

Speaker build – preliminary

- There are many kinds of speakers we could try to build. In keeping with the principle of “Start simple, work towards bigger”, I propose a set of bookshelf (desktop) speakers.
- The “Overnight sensations” by Paul Carmody are a great set of speakers that are relatively easy to build. Carmody designed these in 2008 and probably thousands have been made by enthusiasts over the years. (<https://sites.google.com/site/undefinition/bookshelf-speakers/diy-overnightsensations>)
- Carmody specifies components from Parts-Express. In fact, Parts-Express and Meniscus offer complete kits that have everything, including the wood. (Parts-express: <http://www.parts-express.com/overnight-sensations-mt-speaker-kit-pair--300-706>. Usual price is \$160, but in Feb 2024, they are on sale for \$130.)
- We can probably save a few bucks by buying parts a la cart and cutting a corner or two.



A few details

- The speakers are of the “M-T” variety.
- The mid-range is the 4-inch HiVi B4N.
- The tweeter is the 3/4-inch Dayton ND20FA-6.
- The volume of the box is about 4.5 liters.
- The box is ported. The port tube is tuned for a resonance of 53 Hz.
- The cross-over network is relatively simple, a third-order high-pass with a “pad” for the tweeter and a third-order low-pass for the mid-range. (More on that below.)
- The box can be made easily using medium-density fiber (MDF) board, although there are lot of options on how to make the box.
- Also need connectors and a few other random pieces.. (Not included in the kit described on the previous page.)

Drivers and ports

From Parts Express

Qty	Part Number	Description	cost each
2	297-429	HiVi B4N 4" Aluminum Midbass Round Frame	\$17.40
2	275-030	Dayton Audio ND20FA-6 3/4" Neodymium Dome Tweeter	\$9.98
2	260-388	Port Tube 1-3/8" ID Adjustable	\$2.76
			\$60.28



mid-range



tweeter



port tube

HiVi B4N

Specs from Parts Express web page.

Product Details

Brand	HiVi
Model	B4N
Part Number	297-429
UPC	844632024979
Unit of Measure	Each
Weight	2

Product Specifications

Nominal Diameter	4"
Power Handling (RMS)	25 Watts
Power Handling (MAX)	50 Watts
Impedance	8Ω
Frequency Response	60 to 4,000Hz
Sensitivity	85dB 2.83V/1m
Voice Coil Diameter	1"

Thiele-Small Parameters

Resonant Frequency (Fs)	56Hz
DC Resistance (Re)	6.5Ω
Mechanical Q (Qms)	3.91
Electromagnetic Q (Qes)	0.63
Total Q (Qts)	0.52
Compliance Equivalent Volume (Vas)	0.16ft ³
Mechanical Compliance of Suspension (Cms)	1.11mm/N
BL Product (BL)	5.1T·m
Diaphragm Mass Inc. Airload (Mms)	6.8g
Maximum Linear Excursion (Xmax)	3.2mm
Surface Area of Cone (Sd)	53cm ²

Materials of Construction

Cone Material	Aluminum / Magnesium
Voice Coil Former	Kapton® / Polyimide
Magnet Material	Ferrite

Mounting Information

Overall Outside Diameter	4.59"
Baffle Cutout Diameter	3.66"
Depth	2.85"
# Mounting Holes	4

Parts Express Staff Recommended Enclosure Volume

Sealed Volume	0.15ft ³
Sealed F3	85.2Hz
Vented Volume	0.3ft ³
Vented F3	46.4Hz

Dayton ND20FA-6

Specs from Parts Express web page.

Product Details

Brand	Dayton Audio
Model	ND20FA-6
Part Number	275-030
UPC	844632000874
Unit of Measure	Each
Weight	0.1

Product Specifications

Cone / Dome Diameter	0.75"
Cutout Diameter	1.30
Tweeter Type	Soft Dome
Power Handling (RMS)	15 Watts
Impedance	6Ω
Frequency Response	3,500 to 25,000Hz
Sensitivity	90dB 2.83V/1m

