Design Purpose:

Picture 1

The Purpose of my speakers is for television/home theater speakers. They need to be able to handle fairly low SPLs of around 30-50 for mornings and as background music, as well as higher SPLs around 70-85 for movies and days I am pissed off of, due to crest factor my drivers need to be able to produce 90-105 dB peak. Because they are for music and movie play back they need to have a pretty decent frequency response, on the low end it should start between 20 Hz and 40 Hz, and should go to at least 20 kHz on the high end. These numbers were obtained through listening to music in logic while adjusting a high pass filter.

In order to accomplish these goals I am building a three way system, that will be incorporated into towers, that will be approximately four feet tall. It will be a subwoofer box with a two way system extending up from it. The two way system will be an open baffle extension with wings. The front of the subwoofer box will extend up and the midrange woofer and tweeter will be set flush mounted to that, and it will have side panels for protection of the drivers that will be two to three inches wide, very similar to the picture 1[1]. I decided on a tower speaker because that way I don't have to build or buy speaker stands. The footprint of the speaker wouldn't change much between a tower speaker and a bookshelf speaker, so I figured why not just make it a tower

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[1] *av123,* http://www.av123.com//index.php?page=shop.product_details&flypage=shop.flypage&product_id=266&category_id=21&manufacturer_id=0&option=com_virtuemart&Itemid=37 (accessed September 23, 2009)

speaker and that way I don't have to build a speaker stand or find a place to put the speakers so that they are at the same level with each other. I am planning on staining them a deep red color then using several coats of clear polyurethane, probably a semigloss, to give the speakers some protection.

Drivers:

Tweeter:

ETON 25SD-1[2]

8 Ω

1" diameter

90 dB sensitivity

Mid Range:

Creative Sound Solutions FR125SR 4.5"[3]

8 Ω

Fs 70 Hz

85.5 dB sensitivity

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[2] *Eton,* http://www.etongmbh.de/en/products/home-hifi/tweeters/25-sd-1/1/pid/160/ (Accessed September 20, 2009)
[3] *Creative Sound Solutions*, http://www.creativesound.ca/details.php?model=FR125SR (accessed September 24, 2009)

Subwoofer:

Creative Sound Solutions SDX10 10”[4]

4 Ω

Fs 26 Hz

85 dB sensitivity

Tweeter:

I chose the ETON tweeter because of its flat frequency response from below 1 kHz to above 15 kHz as seen in figure 1. It has a sensitivity of 90 dB which is more than enough for what I need it to do. With that sensitivity and the 80 watts per channel amp in my home theater receiver I should be able to hit 105 dB. Because in order to hit 105 dB with this tweeter you need at least 32 watts[5]. I looked in to LCY

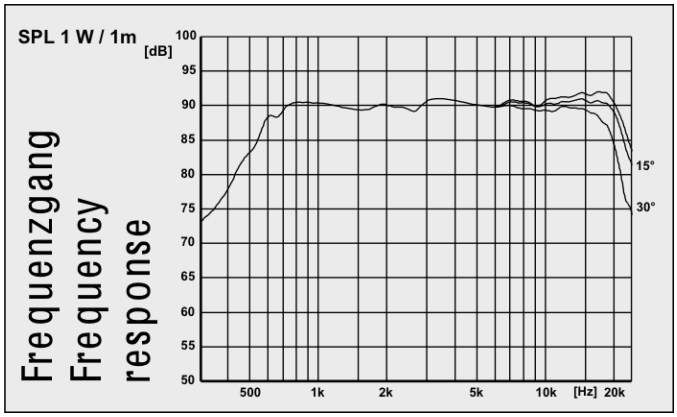

Figure 1: Eton 25SD

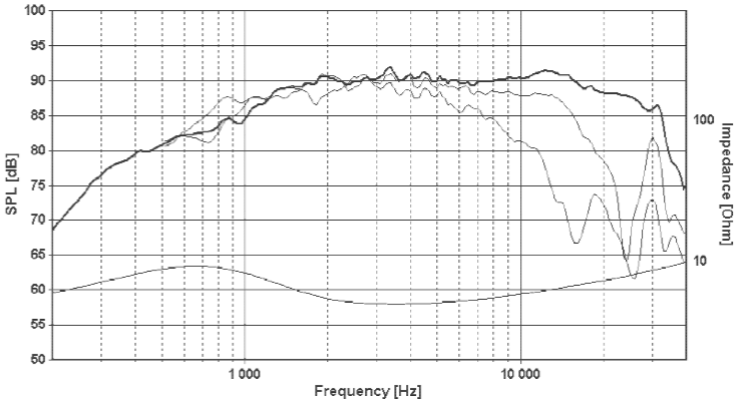

Figure 2: Seas H1189

[4] *Creative Sound Solutions,* http://www.creativesound.ca/details.php?model=SDX10 (accessed September 29, 2009)
[5] *Plummer, SPL Cheat Sheet,* (January 11, 2010)

