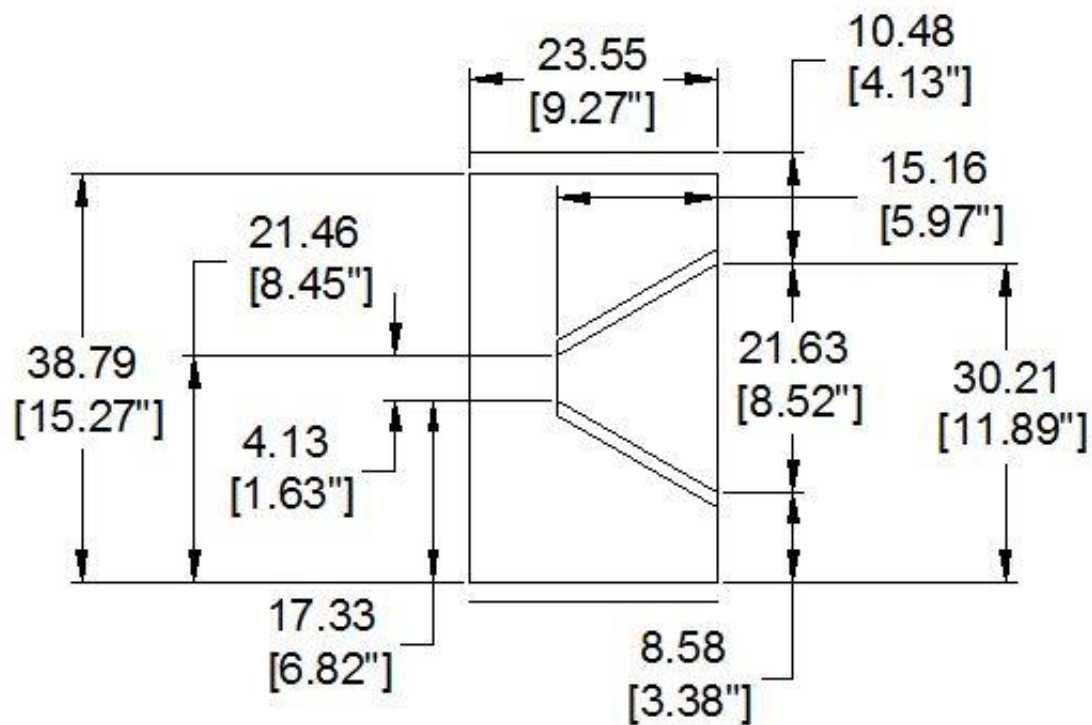
About the Designer

John is a member of the PE design team.

