

ZeroGuardian's

Speaker

Project

A Joint Effort Between 3 Friends John, Andrew, and myself (Garrett). And a Guide for anyone who wants to build their own speakers.

First, I just want to give a brief description of where this project got started. The original idea came from a friend of mine, Andrew, who has previously done a lot of personal modification to speakers that he already owned. He has always been really knowledgeable in electronics and was toying around with the idea of making a set of speakers. Why didn't he do it himself? Well he didn't have the necessary tools nor did he have the money to handle an endeavor like this. He told his idea to another friend of mine, John, who decided he was willing to be the initial tester of this idea. Luckily John's grandfather had all the necessary wood working tools and John had the finances. So they got together and made an initial design that included two floor-standing loudspeakers. These were the first step to prove that we could build and design high quality sounding speakers. Upon listening to these is when I really started giving some serious thought about building a set of my own. I started to talk to Andrew about a set and we started to discuss several different possibilities. I was amazed at the quality of the sound coming out of John's speakers but there was one thing that bothered me about them, how wide they were. I didn't like that wide front look so Andrew and I started to come up with a few ideas so that the speakers could be more like most modern day 5.1 setups.

And thus the project began....

Here is a few pictures of John and Andrew's project:



Those are about 3' tall.

So to start off the actual speaker building project lets first answer a few questions?

Q:Isn't a project like this expensive?

A:Well you really have to look at a project like this in a couple of ways. First being equipment costs. The tools necessary for a project like this are expensive so unless you already have access to them expect a large initial cost. Second being material costs. The material costs of this project are actually much cheaper than buying a set of high quality speakers at a local electronics or home theater boutique store. Final being time costs. Don't expect to be able to do this in a weekend. A project like this is going to take at least 40-100 man hours.

Q:Is a project like this difficult?

A:Its not hard in the sense that many of the design aspects are aided by computer programs that I will go into further detail later on. But it does require skill with power tools and electrical work such as soldering.

Q:How do these compare to say speaker available at Walmart?

A:Well you can't really compare these to those because these are designed for high quality audio and require quite a bit more power and equipment than a standard home theater in a box. If you want to compare these to other speakers you would need to go listen to speakers from the likes of Polk, Infinity, Paradigm, B&W, etc.

Q:How did you decide on components?

A:This is where building speakers has its most difficult design aspect. You do need to have a slight understanding of what the specifications of speakers and crossovers mean. But there are several sources online that can aid in this process.

Ok, lets break this project down into the various steps to completion.

1. Design
2. Materials
3. Planning
4. Construction
5. Finishing
6. Installation
7. Testing

You may be wondering why there is both a "Design" and a "Planning" step. This is because your plans can often change once the materials are all gathered together.

Before we get started, there is a list toward the end of the guide that will include information about many aspects of the speakers and specifications.

Now that we have a general idea of where we are going lets get down to the minute details...

Step

1

Design

The design process consists of gathering and planning all the necessary information to make a set of speakers. Here you are going to do about 30% of the build process. When this step is completed you will know what your component selection will be and the dimensions of your speakers along with what materials you will be making it out of. This step also gives you a good idea on the cost of the project, although it is smart to assume that not all costs will be expected so just remember that some of the information from this stage could change down the road if you are forced to change materials or decide to do something a little different.

For my speakers we first started by deciding what I wanted and several possible options to achieve that goal. I knew from the start I wanted a 5.1 surround system that would give me the same feeling you get in a theater. But your project may just need 2.1 configuration or maybe you'll go all out and get a 7.1 setup with presence surrounds giving you up to 11 different speaker channels. That is what you decide on first. And as many of you have already noticed my design eventually changed to include a full 7.1 configuration.

Now once you have an idea of what you want its time to start deciding how you will accomplish this goal. You need to start making decisions on what your speakers will consist of and what you want your focus on. For me initially I was thinking small bookshelf size speakers for all the surrounds and a slightly larger center channel but after hearing some

demonstrations at different locations it became obvious to me that towers were the only way I would be able to achieve the sound environment that I wanted. Again this may not be the same choice that you make. Speakers require a lot of personal choice and your taste in sound is very different from other people so don't be afraid to go with what sounds best to you. After all, who will be listening to them the most?

So once you have made some decisions on your speakers its time to start getting down and dirty with the details. At this phase its often good to start making design schematics or reference data to help you along in the design process. Now what may come as a surprise to you is that you don't choose the size of the boxes, your components will decide that. Now you may be wondering how that works but there is a lot of research that has gone into speakers over the years and they have been able to develop several math formulas for the perfect box dimensions for a particular speaker. This is based on a number of specifications of the speaker itself but you will not have to be too concerned with the formula because thankfully people have made programs that do all the work for us. We'll get to that in just a few minutes but first we need to decide on speakers. Now again this is based on research and personal preference, so don't feel that you have to copy someone else in order to get results. But I choose to stick with our tried and true method that had been tested on John's speakers. So I decided to stick to Dayton Loudspeaker's Reference Series for our

woofers and Morel for the tweeters.

Once you have made a decision on the choice of speakers then you can start to move on and choose the rest of your components. Now again there is a lot here that you will need to be semi-familiar with. But with a basic understanding you can accomplish quite a bit. In my case I choose the following speakers:

Morel – [MDT-20](#)

Dayton – [RS150S-8 6" Woofer](#)

Dayton – [RS225S-8 8" Woofer](#)

Now you'll notice on these pages are a series of specifications listed. Many that you will most likely not understand. Its ok there are even some that I don't quite get so don't be scared by these.

Here is a chart of the specs:

Speakers	MDT-20	RS150S-8	RS225S-8
Power Handling	120W	40W	120W
Voice Coil Dia.	1-1/8"	1"	1-1/2"
Impedance (Znom)	8 Ohms	8 Ohms	8 Ohms
Resistance (Re)	5.2 Ohms	6.2 Ohms	6.4 Ohms
Frequency Resp.	1.3KHz-23kHz	45Hz-3.5KHz	27Hz-2kHz
Fs	650Hz	48Hz	27Hz
SPL	90dB 1V/1m	88dB 2.83V/1m	88.1dB 2.83V/1m
Vas:		.50 cu ft	2.75 cu ft
Qms:		2.1	1.6
Qes:		0.5	0.47
Qts:		0.4	0.37
Xmax:		4mm	7mm

Now the first thing you probably noticed was that the tweeter was strangely missing several of the specs. The reason for this is the tweeter is sealed in its own inclosure and thus will not affect the other speakers in the box at all. As a matter of fact the tweeter could be out of the box entirely and you wouldn't notice a significant difference. Not all tweeter's are this way but quite of few of them are.

Now your also probably looking at these numbers and scratching your head. Don't worry like I said before even I don't understand them all but that is what the computer program is there for. Now its time to start designing the boxes around the speakers we have chosen.

