

# HowToBuildAPoweredLoudspeaker

From ModernLutherie

by Edgar Berdahl

These instructions specifically describe how to build revision 2 of the powered loudspeaker. Revisions 3 and 4 are very similar and can be adapted from this one -- the main difference being that the two loudspeaker drivers are located in the same face instead of in opposite faces.



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## Parts

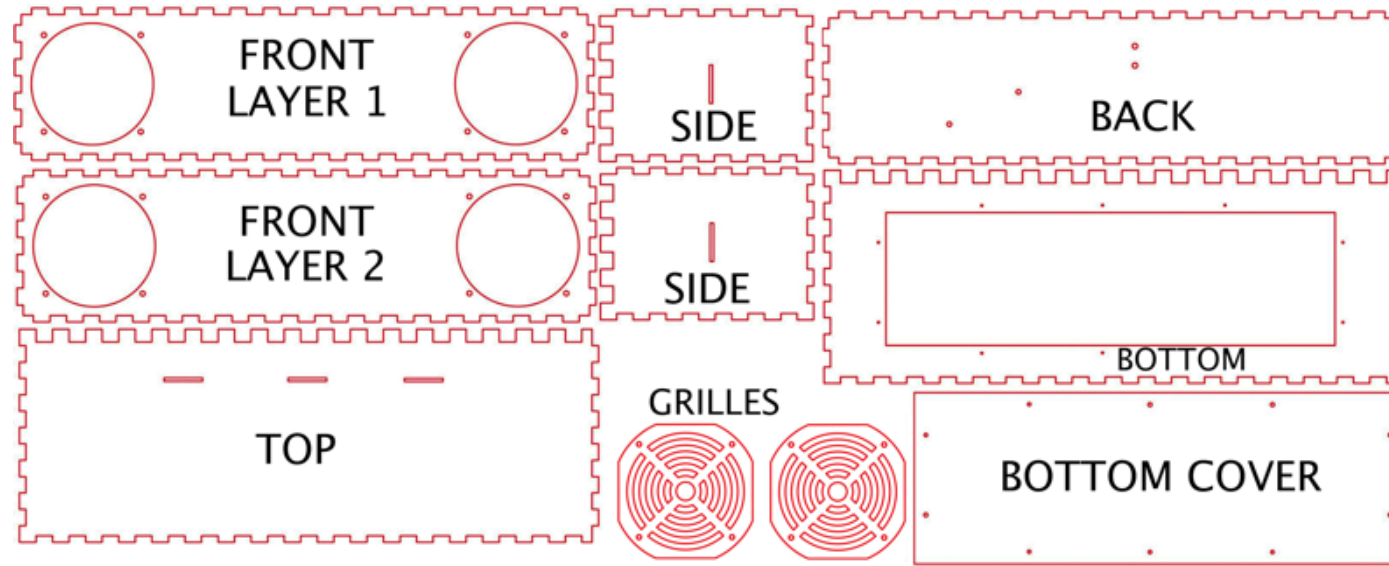
1/4-inch plywood (actual thickness 0.2 inches)	Columbia Forest Products formaldehyde-free plywood	Usually available at Home Depot ( <a href="http://www.homedepot.com">http://www.homedepot.com</a> ) or order precut via ponoko.com ( <a href="http://www.ponoko.com">http://www.ponoko.com</a> ) or [1] ( <a href="http://www.formulor.de">http://www.formulor.de</a> )
1 Audio power amplifier	Dayton Audio DTA-2 Class T Digital audio amplifier module	300-385 ( <a href="http://www.parts-express.com">http://www.parts-express.com</a> )
2 4 ohm loudspeakers	Dayton Audio ND105-4 4" Aluminum Cone Midbass Driver	290-212 ( <a href="http://www.parts-express.com">http://www.parts-express.com</a> )
1 12VDC power supply adapter	2A are recommended	1950497 ( <a href="http://www.jameco.com">http://www.jameco.com</a> )
1 DC power jack	2.1mm	151555 ( <a href="http://www.jameco.com">http://www.jameco.com</a> )

## Laser Cutting

Community members in the United States with access to physical laser cutters may prefer to source environmentally friendly plywood at Home Depot. For instance, Home Depot currently carries Columbia Forest Products' *Purebond* brand of "formaldehyde-free birch plywood. It is advertised to be 0.25 inches (6.35mm) thick but seems to actually be 0.2 inches (5.1mm) thick.

Alternatively, the enclosure parts could be laser-cut via an online store such as Ponoko (<http://www.ponoko.com>) or Formulor (<http://www.formulor.de>) or others. For instance at Ponoko, the design could currently be cut using using birch veneer core, veneer MDF (cherry, walnut or white oak), or acrylic.

The templates for laser cutting the plywood can be found on the main project page. The template for revision three is depicted below. The red lines show where the plywood will