Thiele-Small Parameters

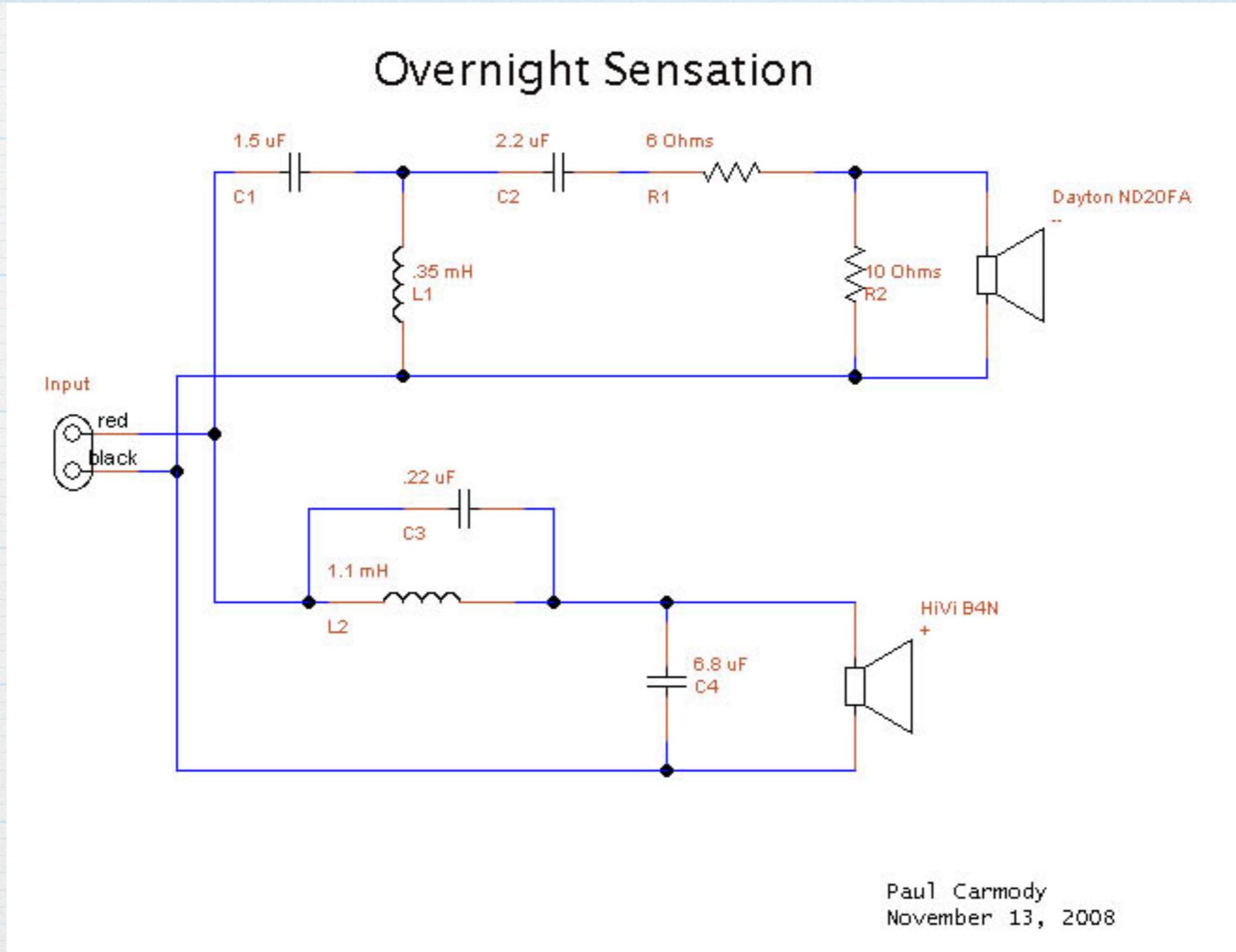
Resonant Frequency (Fs)	2005Hz
DC Resistance (Re)	5.2Ω
Voice Coil Inductance (Le)	0.05mH
Mechanical Q (Qms)	1.5
Electromagnetic Q (Qes)	2.88
Total Q (Qts)	0.99

Mounting Information

Overall Outside Diameter	1.77"
Depth	0.59"