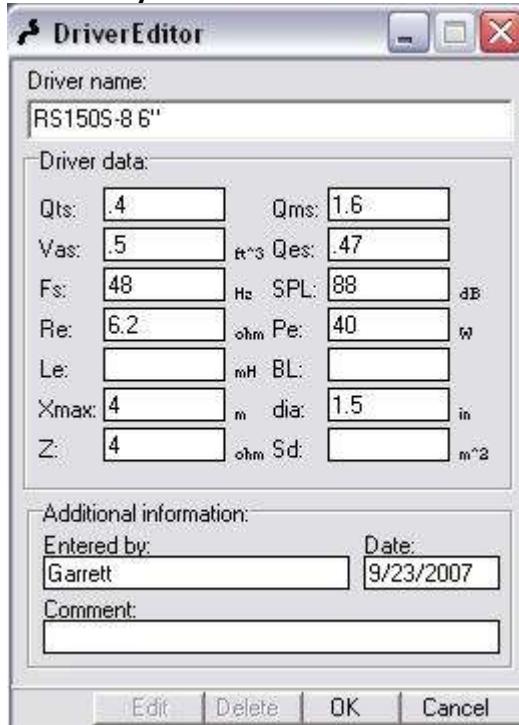
At this point you will need to download the following program.

WinISD

With this program we will be able to calculate the appropriate box size and also be able to see the response curve for our speakers.

When you open the program you will be able to create a new project and will then ask you for the speaker. You will most likely need to create your own speaker with your speakers specs by clicking new. You need to make sure to pay attention to the units of measurement in this program, they can be changed by clicking on them.

It should then show you a window similar to this:

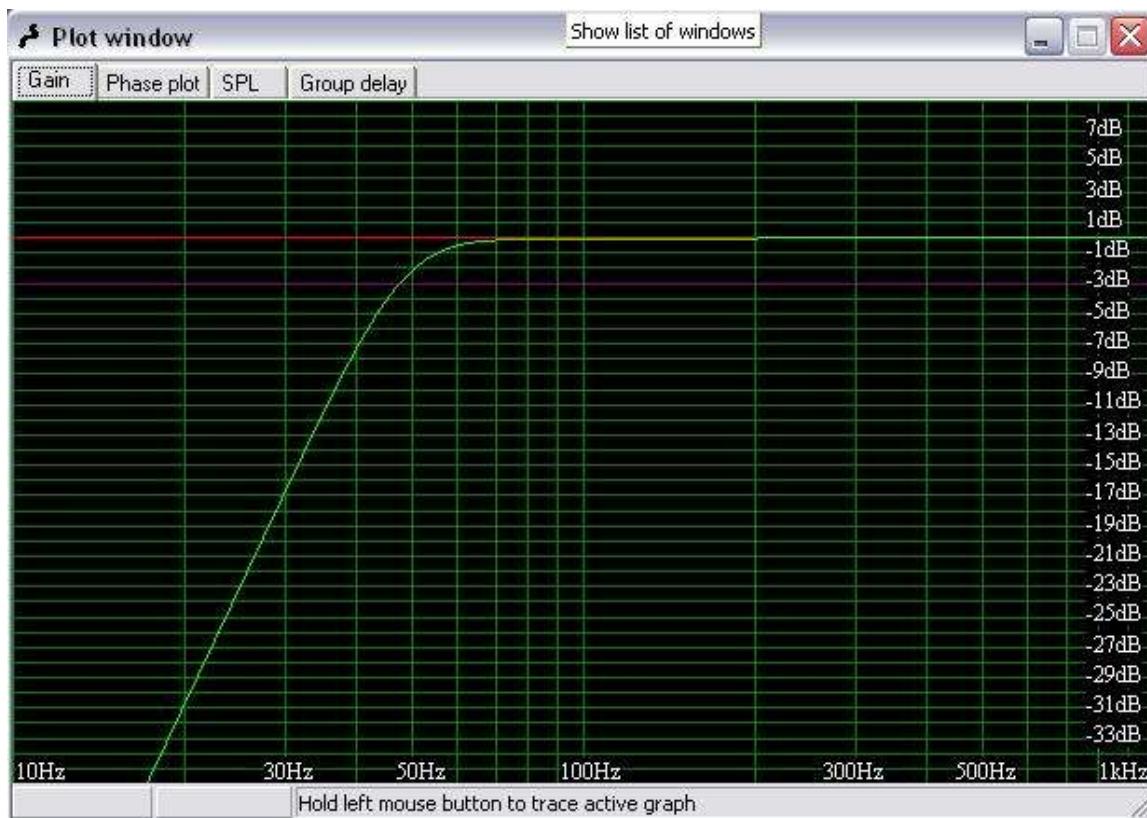


As you can see you enter in the information just like from my table. You don't need to be concerned with Le, BL, or Sd. They will not effect the outcome of the calculations. Pay attention to the units that each is in and change them as needed.

Once you have created your speaker in the program you will create a new project select your speaker and the configuration (# of speakers, whether it is vented or not). And it will then give you a plot read out of the performance of the speaker.

Now you may be wondering about whether to vent the box or not. Venting a box causes two things, a larger box and more bass output. So that is something to consider when designing your speakers.

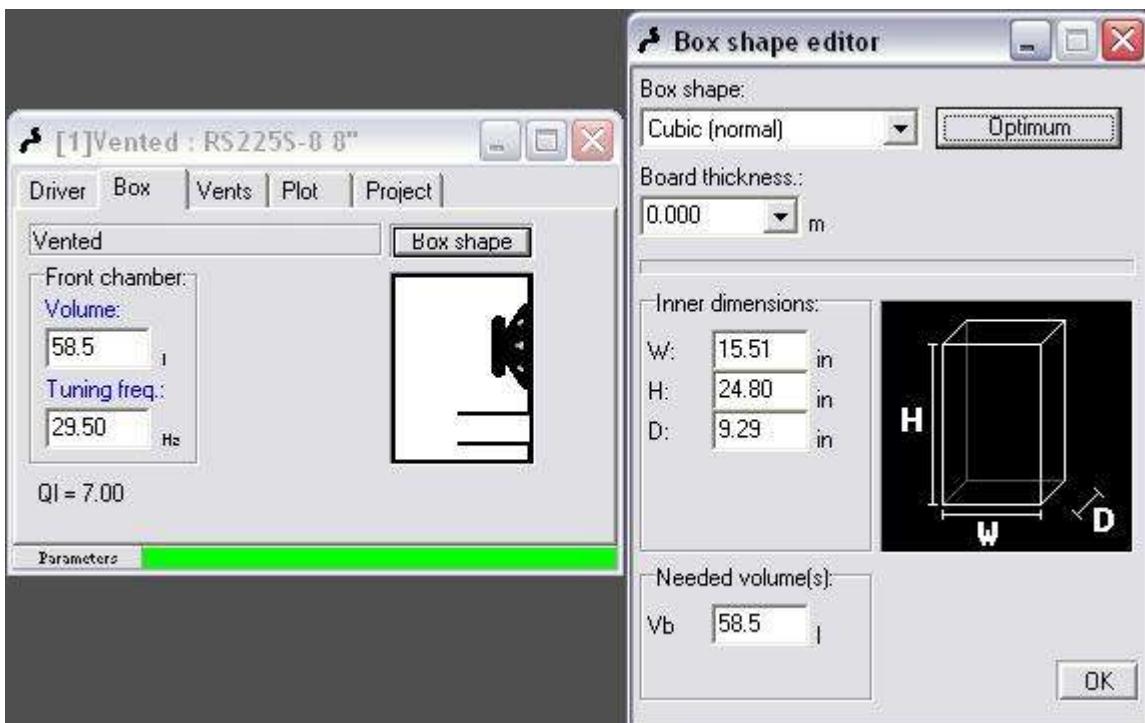
The plot outline on my 6" Woofers is displayed below:



Now I'm sure I have lost a few people at this point. But like I have said before you need a basic understanding of many of the concepts here.

Again if you want to learn more about the specifics of these calculations and so forth there is a list of resources at the end of this project guide.

Now this program can also properly calculate the dimensions of the box. Once you have setup your project open the window to the following tab:

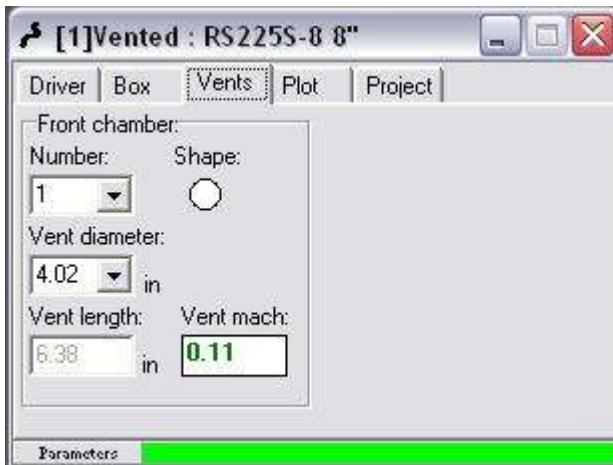


As you can see it display's the internal volume and if you click the Box Shape button then you can find out the optimum size for the box. Now make sure to fill in the board thickness with the thickness of the wood or material you will be using to build the boxes out of that way it displays the outer dimensions not the internal ones. You can also set one or two of the dimensions manually and it will calculate the optimum quantities for the remaining deminensions for you.

So now we have speakers and we have the box dimensions and even an idea of what frequencies the speakers will be able to hit.

There are two things left that we need to calculate for our speakers to function properly. First is the length of the port (vent) if you decided to use one. Second is the crossover frequency.

WinISD can calculate the port length for you. By going to the Vent Tab you'll see it shows the diameter of the port hole and the length. These are both important.



Again pay attention to the units of measurement.

For my speakers (towers) we used a 4" wide port and thus it needed to be 6.4" long. The vent mach is a calculation of the noise air will make as it goes through the port. The lower this number is the better. As long as your under .15 you should be fine.

The port we used for the towers was this one:

4" Port

So now we move onto the crossover. For the crossover we first need to find the optimal crossover frequency.

For this I'm just going to point you towards the best guide on the net for this information.

Choosing a Crossover Frequency

Ok so now we know what your optimum crossover frequency is. So where do we go from there?

Well its time to pull out another computer program. The only downside to this one is its entirely DOS based. But it is still extremely useful.

PE Box

Open up the program and it will first ask you for a part #. Just enter the example number that it gives you and hit enter. Once you are in the actual program itself then hit 'F7' to go into the crossover design portion. Here it will ask you for the impedance of each of the speakers you are using (tweeter and woofer) and then the crossover value that you determined earlier. It will then give you the appropriate capacitor levels and inductor values that you will need to purchase.

For my surrounds I was given the following information:

Tweeter Impedance: 8 Ohms

Woofer Impedance: 8 Ohms

Crossover: 2800Hz

C1 & C2: 3.55uF

L1 & L2: 0.91mH

You then take those values and find the appropriate capacitors and inductors that most closely match your needed value.

For my speakers it was these:

Capacitors

Inductors

And finally you will need a crossover board. We used these:

Crossover Board

The crossover boards come with a schematic to tell you where to put the parts on it and where to solder so don't be concerned about not knowing where to put these components.

One quick side note on the crossovers, in regards to the inductors its important to mount them perpendicular to each other in order to avoid interference. (3 inductors – standing/flat/standing)

Well that wraps up the design phase. Hope you have learned a great deal here and once again if any of this is going over your head there will be a resource guide at the end of the project guide.

Step

2

Materials

This is the easiest step of all. We've already covered most of it in the previous chapter.

Here is where you plan out all your material needs for your speakers once you've decided or calculated all the necessary figures.

Your parts list will include the following:

Speakers

Crossover Boards

Capacitors

Inductors

Wire Terminals

Ports

Wire

Wood (or other material to build the boxes out of)

Dampening Material

Solder

Nails and or screws

Silicone or some other Sealing Agent**

Wood glue

Wood putty

Finishing products

Tools

As you can see there are a lot of parts necessary to be able to build speakers but many of these can be purchased at a local hardware store.

**On the sealing agent, if you do decide to use Silicone be sure to pick up [Silicone II](#) otherwise it might contain chemicals that damage your finish.

Lets start with the tools you will need for the job.

Construction Tools:

Table Saw (Or some saw you are comfortable with using.)

Router (for cutting out the holes)**

Soldering Iron

Nail Gun

Power Drill and Screwdriver

Caulking Gun

Finishing Tools:

Power Sander

Brushes (Or paint sprayer)

Putty Knife

**Make sure the router you are using is at least 1½HP or stronger, otherwise the tool may not be strong enough and could lead to injuries.

All of these can be purchased at a local hardware store some of them can be a little expensive but as I was able to do you might be able to borrow some of them from a friend. And there might even be a place in your area that will let you rent some of them out.

As for the materials, some of them you will need to order others can be found at local stores.

The speakers and crossover components can be acquired at:

Parts Express

Monoprice.com

Radio Shack

The only item that we didn't get in those locations was the dampening material. We picked up some of the sheeted filler foam for pillows from Hobby Lobby. There are other choices and you can go with some extreme choices on dampening materials but you aren't going to need much of it and some of the heavier duty dampening materials may actually dampen too much of the internal sound waves. The dampening material is there just to kill standing waves and prevent waves from reverberating within the speaker box itself.