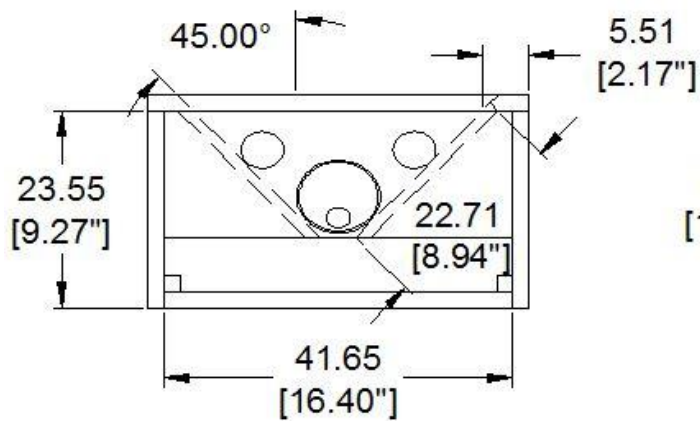
Design drawings



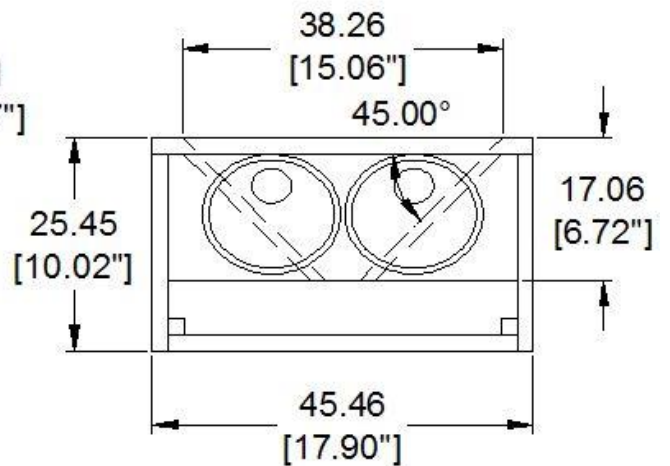
Section, horn panel locations on side



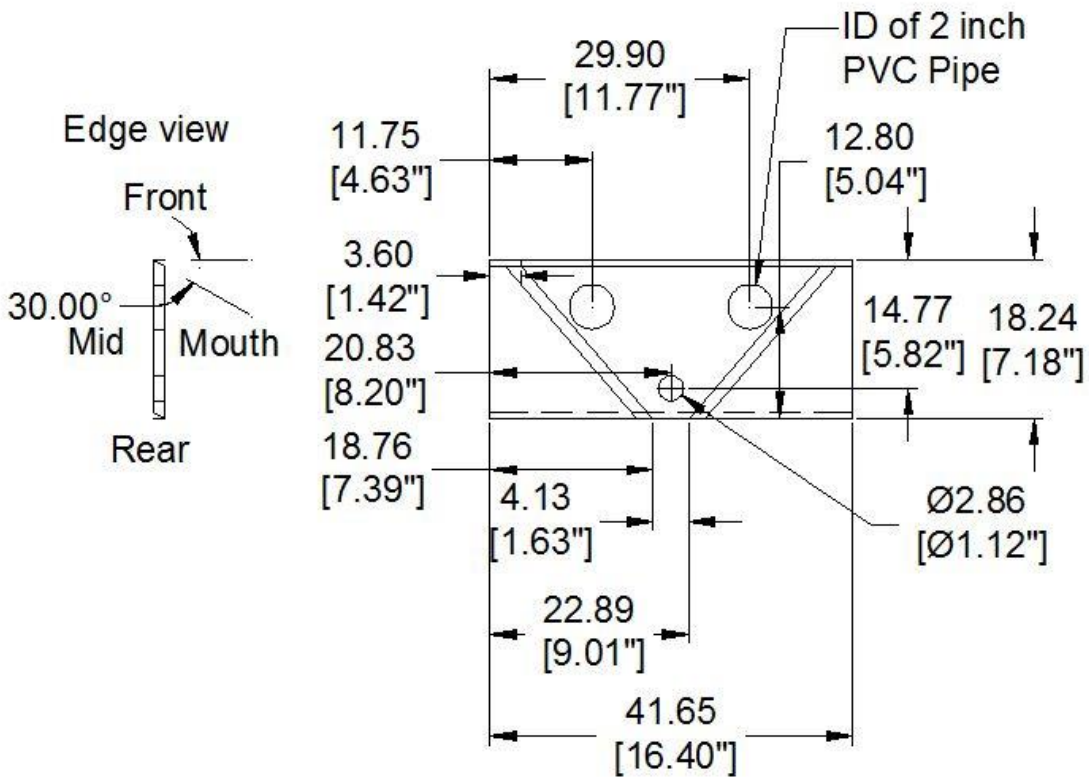
Section through, inside the cabinet looking down from the top



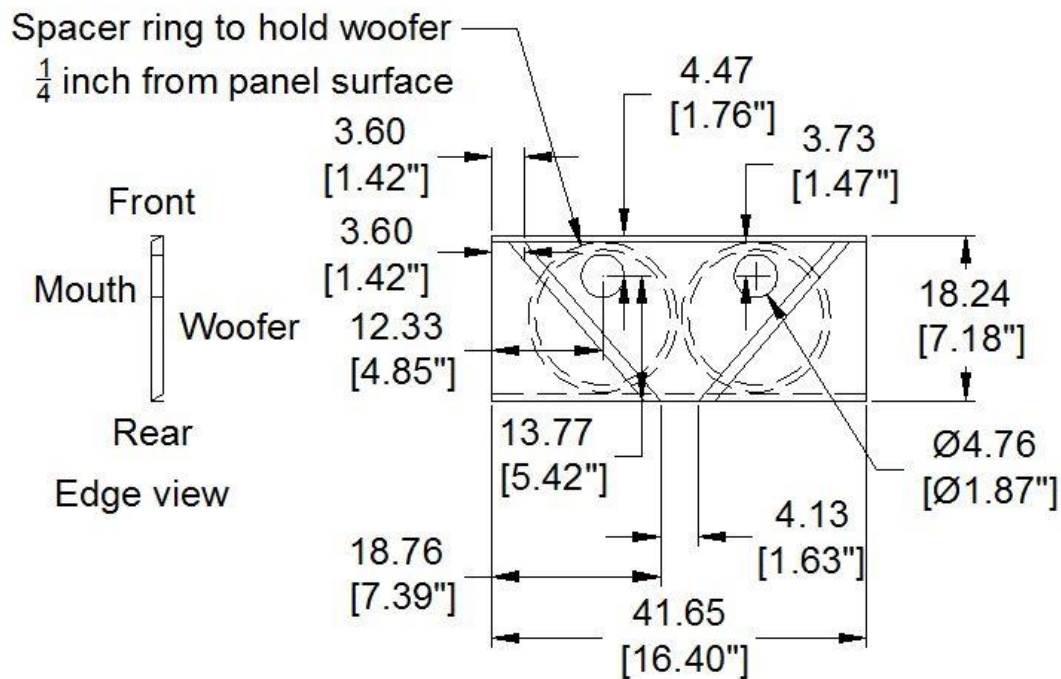
Section through, inside the cabinet looking up from the bottom