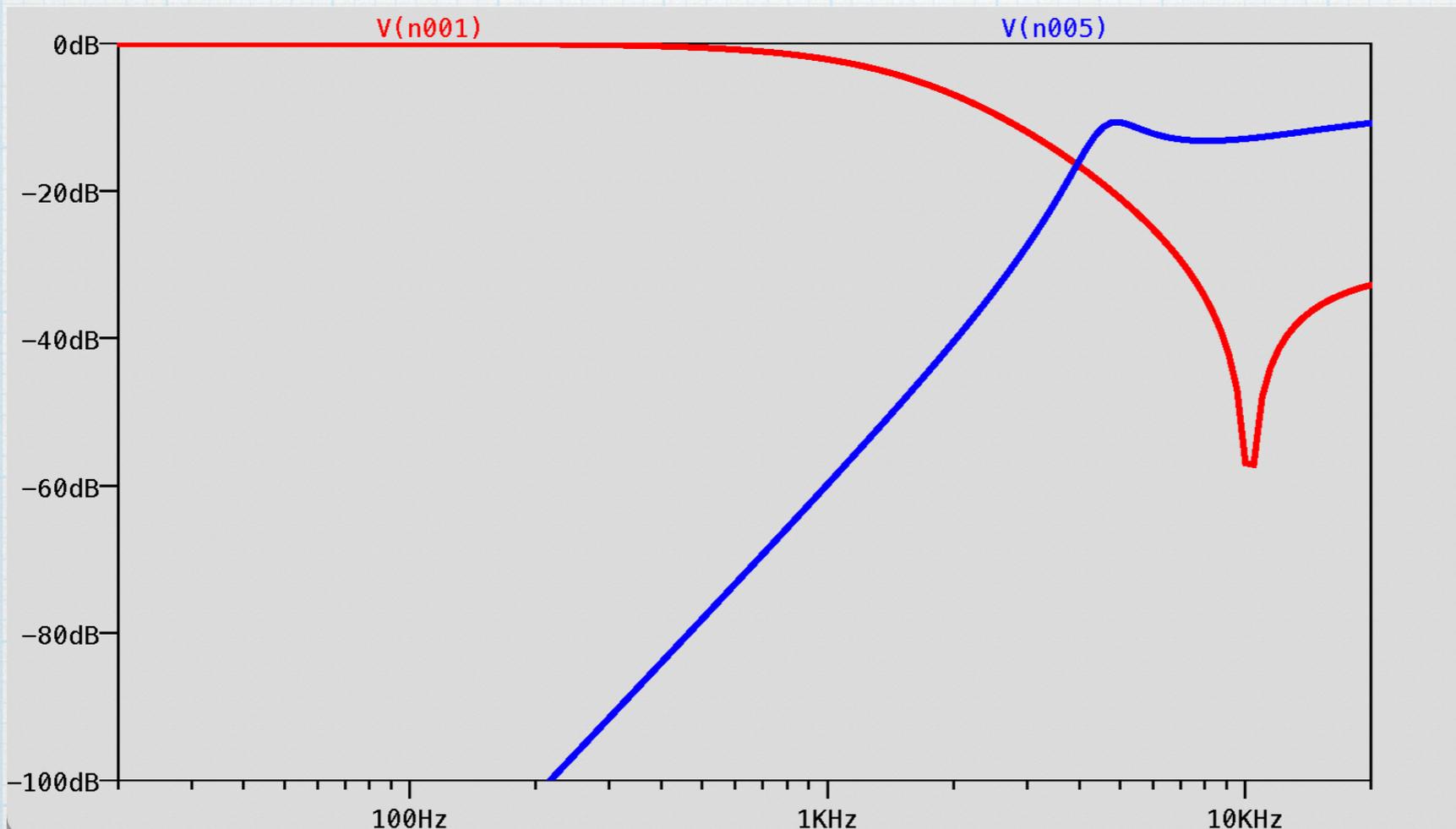
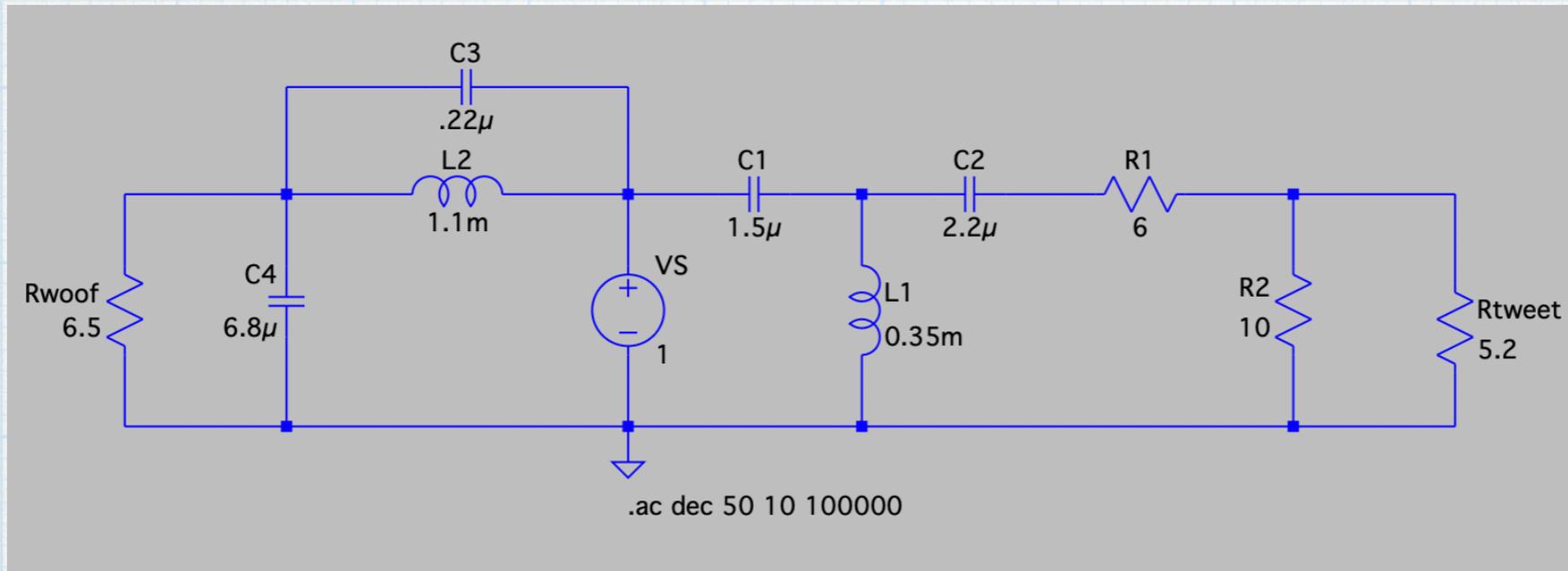
Cross-over network

Here is the cross-over network as designed by Carmody. Fairly strait-forward.