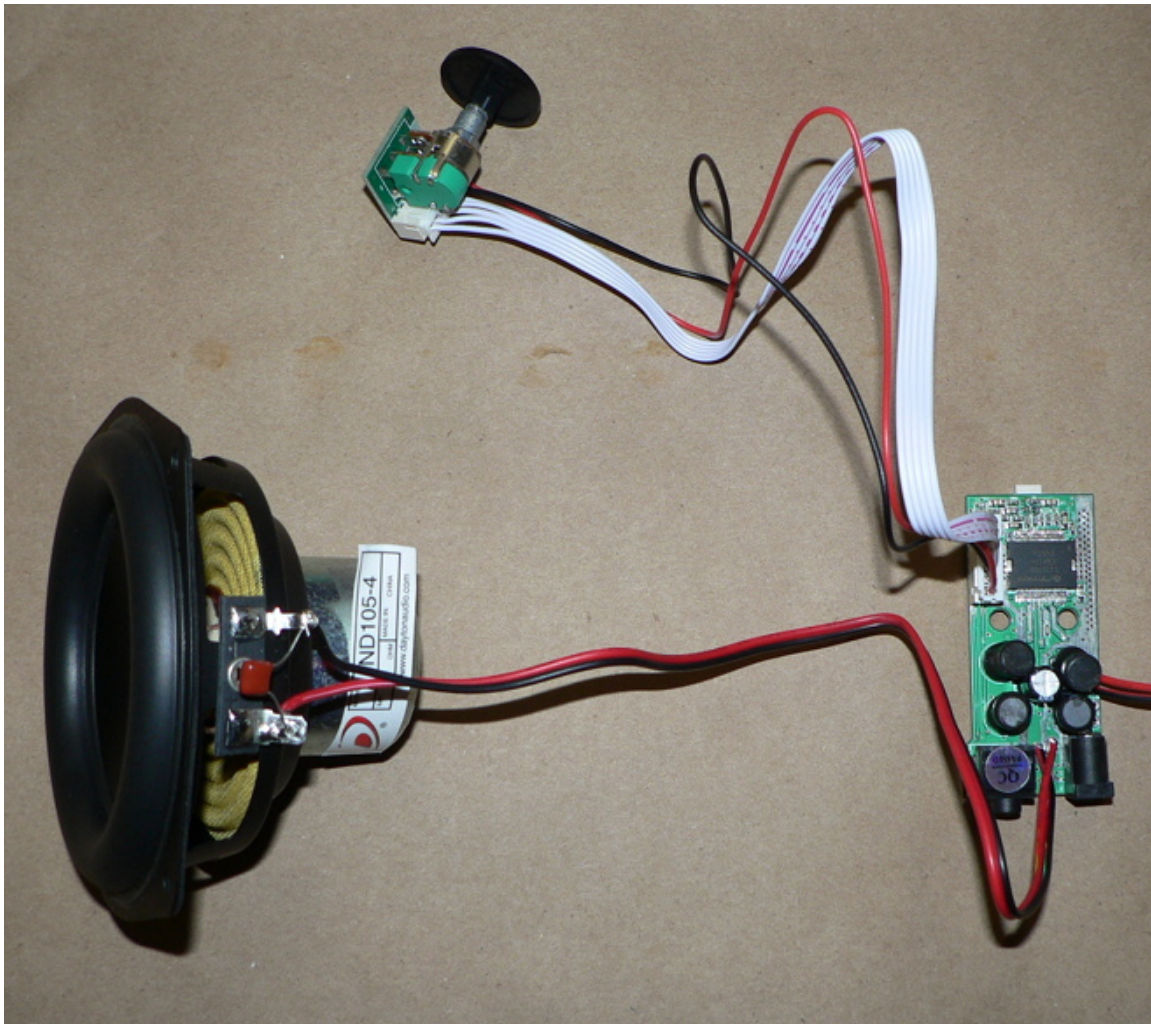
be cut.

## Preparing The Electronics

- Open up the Dayton Audio DTA-2 Class T Digital audio amplifier module kit. Remove the capacitors from the kit.
- Solder one capacitor across each of the leads of the Dayton Audio ND105-4 4" (10.16cm) Midbass drivers as shown below:



- Follow the rest of the instructions for the amplifier module in order to solder it together (except it is recommended not to use the inductive rings included with the kit because they are just more items that you will need to secure to prevent from vibrating.) It may not be necessary to solder any wires for the power supply if you will use the on-board power connector. The soldered circuit is presented below (only for one loudspeaker):



## Getting Ready To Glue

- First check that your pieces of laser-cut plywood fit together nicely and look good. Then take them apart and lay them out as shown below. Keep the edges that will be glued together facing each other. This will make it easier to glue them together correctly and rapidly.



## Glue The Basic Box Together

- First, place some glue on each of the dovetail fingers pointing outward for the edges as shown below. Do not be afraid to use a significant amount of glue. It is better to use too much than too little. When you fold up the outside edges around the piece shown in the middle, then there will be glue in each of the dovetail joints. In this example, all of the edges of the box (except the rear "open" part of the box) will be glued together. (After you have had some practice at making boxes, you could try to also immediately glue the rear "open" part of the box in this sitting, but for now it is probably better to wait -- otherwise, you may find that the glue runs excessively.)



- Then fold up the outside edges.