The only item left on the list that you need to concern yourself with is the finishing products. You will have to decide for yourself what finish you want on your speakers. I'd recommend going to a specialty hardware store and talk to someone who really knows what he is talking about. Get some ideas and then buy a few different products and test them out on a few pieces of wood you have left over from cutting out your boxes. This way you can see for yourself what they will look like when the finish is done drying.

My self I went with [Behlen Solar-Lux Stain](#) in Jet Black. And then went with a clear semi-gloss from Minwax.

So you now have all the necessary tools and materials to get the job done. Now its time to plan the project out.

Step

3

Planning

Ok, so now you have your tools and materials now you need to make a plan on how everything should be done.

There are 3 basic things that you need to plan out. You need to plan out your project and the order in which things need to be done. You need to plan out the cuts on your wood for your speaker boxes, this way you know you have enough and you don't end up with a lot of wasted materials when your finished. And finally you need to plan out the final design for your speakers.

When developing your plan its best to write everything down and have sketches of the boxes written down so that you can always refer back to these later on. You might even go so far as to keep a simple journal that you can write notes in as necessary during the build process.

When we planned out my speakers we had sketched out on graph paper the cuts in the wood (don't forget to include space in between each piece for the saw blade otherwise your cuts will be slightly off) and we also sketched out diagrams of each of the speakers along with locations for the holes. Its important to get everything written down and double checked because if you don't write it down then you might do something incorrectly or cause problems with your project later on when your putting everything together.

This would also be a good time to write down all the dimensions for your cuts, speaker holes, terminal and port holes, and also plan out the inside of the boxes as well. You need to make sure that you will have enough room in the box for your port tubes, as well as the crossovers and the wires as well.

As a final note I just need to remind you that, while its important to have plans and follow them, things do go wrong so don't be afraid to make a few changes later on in the project if you think something is not going to work properly. I know while we built these speakers we changed the initial plans 3-4 times before we even started building the speakers and had to improvise on a few things when we started putting things together.

Alright, so now just follow this simple checklist before you continue on:

- Construction Tools
- Finishing Tools
- Box Materials
- Building Materials (nails, screws, glue, etc.)
- Soldering Tools and Materials
- Finishing Products (stain, sealants, etc.)
- Speakers and Ports
- Crossovers
- Wires and Terminals
- Plan and Journal

If you have all of the above its time to start construction on your speakers!

Step

4

Construction

So your probably anxious to get underway, well before you get started there is one more thing you need to consider.

Safety!!!

Yes I'm sure your probably thinking that nothing can go wrong but anytime your going to work with power tools you should always work safely and smartly. After all what good is a set of speakers if your held up in the hospital for several days or weeks.

Some simple rules to follow:

1. Always work with another person. Even if the job only requires one person make sure someone else is there in case things go wrong.
2. Always were eye protection. One of my friends learned this the hard way while working on these speakers. Luckily nothing really bad happened but even havening to wash out your eyes for 10-15 minutes isn't a fun thing to do.
3. If your working with very loud and noisy tools wear ear protection. It only takes 30 minutes of 110dB noise levels to cause permanent ear damage and that would just ruin the entire point of this project.
4. Finally be careful around all the electricity. With power tools, soldering, amps, and so forth there are a lot of places where you could hurt yourself so always double check to make sure no electrical wires or outlets are within arms reach.

Ok now that that is out of the way, lets get started!

Ok so its time to start the construction of your speakers. Here is where you have a lot of freedom on how things are done. With construction there are a lot of things that can be done out of order so don't take this section of the guide as a set way of doing things its just the way that we did it.

So for the construction portion there are several steps along the way.

1. Crossovers
2. Box Construction
3. Sealing

Ok so we started off by building all of the crossovers for the speakers. Like I said earlier with the crossover boards that you purchase there will be a diagram that will show where the parts should go. You will also need a good background on soldering. I don't suggest that you do this as your first soldering job because once these speakers are built it will be very difficult to open them back up once the crossovers are installed. And a poor soldering job could require work to be done on them a year or so down the road. But if you do everything right the solder joints should last longer than the components that are mounted on the crossovers.

Crossover Construction

Ok, so you have your capacitors, inductors, wires, and crossover boards. Now its time to construct one of the most important parts of your speakers. After all, you don't want the same sounds that go to your woofers to go to your tweeters.

So as stated earlier we used the following components:

[Capacitors](#)

[Inductors](#)

[Crossover Boards](#)

As stated earlier a component diagram is included with the crossover boards so you will need to refer to that when placing your components on the board. When you place your components on the board you need to make sure of a few things.

1. Layout the components on the board before you start soldering so you know where everything will go and how it will all fit together.
2. Glue all your components to the board before you solder them on this will ensure that they won't move around and possibly break your solder joints later on.
3. Mount your inductors so that they can not interfere with each other. Mount one standing up so that it looks like a wheel on a car and mount the other laying down. This will prevent any interference.

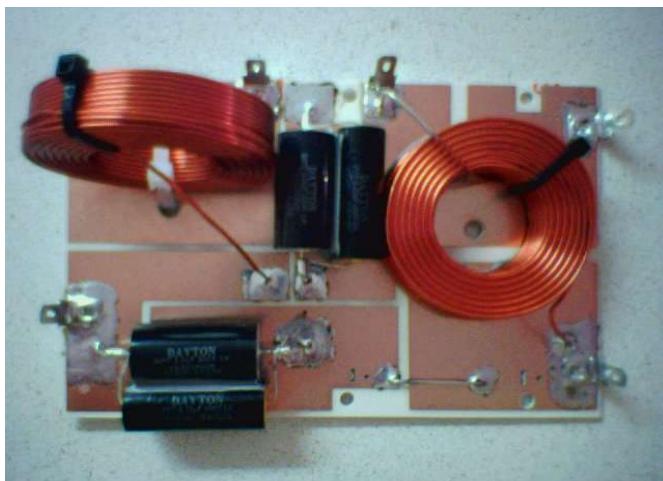
Make sure your solder points are very strong and have enough surface contact with the board and your components. To aid in this I've always found it useful to "tin" the wires coming off the components(Thanks Andrew). In other words wrap some solder around them and then melt the solder to the wire with your soldering iron. This will help to improve the contact with the board and establish a much stronger soldering joint.

When your crossover boards are completed they should look similar to these examples.

Crossover with parts laid out before solder:



Crossover with parts soldered on:



Finally don't forget any "jumper" wires that are called for in the diagram. You'll notice on my crossover there is a jumper wire on the bottom right. This will allow the second portion of the crossover to have audio, which if you haven't guessed is important.

At this stage I would recommend testing out your crossovers to verify they are functioning properly. I went ahead and hooked them up to a Sony receiver I had that wasn't being used. This will give you a small taste of what your speakers will sound like.