Cross-over simulation

LTspice



Cross-over components as originally specified

All parts from Parts-Express

Qty	Parts-Express number	Description	cost each
2	255-252	Jantzen air-core inductor, 1.1 mH (0.57 Ω)	11.65
2	257-030	Dayton air-core inductor, 0.35 mH (0.4 Ω)	3.89
2	027-424	Dayton poly cap, 6.8 μ F	3.29
2	027-415	Dayton poly cap, 2.2 μ F	2.09
2	027-412	Dayton poly cap, 1.5 μ F	1.59
2	027-402	Dayton poly cap, 0.22 μ F	1.09
2	004-10	Dayton 10- Ω , 10 W	1.79
2	004-6	Dayton 6- Ω , 10 W	1.79
		total (for two speakers)	54.36

Alternative cross-over parts

All parts from DigiKey

Qty	Digi-Key number	Description	cost each
2	811-1343-ND*	Murata 1 mH (0.46 Ω)	2.49
2	811-1314-ND	Murata 330 μ H (0.35 Ω)	1.42
2	445-173154-1-ND	TDK ceramic 6.8 μ F	1.02
2	445-173138-1-ND	TDK ceramic 2.2 μ F	0.52
2	445-180637-1-ND	TDK ceramic 1.5 μ F	0.68
2	445-173377-1-ND	TDK ceramic 0.22 μ F	0.31
2	10W-10-ND	Yageo 10- Ω , 10 W	0.81
2	6.2W-10-ND	Yageo 6.2- Ω , 10 W	0.81
		total (for two speakers)	16.12

So, we could save about \$38 by not using “audio-grade” components. The risk is in possibly having some distortion due to ceramic capacitor non-idealities and inductor-core saturation at higher currents.

* Feb. 2024. Digikey is OUT of the 1 mH inductors (Murata 1410516C). They have a small number of Murata 1410517C inductors, which are similar. However, Mouser has a good selection of the 1410516C inductors at the same price. I would advise ordering there.

Miscellaneous

- Two perf-boards for wiring together the cross-over circuits, about \$2.00 each. (We could use “hard board” or even some sturdy cardboard to mount the circuits.) Also need a couple of feet of speaker wire for internal connections.
- Two sets of binding posts or connectors for the audio input. I’ve used Dayton audio BPA-38G from Parts-express in the past. They work fine and look nice. They are \$9.98 for one set. However, I’ve come to prefer using Neutrik connectors (NL2FX and NL2MP), which are easier to plug and unplug. One set (male and female) costs \$6.12. (Unfortunately, the NL2FX seems to be discontinued.)
- A few square feet of MDF, a handful of screws, and some wood glue. These probably cost about \$10 total from Lowes, Home Depot, or Menards.



Dayton BPA-38G
\$9.98 at Parts-Express.



Neutrik NL2FX.
\$3.63 at Parts-Express.
(Seems to be discontinued.)



Neutrik NL2MP.
\$2.66 at Parts-Express.

Total cost

- Drivers, ports, all “audio-grade” cross-over components, connectors, perf-boards, and wood: approximately \$145 for two speakers. Then add a few bucks to opt for the gold-plated binding posts.