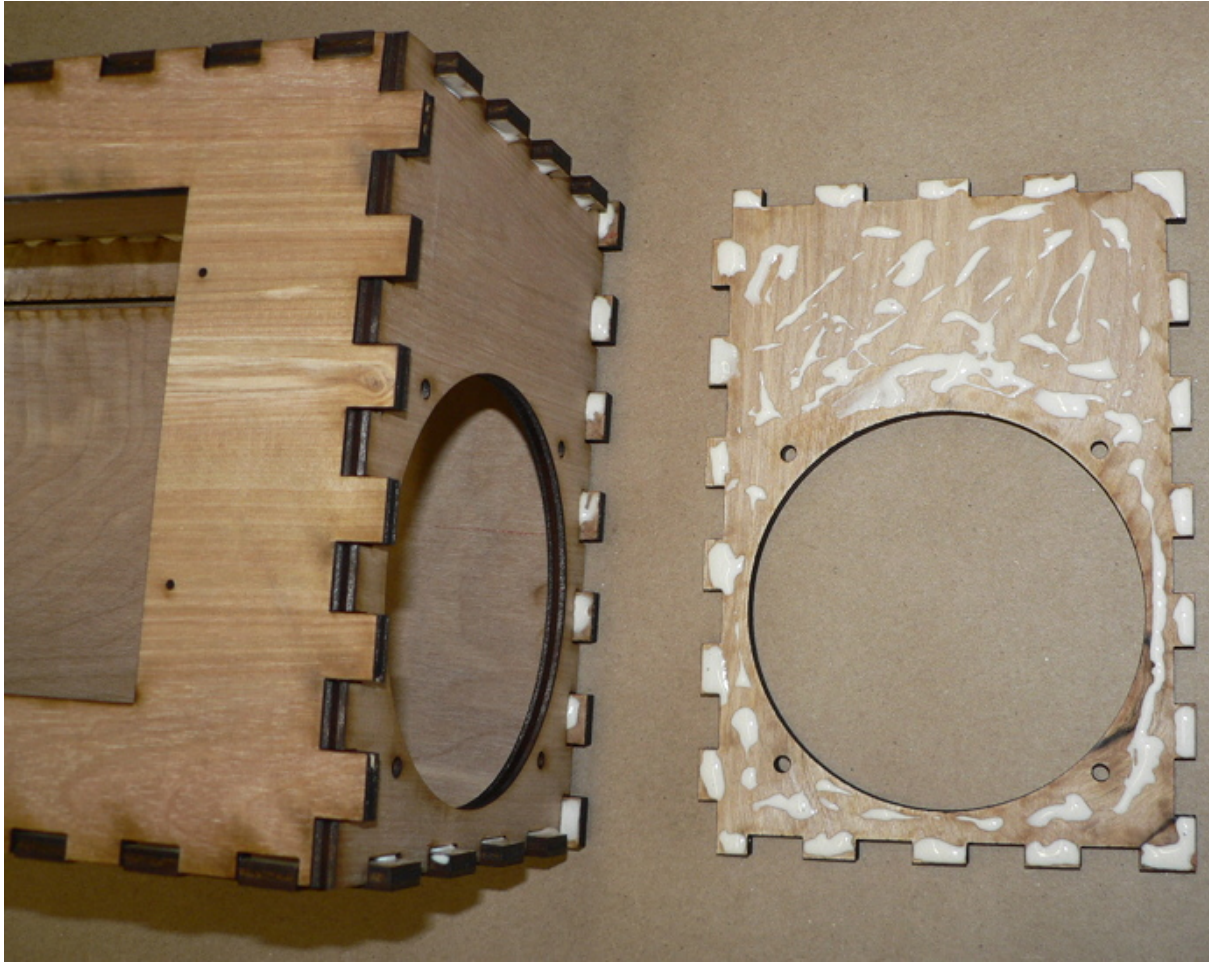


- Put the top on, but don't glue it yet. This will help ensure that it will fit nicely after the glue in the rest of the box sets. However, if there is some glue in the way, carefully clean it out first. Otherwise, you will not be able to get the rear "open" face off again.



- The faces with speakers have double the thickness to help keep those faces from vibrating too much. It's important to glue these double-thickness faces together. A lot of glue is necessary in order to ensure that a strong bond is made.

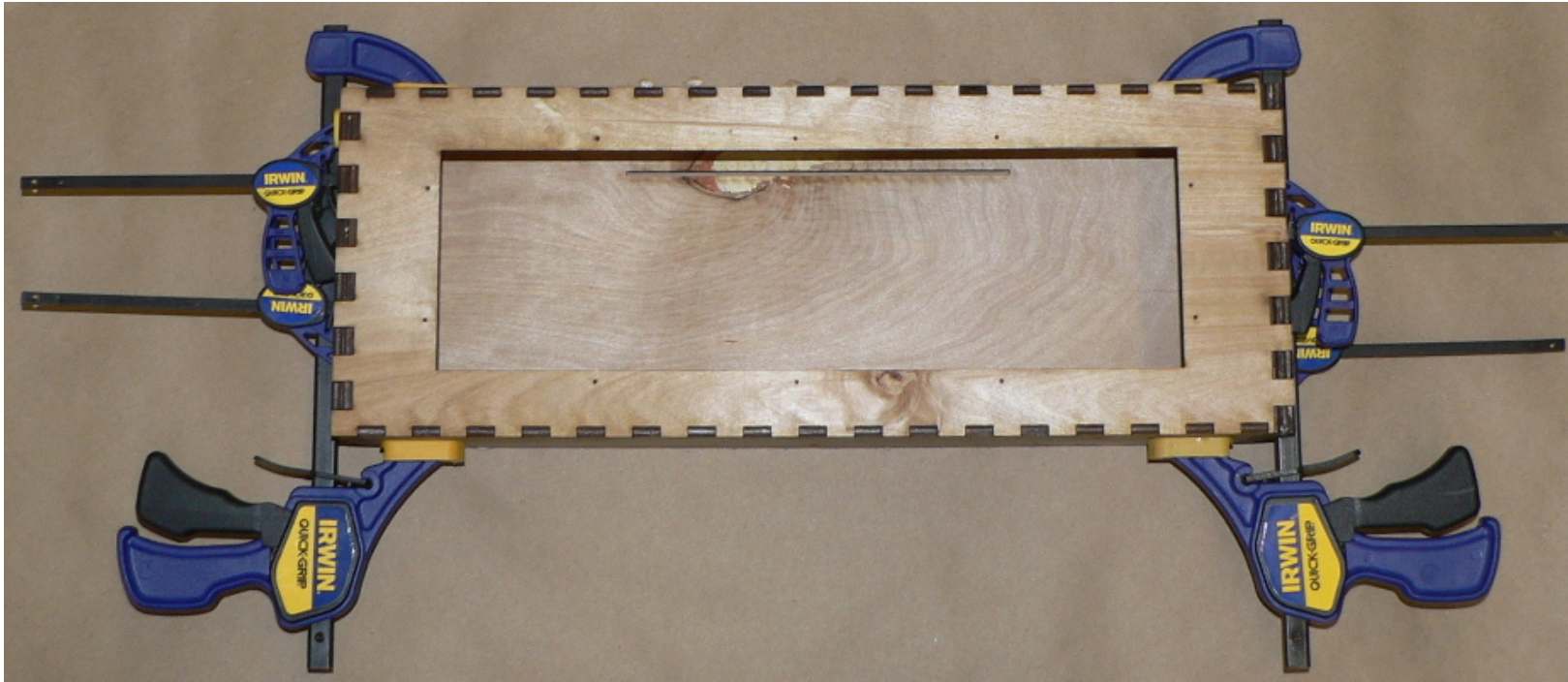




- Add clamps to securely hold the double-thickness faces together.