Just to give you a heads up your woofers will not perform well in a setup like this because the waves coming from the front and back will cancel each other out. But it will at least tell you if the crossovers are functioning which is the point of this test.

Box Construction

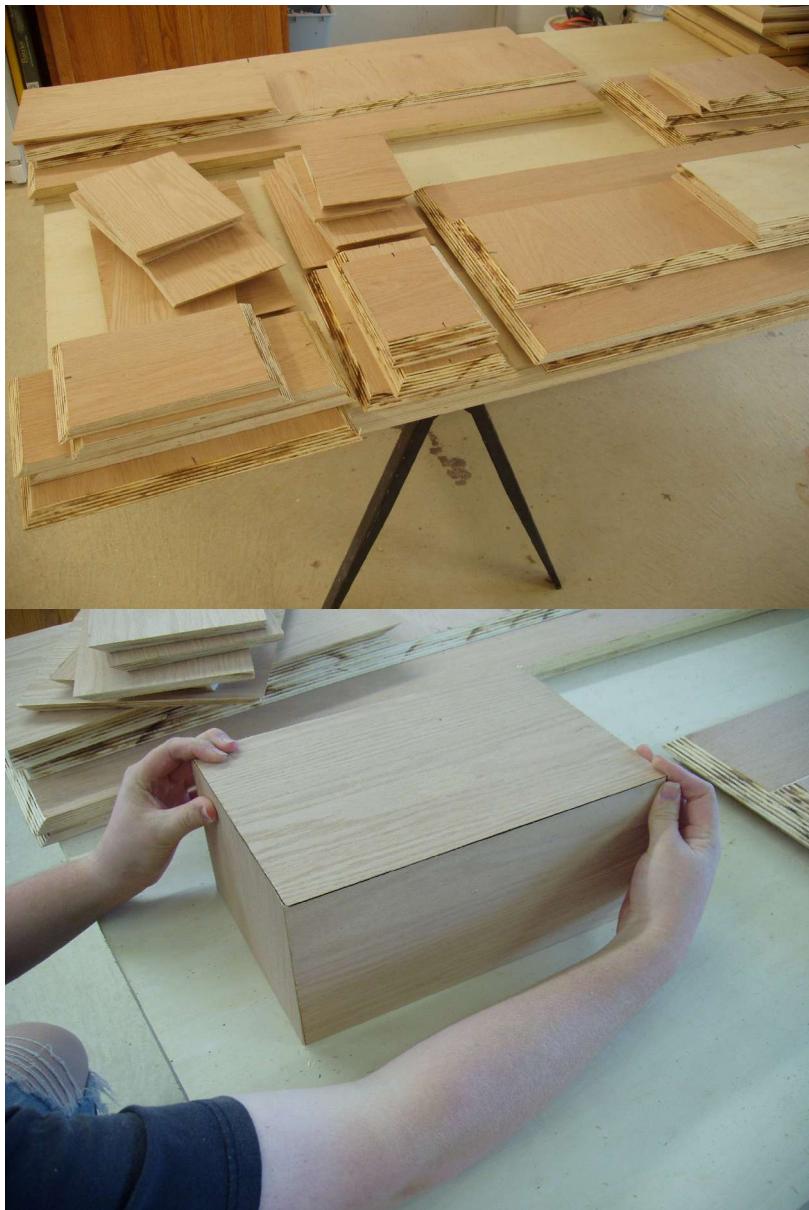
Ok so you've got the crossovers finished and have gotten a taste of what your speakers will sound like. Now its time to give those drivers a home.

Alright with the box construction there is a lot of freedom here. You can go with simple rectangular box designs or if you've got the skills and equipment you can make them as complicated as you want to provided that the internal volume stays the same and your design doesn't cause massive reverberation problems. For this guide however we are going to stick to the simpler of the choices.

First we'll start with a description of how John's speakers were built. John and Andrew decided to go with the simplest design to avoid any unnecessary complexity. They built simple boxes with just straight cuts out of a few 4'x8' sheets of birch plywood. This is the easiest way to build speaker boxes and is an excellent place to start if your building your first set. Here is an example shot of what John's speaker boxes looked like when they finished.



With my design we decided to try a slightly different approach. With my boxes we cut all the interior edges at 45 degrees to allow the outside veneer to cover the entire outside portion of the speakers. This allowed them to look a little more professional in the end but we paid for that by having a much more complex build. Here is a shot of the wood after we did the 45 degree cuts and a shot of how the boxes fit together.



As you can see this allows the wood grain to cover the entire box but because of the 45 degree cuts it made construction a little more difficult because we constantly had to worry about screws and nails not going in properly. But the hard work paid off later and you will get to see the results, but first we need to get your build going.

So with the box construction you should already have a written down plan of the shape of your boxes and the dimensions. With this information you should use a sheet of graph paper and map out the cuts for your wood so that you can use as much of the wood as possible. But do not forget to include space for the saw blade otherwise your cuts will be slightly off.

After you have your cuts planned out on a sheet of paper you will be able to move through the cuts faster because you'll always know which cut is next. And I would recommend getting all your cuts finished at once so that you don't have to go back later to finish up. This helps by keeping your project moving forward and allows you to move on to the next step without having to worry about going back to a previous step and possibly causing confusion later on.

When you have all your cuts finished its important to separate the boxes out and label the pieces so that you don't get them confused later on. This will also allow you to concentrate on one speaker at a time when you start putting the boxes together.

Alright so you have all 6 sides for each speaker cut out, now its time to get the front and rear of each speaker prepared before you assemble the boxes. It's time to pull out the router. Now at this stage its very important to have accurate measurements of the drivers, port tubes, and terminals. Because at this stage you are going to be cutting out the holes.

For this part you are going to need a few accessories for your router.

- 1.Circle Jig
- 2.Rabbeting Bit (a variable one is most useful)
- 3.Straight Bit

I'm not going to include instructions for your router, I'm assuming that you have a better understanding of how your router works than I do.

At this stage you will use the router with the circle jig and straight bit to cut out perfect circles for your drivers, ports, and terminals. And then use the rabbeting bit to cut out a counter sink for your drivers so that when they are mounted on your speaker boxes they are flush. However, you want to avoid counter sinking them too low as the lip of wood surrounding the drivers can affect the sound waves coming out of the drivers.

Your port tubes and terminals can be sunk in as well or you can just mount them straight onto the rear surface. Either way it will not effect the outcome of the sound.

Here are some photo examples of the cutouts as well as some shots of us working on the driver holes for my towers.



Alright so the box faces are prepared for your drivers, port tubes, and terminals. Now its time to get the boxes put together. Here it is definitely a good idea to concentrate on one speaker box at a time.