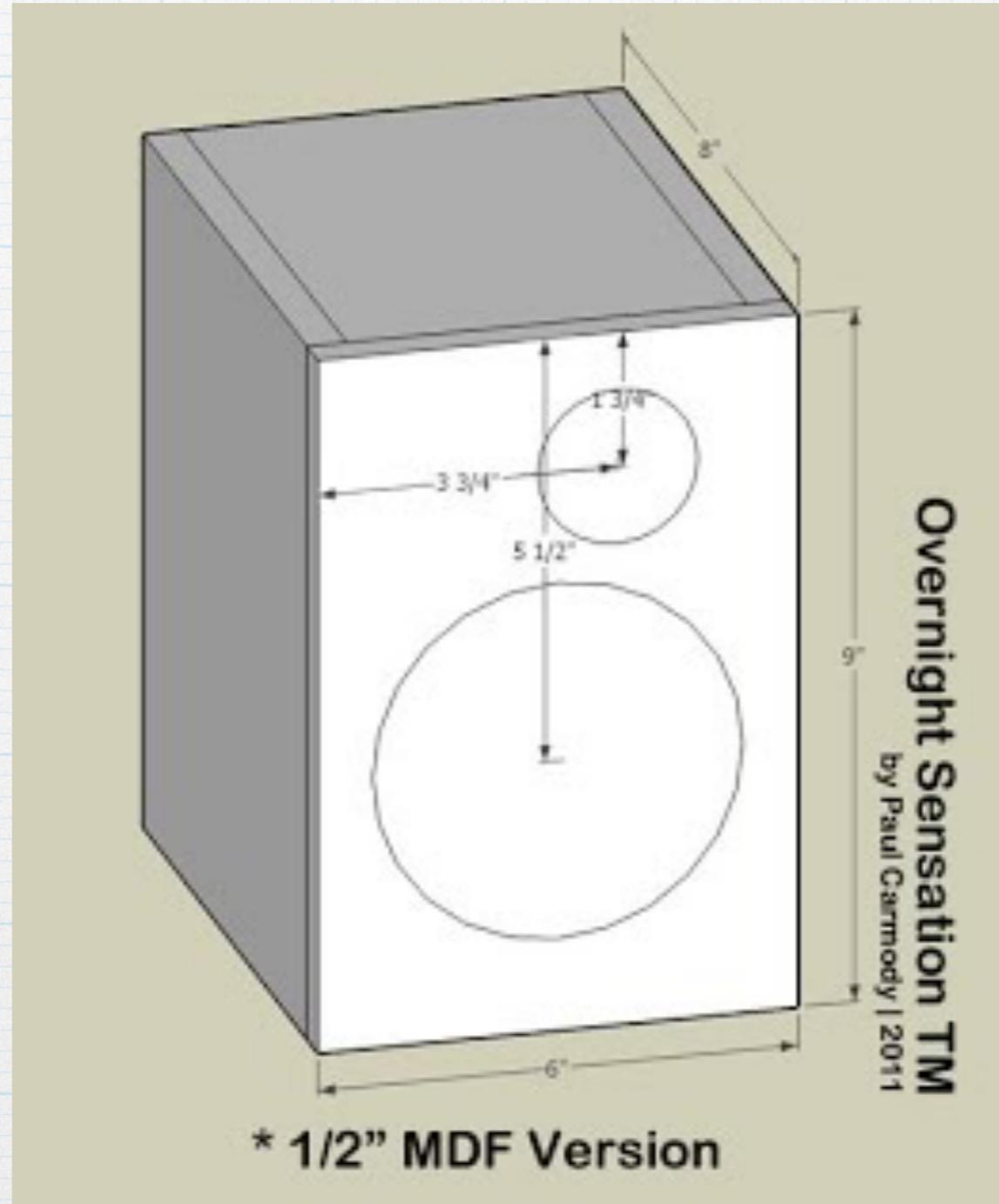
Note that this is just a bit less than buying the full kit from Parts-Express. If we want audio-grade parts throughout, it is probably easiest to just buy the full kit.

- Drivers, ports, cheaper cross-over parts from DigiKey , connectors, perf-boards, and wood: approximately \$105.
- So if we are willing to forego the higher-grade crossover and cut some wood ourselves, we can save about 25% on the cost for a set of speakers.
- Note that the last time we had a major speaker build in Spring 2018, the cost was just under \$100 for a pair of speakers (using the cheaper components). So inflation hasn't had a huge effect.