- Add clamps to hold the rest of the box portions that are getting glued together.



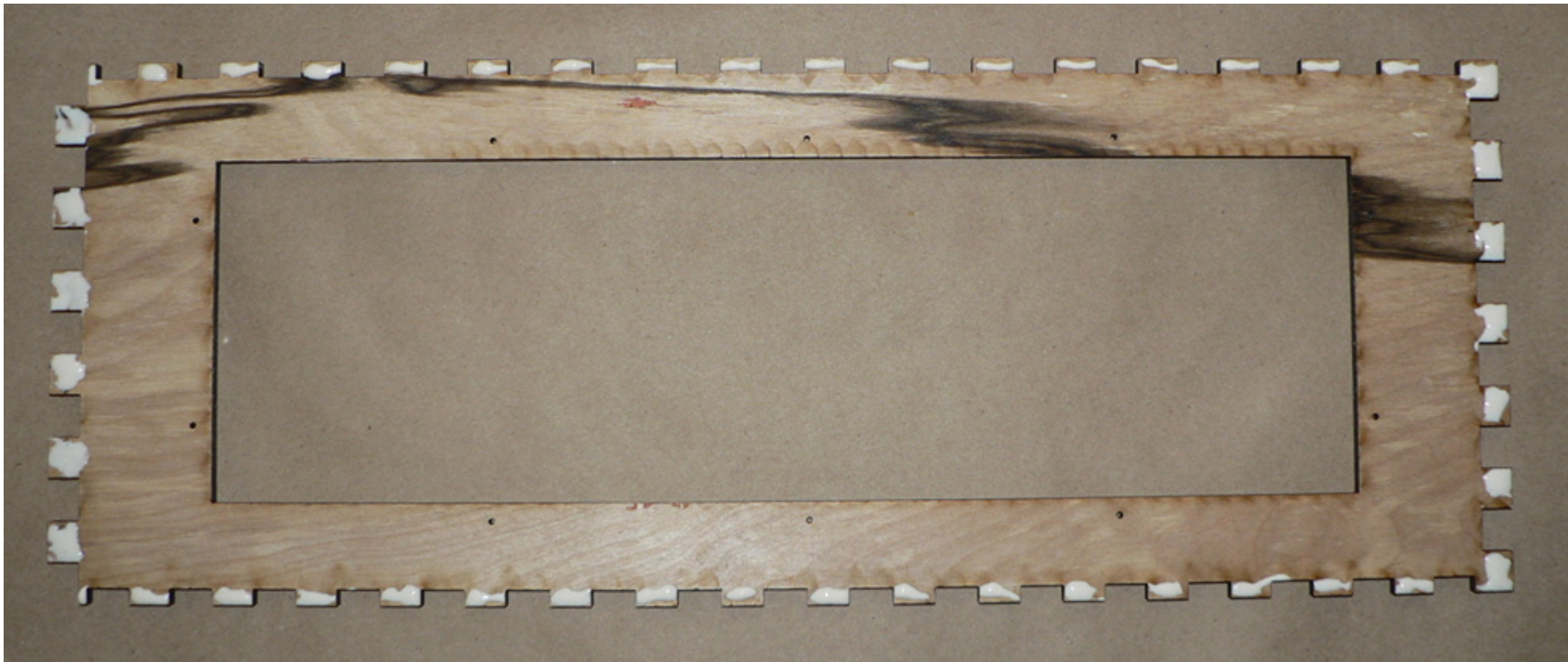
- Wait for the glue to set. Wait at least long enough until the glue is dry enough to remove the clamps. For Elmer's wood glue this may be 60 minutes. However, it may be a better idea to wait for the glue to entirely set before moving on. Therefore, if you are able, come back to the project in 24 hours after the glue is completely dried.