The best way we found to put the boxes together is to use a combination of finishing nails, wood glue, and screws. When you start to put the boxes together it is best to put wood glue in the seams and then hold the pieces together using finishing nails from a nail gun. The wood glue serves two purposes it helps to strengthen the box and it also helps to provide a sealant on the seams. This combination is actually adequate for most book shelf size speakers. But for larger speakers like center channels and towers it is a good idea to provide additional strength with wood screws. You can see that we used wood screws on the towers in the image on the previous page. Don't worry about the screws being visible that is what the wood filler and finishing stages are for.



Sealing Your Boxes

Ok so now you have several boxes built, so its time to mount everything and test these babies out right? Unfortunately not yet, there are still several steps we need to complete before we can mount everything. First we need to seal the interior of the boxes up. Why you ask? Well speakers are able to produce their sound and provide lower frequencies by producing sound waves. But the inherent problem with drivers is that they produce two opposite sound waves and these work to cancel each other out. So we mount the drivers in a box to prevent one set of the sound waves from canceling out the other. This also has the added benefit of creating the hollow bass feel that you get with ported speakers. But I still haven't answered the question as to why we seal the inside of the boxes. Well the answer is simple. If the boxes weren't sealed then the opposite sound wave inside the box would escape through the cracks and openings and would cancel out portions of the sound, thus causing distortion and decreased performance from your speakers.

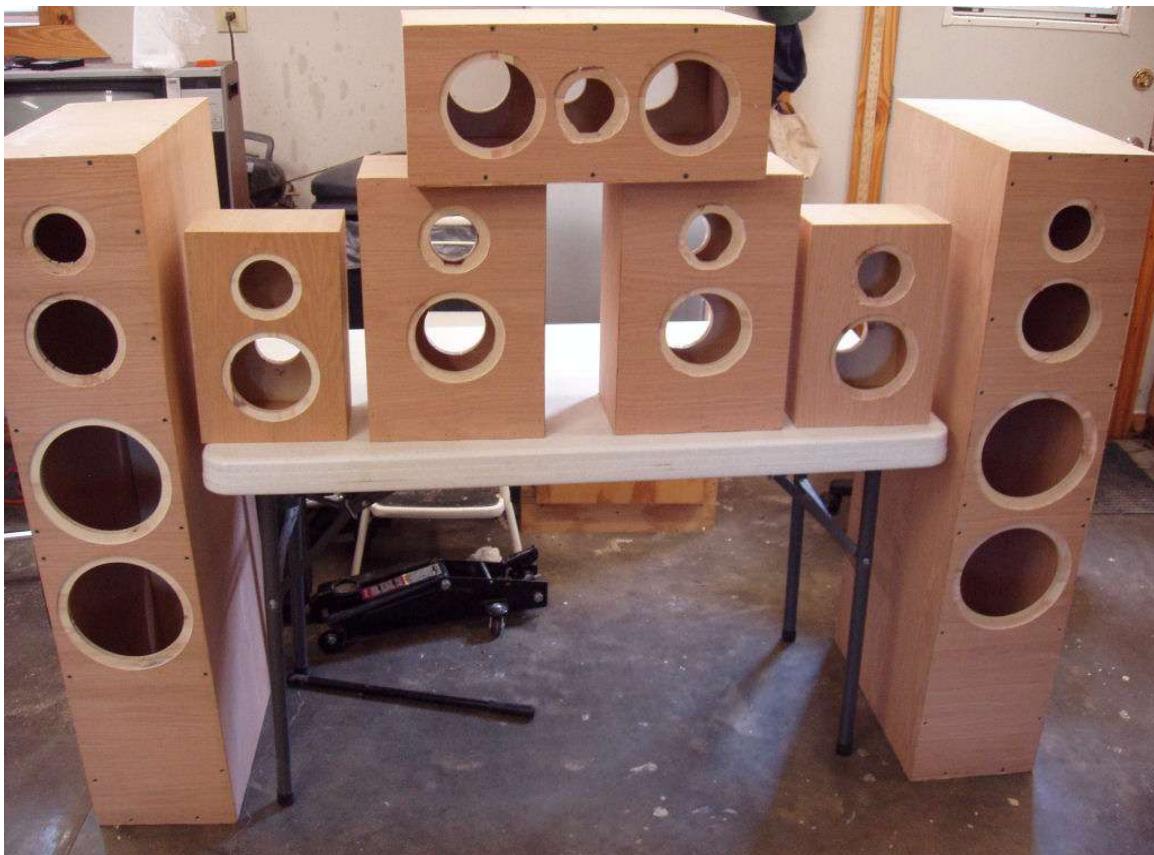
So how do you go about sealing the speakers? The best way is to use silicone gel along all interior seams. I'd recommend picking up several caulking gun inserts of silicone gel along with a caulking gun. Doing it this way allows for easier application and a steady stream of silicone to provide the best seal. When you are sealing the boxes up you want about a 1/4" layer of silicone along all interior seams. Be sure to let it dry and set for several hours and then

double check the seams to make sure none of the gel has moved significantly and created openings. This is one of the most important aspects to your speakers so be sure to devote some time to making sure that they are properly sealed.

If you experience any distortion, whistling noises, or vibration then the box has not been sealed properly and you will need to reapply sealant inside the box. The easiest way to pinpoint locations of leaks is to turn the volume up and you should be able to feel the air coming out while sound is being produced. It would feel similar to a hole in a tire except this will fade in and out with sound volumes. Be sure to locate these problems as quickly as possible otherwise it will be much more difficult to fix the problems once the speaker has been allowed to set.

Ok, so at this stage you should have assembled boxes with driver, port tubes, and terminal holes all cut out and ready to go. And the boxes should be held together tightly by a combination of finishing nails, wood glue, and/or wood screws for the larger speakers. Finally, all the boxes should be well sealed with silicone gel to prevent any sound waves from escaping and causing sound distortion.

So you should be looking at boxes that look very similar to these.



Now I know your getting anxious to try out your speakers but there are still a few steps to go before they are ready. Here is a prime example of where you could do things in a different order. Here we went ahead and mounted the crossovers and got all the wires and internal sound dampening ready to go. But for this guide we are going to go ahead and continue with the finishing work. We'll cover the rest in the Installation chapter.

Step

5

Finishing

Ok, so now it's time to get your boxes looking like the professional speakers you've been dreaming them up to be this whole project.

The finishing work, as any person that has done wood working can tell you, is the easiest work to perform but the hardest to master. It requires a lot of dedication and patience, you can't just rush through it otherwise you'll end up with sloppy results.

At this stage it is important to do some preparatory work. You should have several pieces of left over wood from your cuts in the fourth step. You are going to use these left over pieces to test out various finishes so that you can find one that works well with your wood and that you like. Finishes have a bad habit of being very different than you think they will so its important to test them out on your material. I'd suggest taking some samples of the wood to a paint or hardware store to get some opinions from people who deal with stains every day. You'd be surprised by some of their recommendations and how well they turn out. But also don't forget that the internet is a valuable resource, there are several forums online that have a lot of information and photos on stains.