Tools and miscellaneous stuff needed for the build

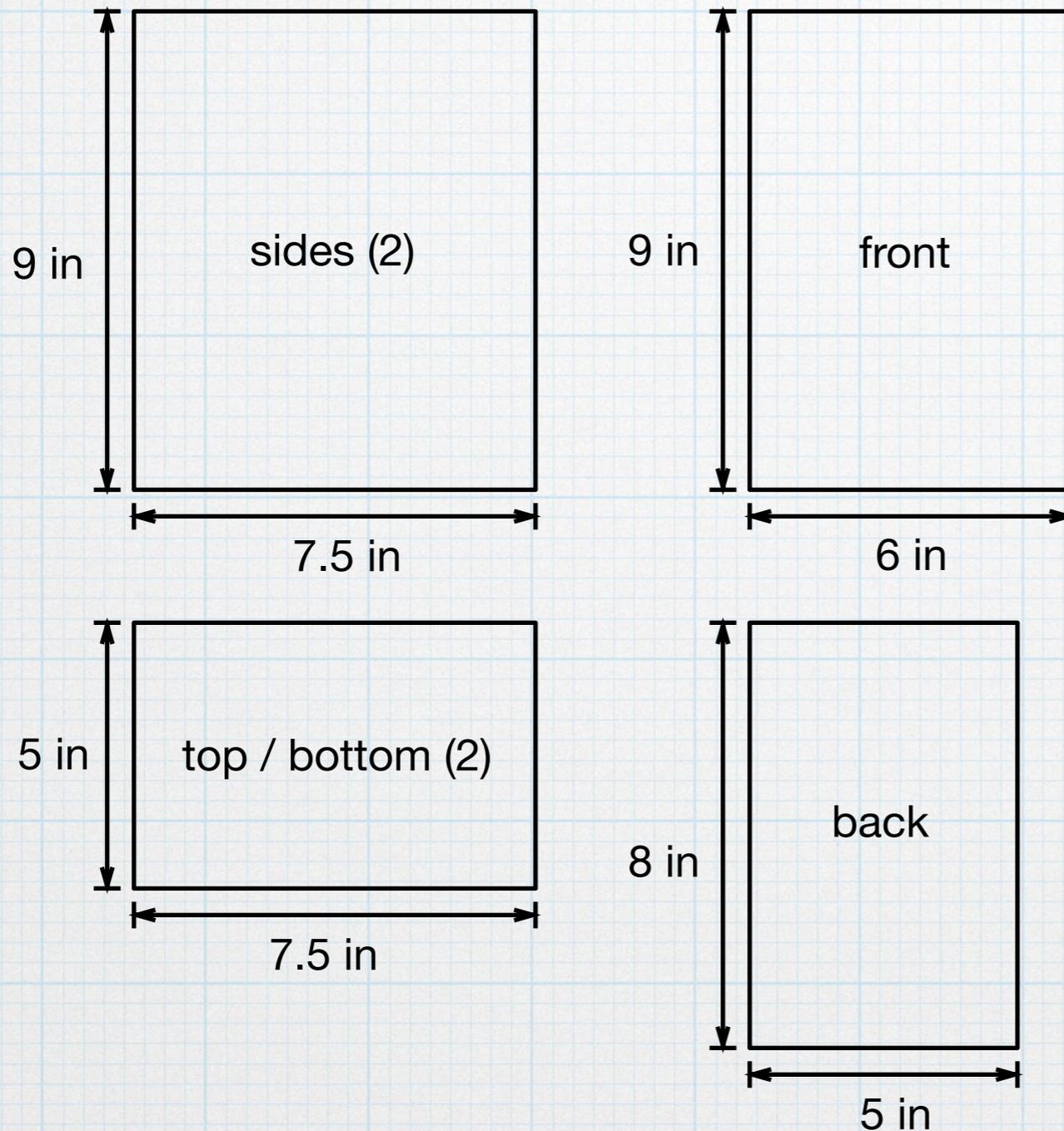
- An electric drill, hole saws (3 5/8 inch, 1 3/4 inch), spade bit (1 1/4 inch), and 5/16 inch twist bit. GT has these items for drilling. (If you have a jig saw or router, you can make the bigger holes with those.)
- Tape measure or ruler and marking pen.
- Wood glue and clamps (or a few heavy books).
- Sand paper (medium grit)
- Wood filler and paint. (Optional but recommended, if you want to make it all look less gnarly.)
- Soldering iron and solder.
- Two or three feet of speaker wire (18 gauge or bigger is fine).
- 18 screws — #6 x 3/4 inch.