## Gluing On the Rear "Open" Face

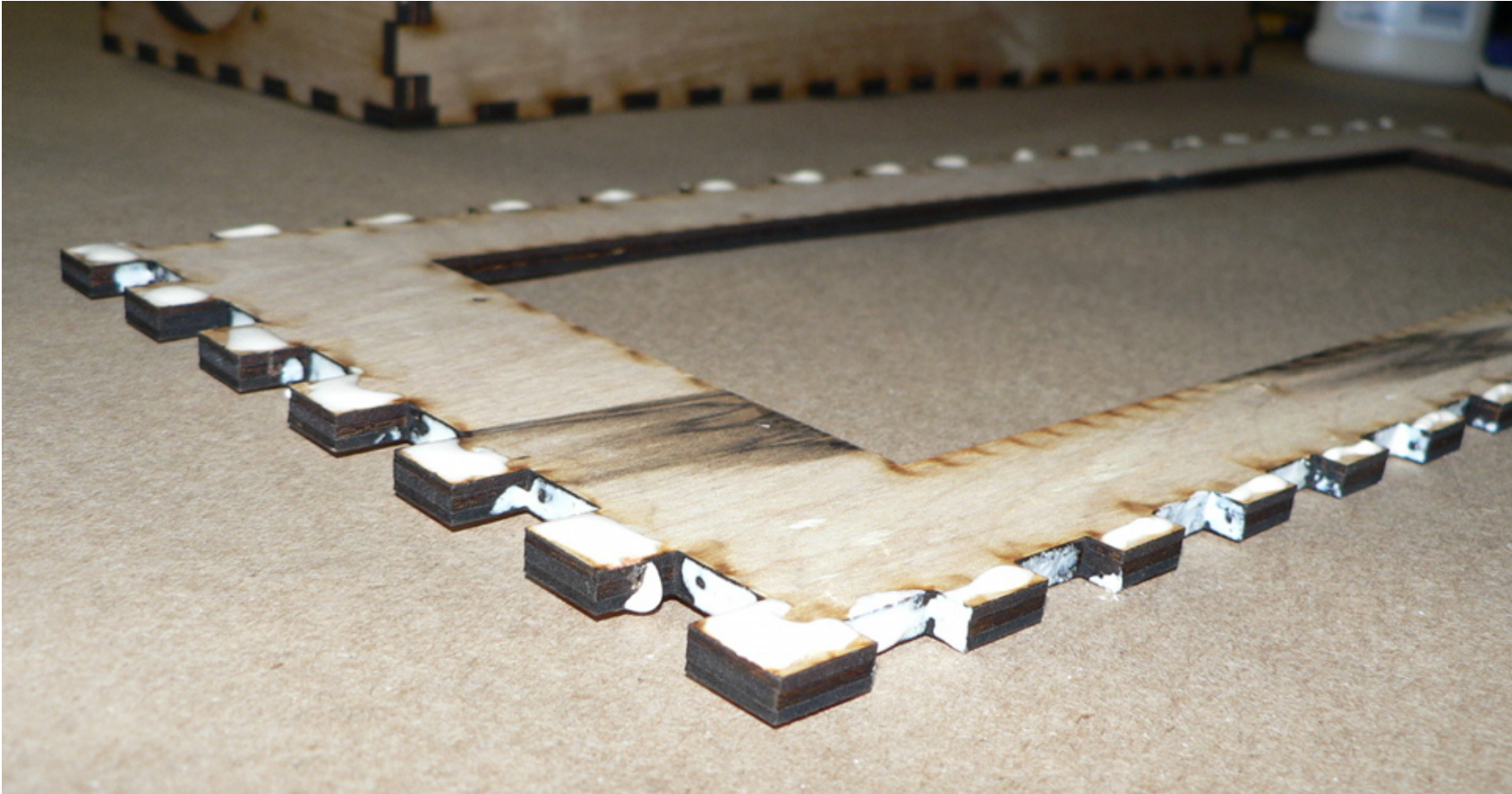
- Now it is time to glue on the rear "open" face of the box. In the near future, glue will have to be placed precisely on the insides of some of the dovetail fingers. For this reason, it is a good idea to make a little puddle of wood glue and lay out some Q-tips.



- Carefully remove the face that hasn't been glued yet. You might need to gently use an exacto knife to encourage some of the dovetail fingers to let go.
- Put glue on the outside of each of the dovetail teeth on the side of the rear "open" face of the box that will face the inside.



- This time, also put glue on the insides of the dovetail teeth of the rear "open" face of the box. Probably you will want to use the Q-Tips to do this.



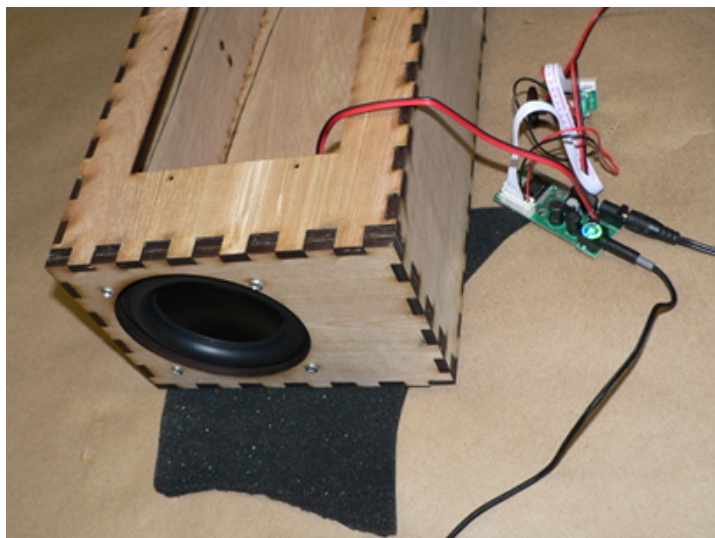
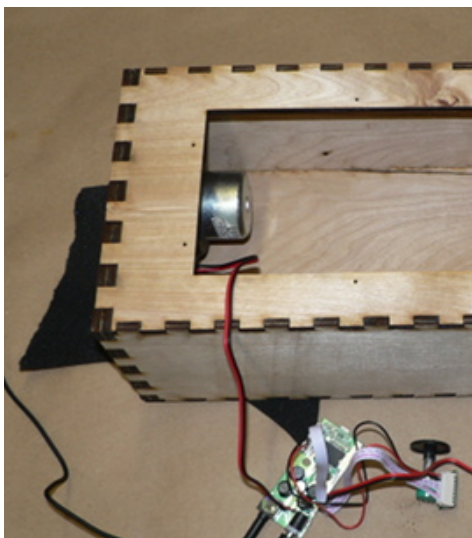
- Clamp the rear "open" face on (not shown) and again wait for the glue to set.