So once you have several test selections its time to find out how your wood is going to react. Be sure to follow the same steps in your tests as you will perform on the actual speakers otherwise there will be some deviation in how the stain appears.

I'd also like to recommend using various different clear coats with each stain to see how it looks with the different sheen levels (satin, semi-gloss, and gloss). Once you have chosen the stain and clear coat you want to use its time to perform the same steps on your speaker boxes. Remember don't rush through this. Be thorough and patient, it will all pay off in the end.

You will want to follow these steps when applying your finish:

1. Apply wood filler to all holes, gaps, and seams.
Make sure to fill them up well otherwise the filler will just fall out during sanding. Allow the filler to fully dry before sanding.
2. For your first sanding use a heavy grit (80 or so) sand paper to get rid of all the blemishes and problem spots on your wood.
3. Apply more wood filler to fill in any holes that reappeared during sanding.
4. Now sand with a medium grit sand paper (150 or so) to help smooth out the surface and get rid of any further detailed blemishes.
5. Apply any further wood filler as necessary. Be sure that your entire surface is flat and without any holes or gaps.
6. Perform the final sanding with a fine grit paper (220 or higher) this will help to make the surface very smooth for the stain and clear coat.
7. Once you are satisfied with the surface of your boxes, using a tack cloth, clean the surfaces of your speakers. Once clean, apply a single heavy coat of your selected stain and allow it to fully dry

(anywhere from 8-24 hours depending on climate and elevation).

8. Apply as many additional coats of stain as you see fit. Allow each coat to dry fully before applying the next coat and be sure to clean the surface with a tack cloth between each coat.
9. Once you are satisfied with the stain its time to apply the clear coat. Here you will repeat the same steps as with the stain. Apply a first heavy coat and allow it to dry, once dry use steel wool* to make the surface abrasive enough for further coats to stick properly. Then apply additional coats as needed.

Keep in mind as you are working on your stains that often the stain itself will look odd until the clear coat is applied. So when testing out your stains don't be discouraged if the stain looks a little odd.

*The steel wool needs to be '00' or '000' steel wool so that it doesn't scratch the lower surfaces. This rating is similar to the grain rating for sandpaper and refers to the coarseness of the steel wool. You should be able to find this at any hardware store.

Here is a picture of my speakers with just the stain on them:



As you can see they don't look completely black.
So lets take a brief look at what all we have
accomplished so far...

We've designed our speakers using a combination of computer programs, personal taste, and a little bit of good old fashioned brain power. We've gathered all the necessary materials to get the job done, including all the tools and finishing products. Once all of that was gathered we planned out the build and made sure we had accurate measurements for all the boxes as well as measurements for all the holes. We sketched out the plans so that we could refer to them later and kept a journal of any and all problems or changes made along the way. Then all the design and planning was put to good use. We started

building the speaker boxes and crossovers, as well as making sure the boxes are well sealed.

Finally we tested out several different finishing options and made a selection for our speakers. Once the selection was made we filled in any holes or gaps in the boxes with wood filler and then sanded down the sides to make them nice and smooth. Once the boxes were prepared we stained them and covered them with the protective clear coat.

So now you are looking at several very good looking boxes, but they are missing something???

Step

6

Installation

That's right it is time to install all the components! Its the moment you have been anticipating during this entire build.

So you've got your boxes, drivers, crossovers, ports, and dampening material all ready to go, right?

Not quite. Before you jump head long into installation you need to double check all your components and make sure the internal wires are cut to appropriate lengths. Always remember that finding a mistake now is easier to fix than finding it later.

Ok, so onto the installation.

With the installation we found the easiest way to do the speakers is to mount the crossover first, then apply the dampening materials, then mount the drivers, and finally mount the vents and terminals. So lets go into detail on each of these items.

I'd like to apologize at this stage. We were so involved with getting the speakers finished we forgot to take pictures and most of the ones that we did get were very rushed. I'll update this guide with pictures when we finish up the rear 7 speakers since we still need to install the components in them.

Crossover Installation

The installation of the crossover is a very important aspect as you need to make sure it is mounted close enough that the cables stay fairly short (the longer they are the more likely it is for sound loss or distortion), but you also have to make sure that none of the other components are going to be obstructed by it so you might need to test fit several of the components to find a good location to put the crossover.

The first step for your crossover is to solder your speaker wires to their appropriate terminals on the crossover board and make sure the wires are capable of reaching your speakers and terminal from the desired mounting location. Remember that a little slack isn't going to hurt anything and will help you down the road if you ever needed to open the speakers up. Once you have a location within your box grab your silicone gel and apply a heavy application of it to the underside of the crossover. This servers two purposes, first it prevents any form of short from happening on the underside of your crossover and second when it dries it will provide a nice glue structure to help hold the crossover in place. Once you have it applied to the box with silicone gel screw it down using very small screws so that they don't puncture the exterior of your boxes. The crossover boards that we used had screw holes already on them but you can make your own if your crossover board doesn't have them, just be sure to seal off the hole so that no short is created.

Dampening Material

The dampening material is one of the easiest parts of installation. I suggest getting a staple gun to mount the dampening material with as that seems to be the easiest way. Like stated before there are a lot of choices when it comes to dampening material but keep in mind that this is only to help cancel out standing waves and does not need to be very large nor does it need to be very expensive. As stated previously we just used sheets of pillow stuffing from Hobby Lobby.

For your speakers you're going to want at least a square foot or two of material on each side for large tower style speakers. For smaller bookshelf speakers cover both of the sides and rear leaving holes for your vent and terminal.

As stated previously we were a little over zealous in completing the builds so no pictures to demonstrate but I think the concept is pretty easy to understand.

Driver Installation

This is where installation becomes tricky. In order to install the drivers you need to solder the wires onto the driver's terminals before mounting them in your boxes. This is another reason for having some available slack in your cables coming off your crossover.

Once you have your cables soldered onto their appropriate terminals (double and triple check this there is nothing worse than backwards cables or a tweeter line going into a woofer and vice versa to have to fix after everything is mounted) its time to mount the drivers onto the speaker boxes. When mounting the drivers you want to apply a layer of silicone gel around the lip of the driver to provide a good seal for the speaker. Once sealed make sure it is properly screwed down, its important that the driver isn't able to move around otherwise your speaker will develop a vibration.

Once all of the drivers are mounted be sure to clear off any silicone gel residue as it can cause problems for your finish.

On a side note, in order for my screws to match the speakers I applied a flat black primer to the screw heads so that they would not stand out.