Making the boxes



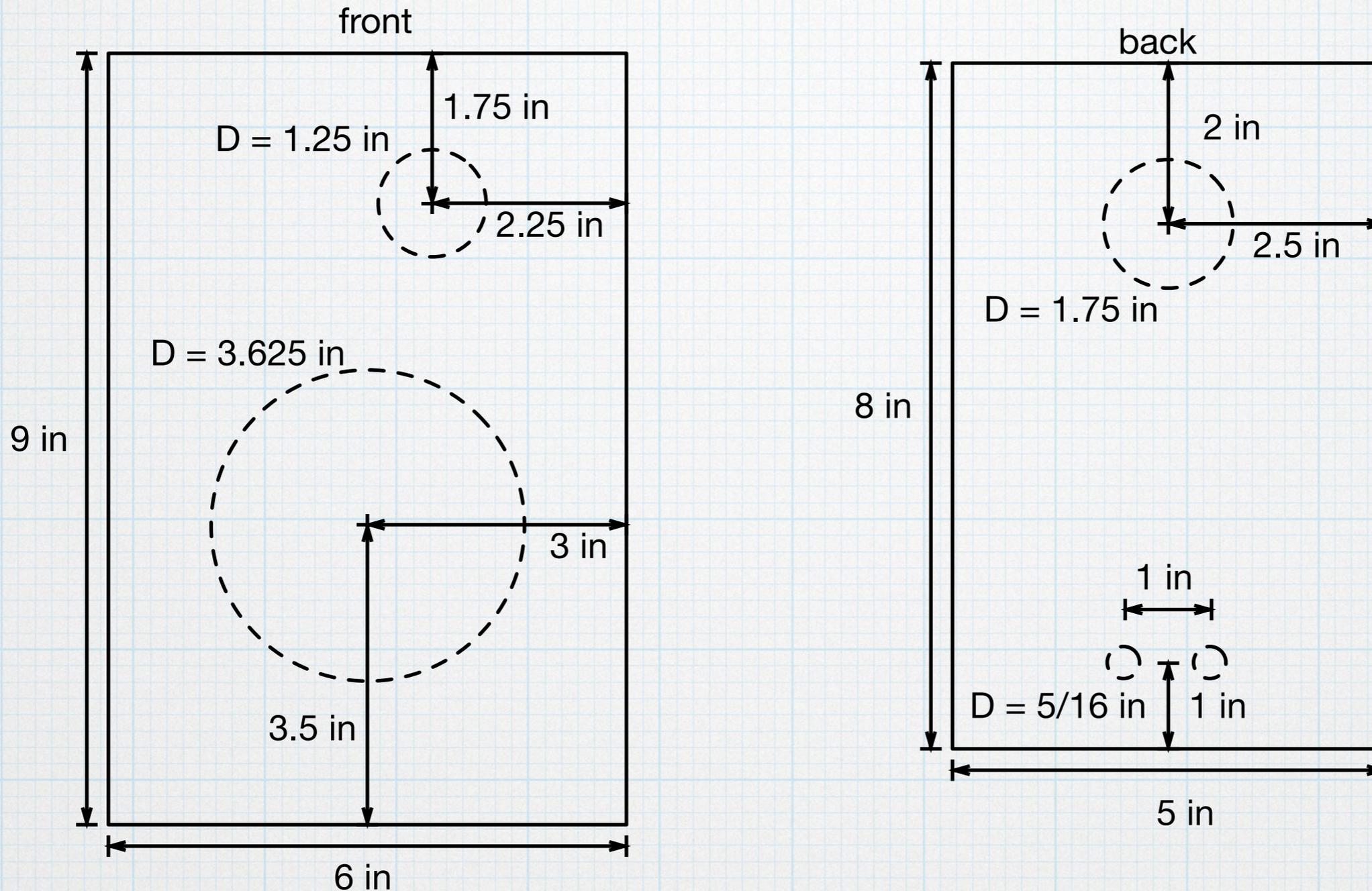
Box dimensions from Paul Carmody: 6 in wide, 9 in tall, 8 in deep.

Six pieces for the box



Also a couple of small pieces - say 1 in x 5 in to serve as “back stops” to hold the back plate in place.

Hole locations



The exact hole locations are not critical. In particular, the tweeter does not need to be offset as shown — since it is sealed, it can go anywhere. Mainly, be sure that holes are not too close to the edges. Also, make certain that the port, which extends inward from the back, does not interfere with the bigger driver, which extends inward from the front — keep one low and the other high. Also note that the fronts should probably be mirror images of each other, if you care about symmetry at all.