## Acoustic Testing

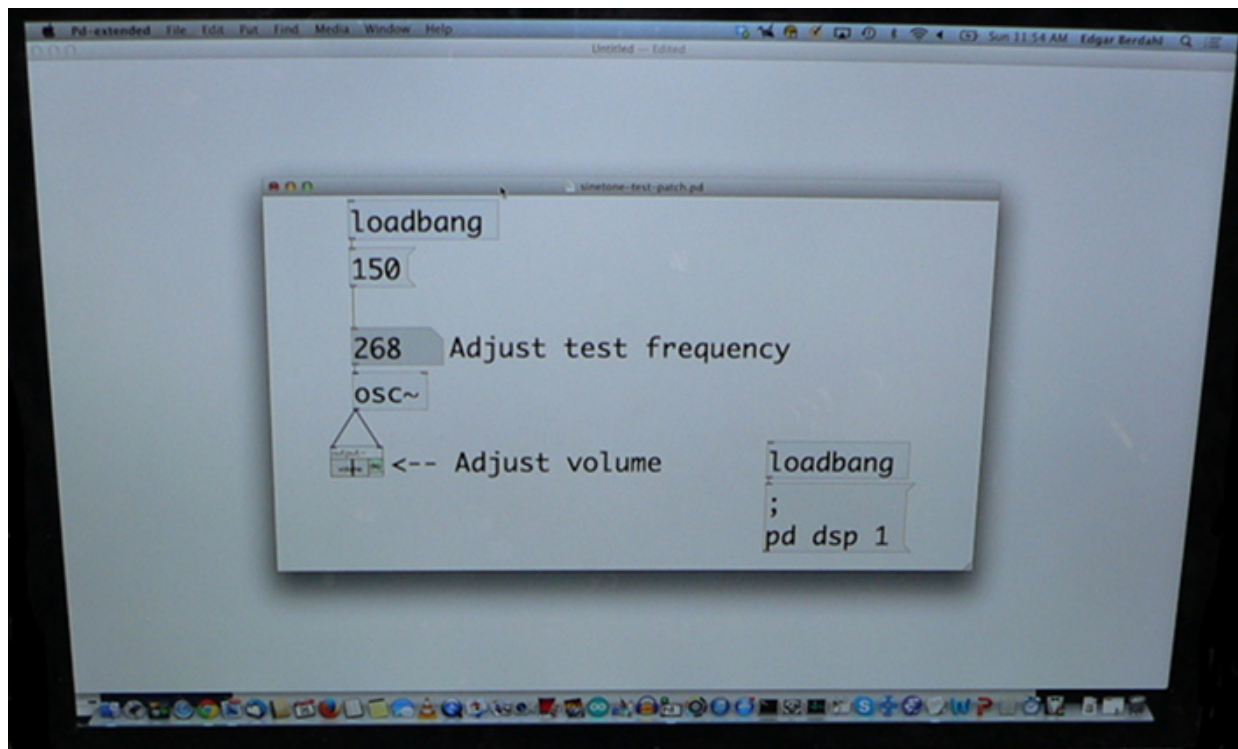
- Acoustic testing will be essential for making a powered loudspeaker that sounds good. To test, you will need to install one or both of the drivers. These instructions assume that you will install the drivers from the inside. (Because the surround from these loudspeaker drivers protrudes so far outward, if you were to install these drivers instead from the outside of the box, then you would need to find a different way of putting a grille in front of these particular drivers or forget the grille altogether.) Put the gasket on top of the driver as shown below. If you are using a different driver and no gasket is readily available, then you will want to cut one out of a thin layer of foam or make one using a silicone sealant (which could make a mess!)



- Install one of the loudspeaker drivers into the box as shown below from two angles. Use some lock washers with machine screws or use locking nuts so that these screws will not come unscrewed by themselves due to vibrations. If you are feeling bold, you will probably want to install the grilles at the same time (not shown here, see the first figure at the top of this page). In the example below, the box is placed on top of a layer of foam so that it will not vibrate against the table when being tested. Keep the amplifier parts out of the box for now so that they don't interfere with initial testing.



- Start up the Pure Data (pd) patch **sinetone-test-patch.pd** in order to excite the loudspeaker driver with a sinusoid. Connect the headphone output of your laptop to the amplifier. Turn on the amplifier and turn up the volume. Increase the volume in the Pure Data patch until you hear something.