Ports and Terminals

This is probably the single easiest step in this guide. To mount the ports make sure they are cut to the appropriate length (discusses in the design stage). And the length is a measure of the entire port so be careful when your measuring them although if it is slightly off it won't cause any noticeable distortion. Then mount the port onto the appropriate hole and screw it down, don't forget to properly seal the vent with silicone gel.

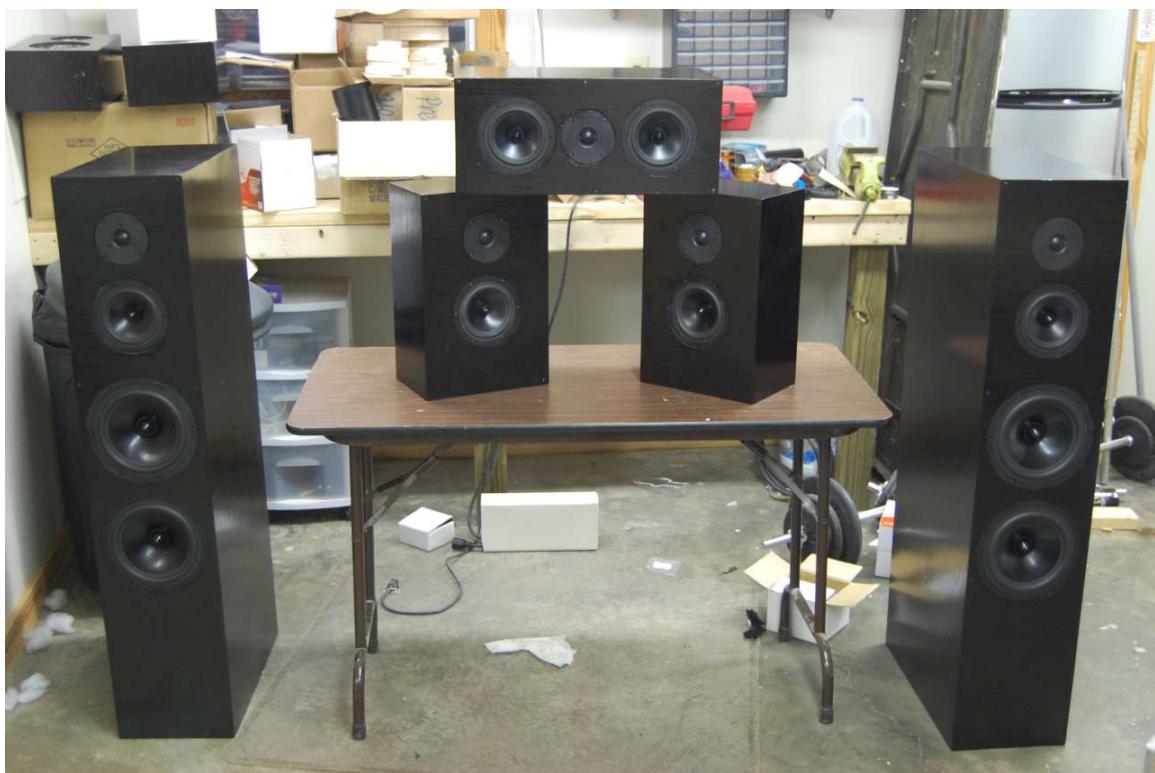
Once the port is mounted its time for the final step in the installation process, mounting the terminal. Here it will be necessary to pull out the soldering iron again to solder the terminal cables from the crossover, without these no sound would be produced. Once the cables are properly soldered mount the terminal in the same way you did the port with silicone gel and screws.



Allow the silicone gel and wood glue to set for at least 24-48 hours before regular use. Testing them out is fine but you don't want to cause leaks just because you tested your speaker a little too much

Congratulations!!!

You've just completed building your first (or maybe not) set of speakers! Stand back and admire your handy-work, and a job well done.



Step

7

Testing

Alright so now you have a set of speakers and don't they look beautiful. But that is not the reason your built them, is it?

That's right its time to get those bad boys hooked up and see what they can really do.

Obviously this stage doesn't require much instruction but I am going to provide some personal guidance.

First, make sure you can really test them out the first time. Test out the speakers your choose and find the maximum sound levels for your equipment. In my case we could crank them but my speakers were so power hungry at those levels it would cause my receiver to shut off. So I can't exceed my speakers capabilities but that doesn't mean you won't be able too. So don't be afraid to test it out just be careful for the first few tests until you have a feel for them. Otherwise you might end up with blown drivers and then all your work would be for nothing.

Second, find a receiver or DVD/computer program that can analyze your speaker and tweak the outputs so that they match up with your room. Just because your speakers sound damn good doesn't mean they can't sound better with a little tweaking.

Third, have some fun! Pick out some of your favorite music, movies, etc. and just go with it. Make sure they can handle what you are wanting to use them for. I'd highly suggest picking up some of the surround sound encoded music like DTS and Super

Audio CDs. They really will show you just how good your speaker system is.

Finally, NEVER match up a set of well built speakers with a cheap receiver you picked up at Best Buy, find something in your budget range that provides the best sound quality for the price. I'd highly suggest reading online reviews and forums to find out what will best fit your budget. Its better to have a really good sound source with cheap speakers than a cheap sound source with good speakers, but its best when there is an even balance.



Well I hope you enjoyed my guide/project and I hope that you have learned something in the process. This really isn't as hard as many would believe. Yes it does take work and dedication and some experience with a soldering iron and wood working but it isn't out of your reach. Always remember that you'll never know if you can do it until you try.

Thanks for taking interest in my speakers and a special thanks to my friends John and Andrew, without your knowledge and expertise this project would never have come to fruition. Thanks to Alex for helping with taking pictures, otherwise this guide would be a lot more boring. And a special thanks to John's grandparents who generously allowed the use of their tools and put up with all my speaker mess for several months while trying to fit in time to work on them during the school year.

As was stated earlier a list of good information sources is on the following page.

RESOURCES

Crossovers

[Choosing a Crossover Frequency](#)

[How Stuff Works](#)

[Crossovers – Wikipedia](#)

Speakers in General

With drivers its going to be in your best interest to do a lot of research and ask around. If you can find some place that will demonstrate them all the better.

[Parts Express](#) – Good information about several aspects

[Audioholics](#) – A great source for everything audio

[Audiogon](#) – Great info on components

Understanding Speakers

[Loudspeakers](#) – Wikipedia

[Speakers](#) - "How Stuff Works"

Part Retailers

[Parts Express](#)

[Madisound](#)

[MCM Electronics](#)

[Speaker City](#)

[Monoprice](#)

That should get you pointed in the right direction. But don't throw out the help that can be found on forums on the internet. Sometimes its just best to talk to someone that has done it before.

Stay tuned in the coming months for a component selection guide, as well as adding a troubleshooting guide right here. So until then, enjoy your speakers!!!