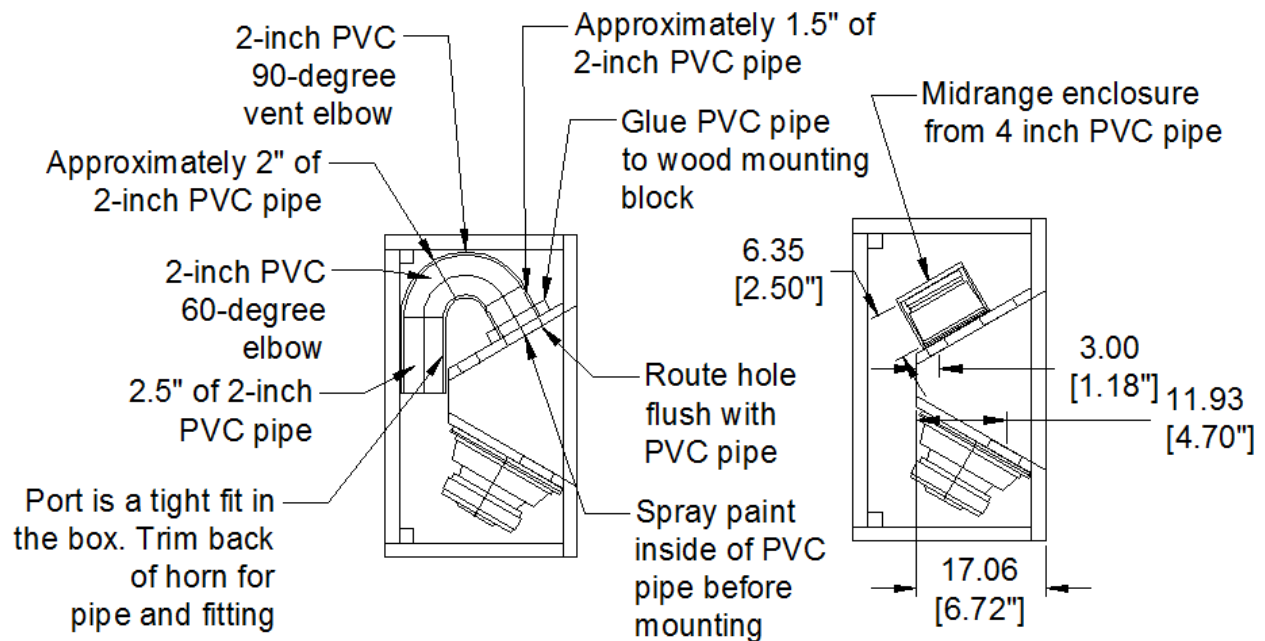
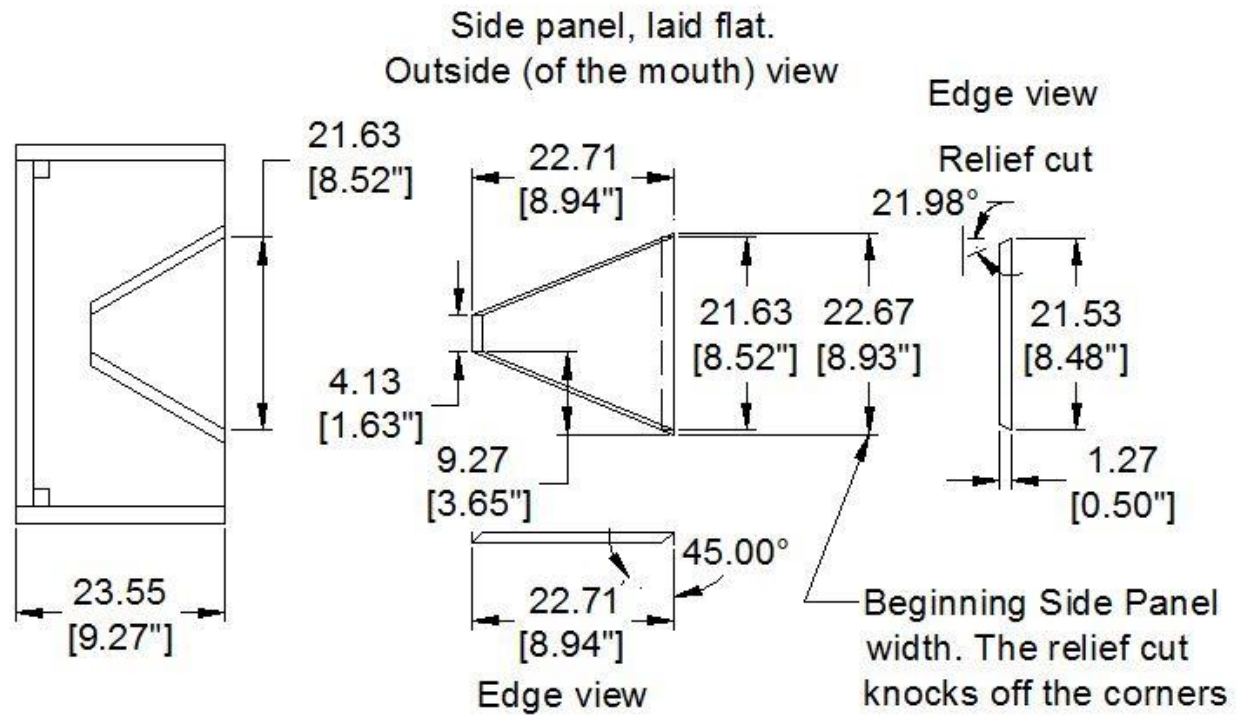