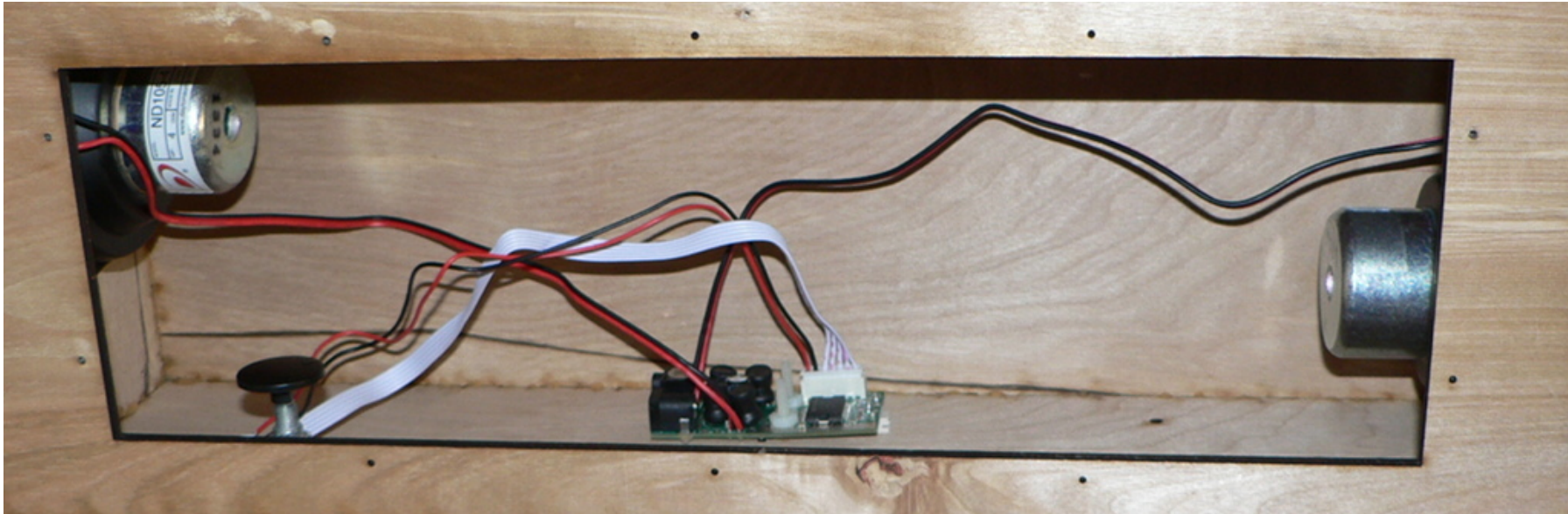


- Put on ear plugs and get ready for some high sound pressure levels! Set the frequency to a fairly low number, such as 250Hz, and then increase the volume in pd, on your laptop headphone output, and on the amplifier. The strategy here is to test your powered loudspeaker using a pure tone (a sine wave) to find out what might prevent it from sounding pure in the box. Eventually as you increase the volume far enough, the nature of the sound will become impure (i.e. distorted). It could happen because of clipping in the signal chain or the driver being over driven, so move the frequency up and down to hear what happens. We want to find distortion due to the box because this can be fixed to greatly improve the sound quality. If the distortion is because of the box, then it will have a rattling sound that will only happen at specific (resonance) frequencies. As you play around with the test setup for a while, you will be able to identify what is causing the various distortion sounds.
- The rattle distortion comes from the faces of the box moving in and out. Using your hands, you can feel the faces moving if the volume is loud enough. Now, select a frequency and volume setting that causes rattling distortion due to the box. Probably the frequency setting for this will be between 200Hz and 500Hz (for this box design). Now manipulate the box to get the rattling to go away. For instance, try moving wires around and grabbing different faces, etc. Repeat again at other "rattle" frequencies. Unless your box has a serious defect in one location, the rattle at different frequencies will come from different parts of the box. Keep playing around with the box until you think you are familiar with the problem of the faces vibrating. Try listening to a few different kinds of music at various volume levels using the speaker.
- Carry out whatever steps are necessary in order to reduce the rattling. For instance, it might help to (first turn off the sound) tighten or loosen the screws holding in the



loudspeaker drivers. They should be firmly tightened but not so much that the wood starts squeaking, groaning, or crunching while you are tightening the screws.

- If you are having a lot of difficulty, look at some suggestions in the troubleshooting section below.
- Finally, once you have eliminated the rattling to the extent that you desire, finish making the powered loudspeaker. Your box will sound better with multi-instrument music than with sine tones anyway. It is suggested to screw down the audio amplifier as shown below and to use hot glue to attach the volume control/power switch. **Repeat acoustic testing after adding each element! That way, you can know for certain what is causing rattle and can fix it.** It is very important to sandwich a layer of foam between the box and the amplifier module to prevent rattle (not visible in this picture).

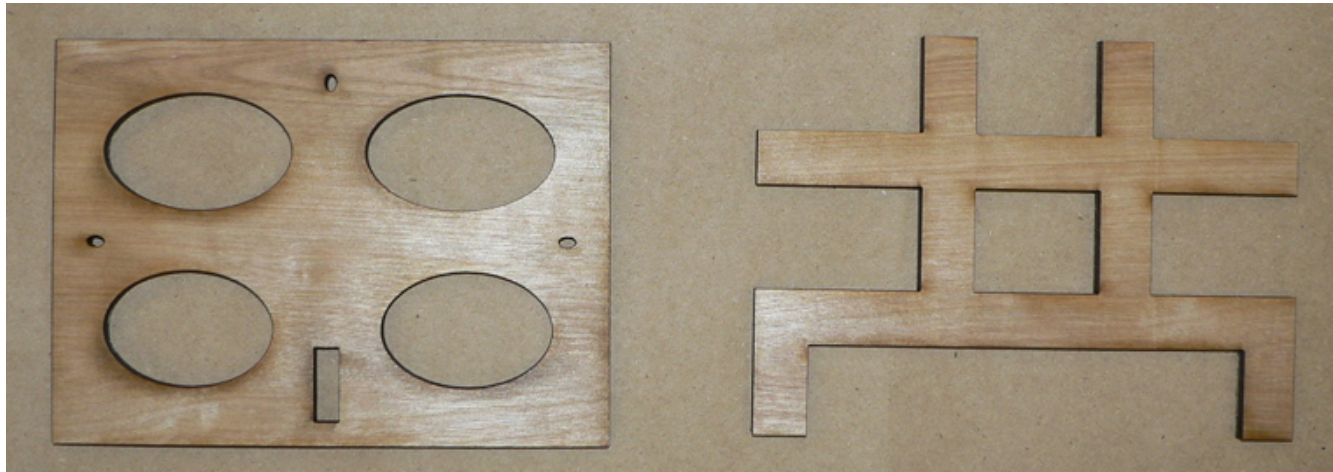


- **Repeat acoustic testing after adding each element! That way, you can know for certain what is causing rattle and can fix it.** This item is repeated here to emphasize how important it is!