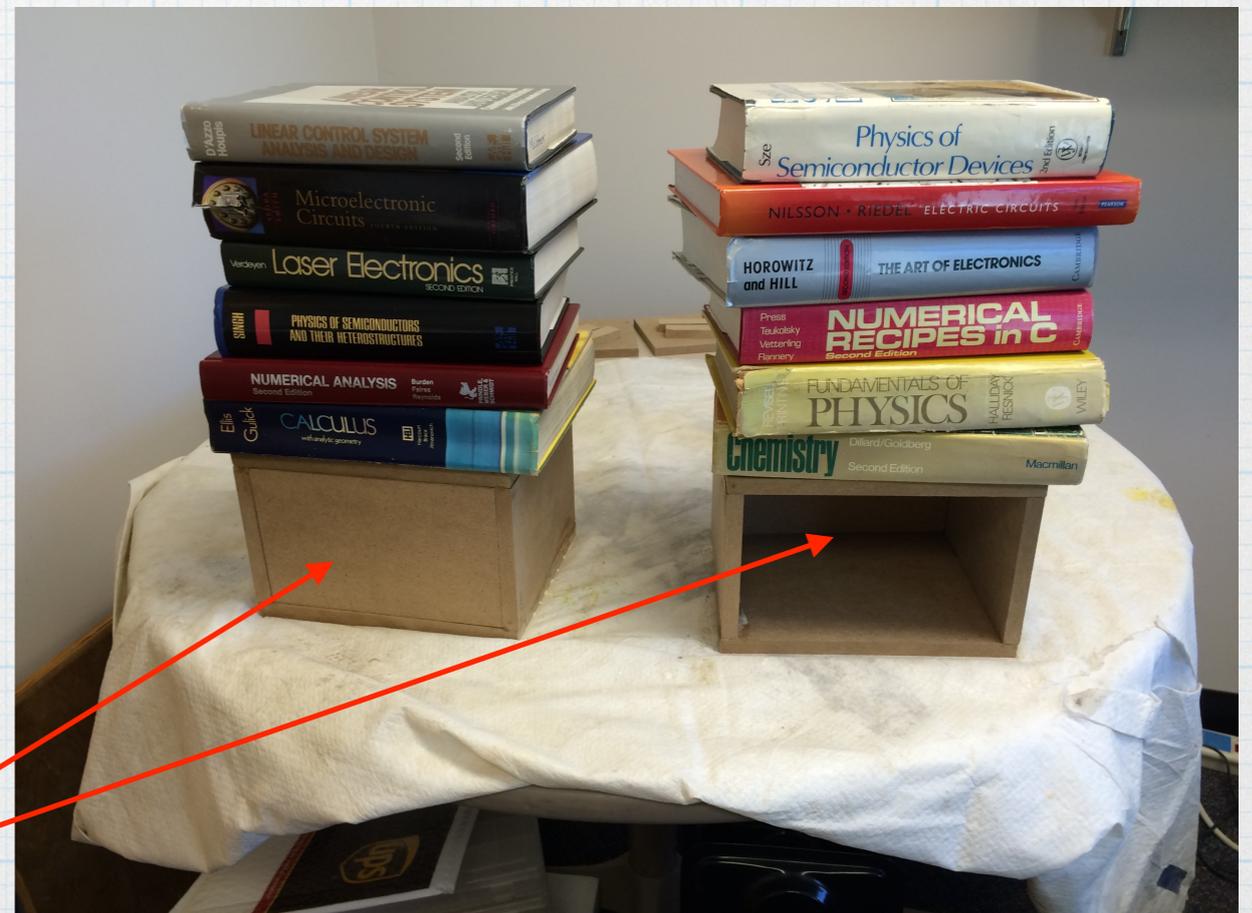
Assemble your wooden parts



Glue sides, top, & bottom

- Make sure that you have the right pieces. Dry fit everything to see how it all lines up.
- Apply a bead of glue to the edges of the top and bottom pieces. You don't need a huge amount. More is not better, since the excess will be squeezed out anyway.
- Put the top and bottom onto one of the sides. (Top photo.) Then put on the other side. Insert the back piece into the space to help keep everything square. However, be careful so that the back does become glued in — it needs to remain loose.
- Spend a minute or two adjusting the fit so the edges all line up. The better the alignment now, the less fiddling you will have to do later.
- Apply pressure (clamps or books + gravity). Be careful so that pieces don't shift.
- Mop up excess glue squeezed from the joint with a damp rag.
- Let the glue dry for at least a half hour. Longer is better.

Back pieces loosely inserted to keep things square.



Drill the holes.

- Mark the hole centers for the front and back. Double check everything. (Old woodworkers rule: Measure twice, cut once.)
- Use some scrap wood as a buffer — don't drill into the table top.
- The 1 1/4 inch hole for the tweeter is probably a little tight. Test fit it now. If it does not fit, use sand paper or a file to make the hole larger. The tweeter should slide in, but with a tight fit.
- The holes for the binding posts are not shown here. Use a regular 5/16 in bit for those.



Glue the fronts

Same story:

- Check alignment.
- Apply glue.
- Apply pressure.
- Mop up the excess.
- Wait till the glue dries.



Glue in back stops

These small pieces will hold the back in place. Here I used clamps, but these are bit tricky because the small pieces tend to slide around in the slippery glue. I think it might be better to do one side at a time and just use a small weight on each piece to hold it in place while the glue dries.

- On the inside bottom measure in 1/2 inch. (Or turn the small piece on its side and use that to mark a line 1/2 inch in.)
- Apply glue to the small piece.
- Carefully line it up with your mark and put it in place.
- Place a small weight to hold the piece in place — don't let it slide. This joint does not have to be super sturdy, so it is not necessary to clamp it tightly.
- Let the glue dry.
- Turn the boxes over and repeat on the inside top.



- Now you are ready to paint and make everything spiffy, if you want. (Note: You can always paint later. As long as you don't glue the back in, you can completely disassemble the speaker and paint whenever you would like.)
- Use wood filler (available almost anywhere) to fill in cracks and fix corners that may not have lined up perfectly.
- Sand everything until the surfaces are smooth and the corners are sharp and square. (Or round them off if you want.) Note that none of this exterior work will have any affect on how the speakers sound.
- It may be necessary to repeat the wood filler / sanding sequence two or three times to make all the surfaces look nice.
- Then paint the boxes your favorite color (or colors). A primer coat is recommended, but optional. Use spray paint or brush it on. You should plan to do multiple coats, and possibly sand the surfaces between applications.

Here is a set of speakers that my daughter decorated. She used decoupage to produce the patterns on the fronts. Check the internet for lots of other clever ideas.

Coming later: Building the cross-over.



MTM 2.1 – recent build

MTM versions of the Overnight Sensation speakers, along with a sub-woofer (with separate amp) to fill in the lowest frequencies.