Midrange panel, laid flat inside the horn mouth view



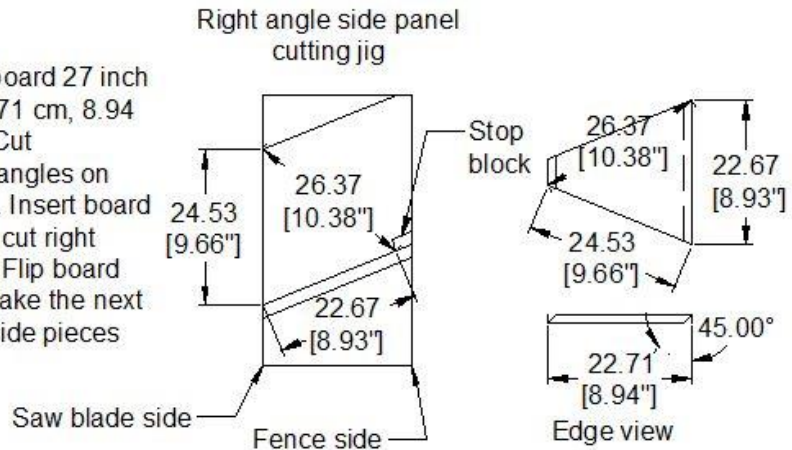
Woofer panel, laid flat inside the horn mouth view





Create the inside angle pieces by cutting a rectangular piece of $\frac{1}{2}$ inch MDF 8.94 inches wide with 45 degree angle cuts on the long sides. Cut out the angle pieces with the right angle jig, then make the relief cuts with the second jig

Cut $\frac{1}{2}$ inch board 27 inch long by 22.71 cm, 8.94 inch wide. Cut 45-degree angles on long edges. Insert board into jig and cut right angle cuts. Flip board over and make the next cut until 4 side pieces are cut.



Relief cut angle side panel cutting jig

It's important to orient the side piece 45 degree angle cuts so that the relief cut trims the corners of the wide end. Rotate the side piece and make the second relief cut.