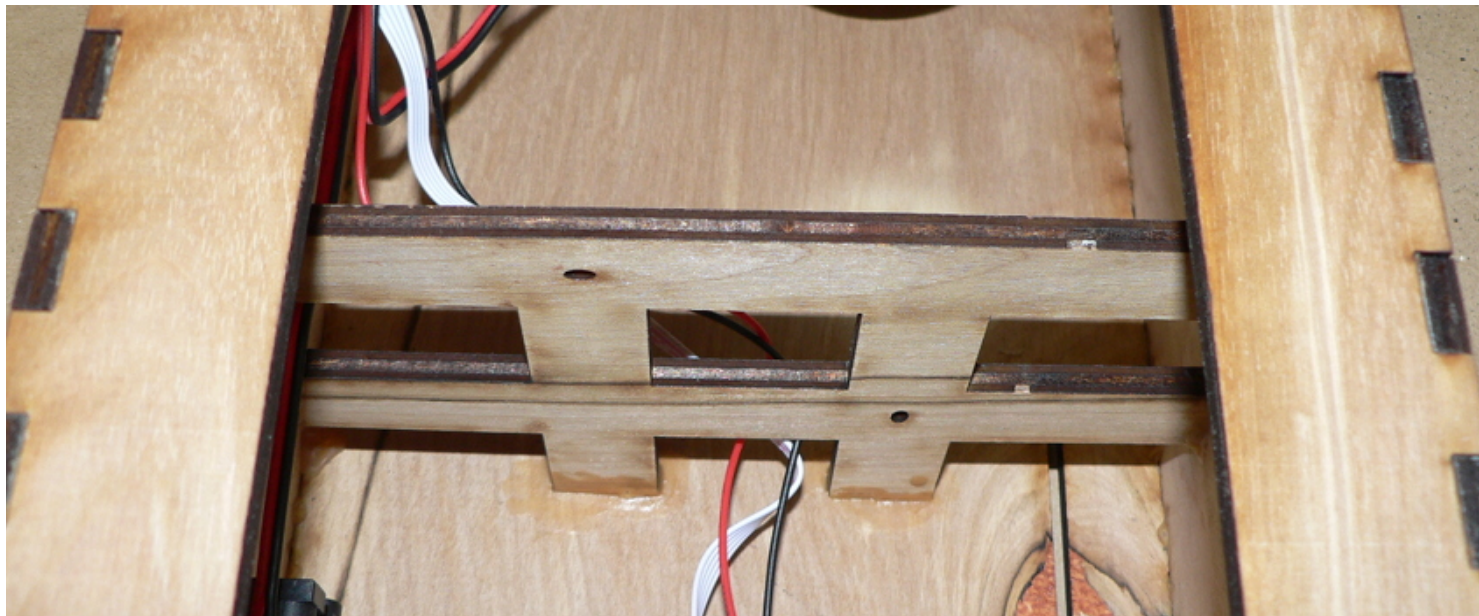
## Troubleshooting

- Use cable ties and hot glue to prevent the wires from rattling.
- Braces are an excellent way to help reduce the vibrations of the faces in order to inhibit the sound of rattle. It's easy to make 2D braces using a laser cutter. Braces are

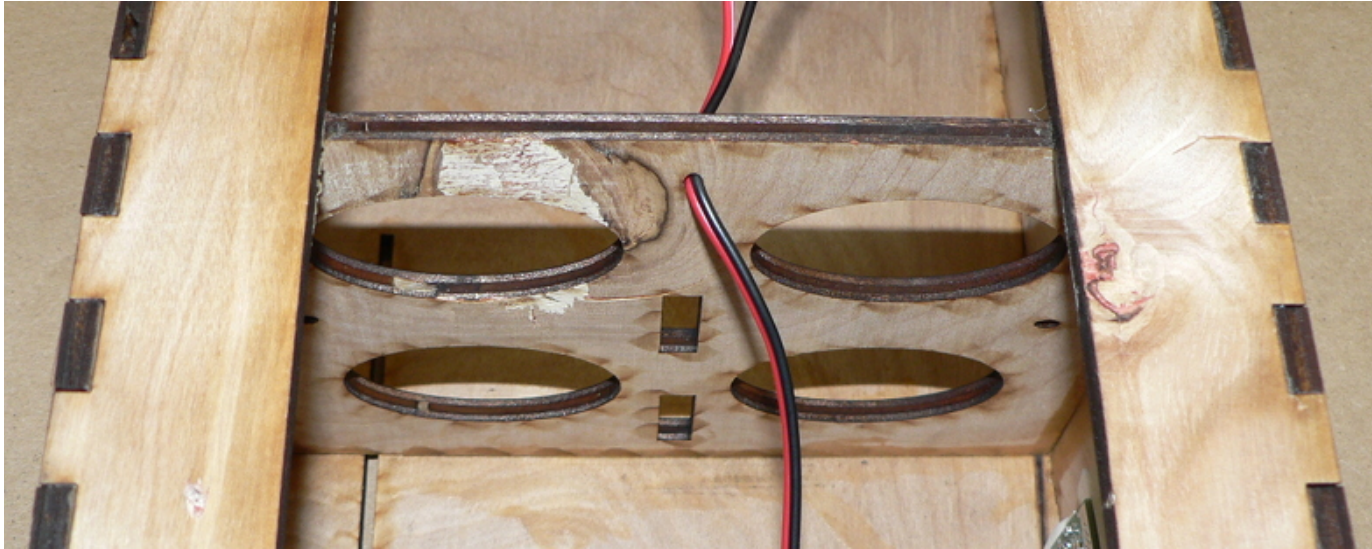
included with the templates for this project. The brace shown on the right is easier to install because it can generally be installed after the fact even after wires have already been soldered. In contrast, the brace on the left is harder to install because it meets the faces in over a greater surface area, which also explains why it might be slightly more effective. In general, if installing braces, it is best to do so while making the box itself in the earlier steps; however, braces are only mentioned at this point because it is a good idea to first try building a box without braces. It might already sound OK, and improperly glued braces can contribute to more rattle. Therefore, it's important to practice gluing some first and to experiment with acoustic testing before attempting braces.



- Here is an example of the kind of brace that can usually be installed after the glue for the main portion of the box has set:



- This brace is easier to install during the making of the main box portion itself. Wires also need to be individually routed through holes.



- Sometimes when manufacturing traditional loudspeakers, almost cubic blocks are glued into the corners of the box to increase its strength. These are called "glue blocks." They could sometimes come in helpful when trying to eliminate rattle; however, they are not recommended for beginners because they usually cannot be mounted flush with the corners once the glue for the main box has set--the previously hardened glue gets in the way.
- Try lining the walls with a material like Sonic Barrier's VE-1 damping material. This can help reduce the vibrations of the faces by dissipating the vibrational energy as heat.
- Some connectors will rattle. For example, if you are embedding additional electronics inside your box, you might need to permanently hot-glue the connectors. This is an issue with USB micro connectors.

## Extensions

- Add some Acousta-Stuf, polyester batting, or acoustic foam inside to decrease any acoustic resonances. **Don't use fiberglass -- fiberglass fibers can be hazardous to your health, and they can make a mess.** (Adding acoustic damping material is crucial if you will be screwing on the back plate over the rear face to seal the box, which will boost the low-frequency response. If you do this, you will also want to seal up any of the holes that could leak air -- those were designed into the enclosure for adding possible other electronic parts. If you are not sealing the box, then acoustic damping material is more optional.)

- Put layer of varnish on it!
  
- Paint it!
  
- Modify the design files and personalize the design -- for instance, can you make some cool grilles?

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