ribbon tweeters because their technology is pretty cool, however their less expensive tweeters don't have quite the frequency response that the price should dictate. I also looked into a few different Tangband tweeters but they weren't rated to handle much power. Figure 2[6] is the frequency response graph for a Seas H1189 soft dome tweeter. As you can see the off axis response drops off rapidly, as compared to the Eton tweeter. Figure 3[7] shows the frequency response for a Vifa D27TG soft dome tweeter and well it has a pretty flat frequency response like the Seas tweeter its off axis response is pretty awful.

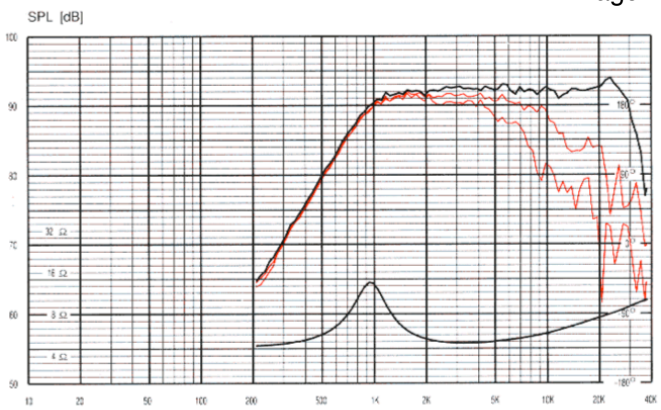

Figure 3: Vifa D27TG

Midrange:

I looked into quite a few different mid range drivers,

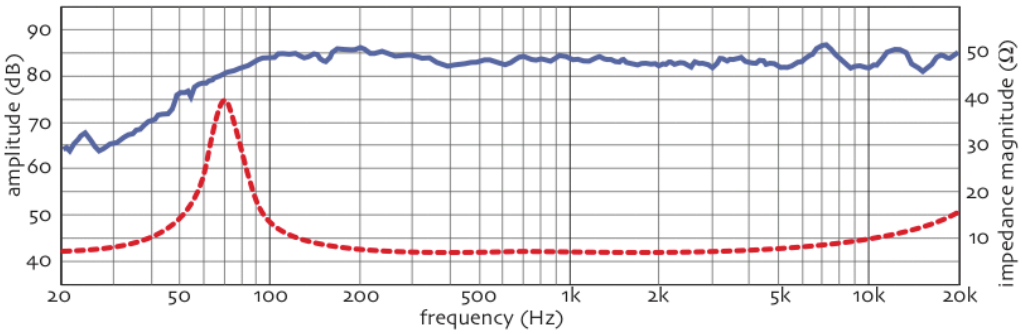

Figure 4: CSS FR125SR

but I choose to look more into full range drivers because they give you a better frequency response out of a smaller driver. Full range drivers give you more options for crossover points both with the tweeter and the subwoofer. I ruled out anything smaller

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[6] *Seas The Art Of Sound Perfection*, http://www.seas.no/index.php?option=com_content&task=view&id=90&Itemid=114 (accessed September 24, 2009)
[7] *Tymphany, The Sound of Modern Design,* http://www.tymphany.com/d27tg-05-06 (accessed Febuary 20, 2010)

than 4 inches because they just won't have the bass response required. I looked into drivers between 4 and 8 inches, and there are a lot of really nice full range drivers out there, but for the price the Creative Sound Solutions FR125SR which is a four and a half inch full range woofer[8] show above in figure 4 is by far the best that I found in my research. It has a fairly flat frequency response from about one hundred hertz to about six kilohertz. Which gives me a large range in which to place my crossovers. It also has a sensitivity of 85 dB which is a bit low for my SPL needs, but since you gain 3 dB every time you double the power[9] I only need 64 watts, which is less than the 80 watts my receiver puts out. Figure 5[10] and 6[11] are Fostex full range drivers and as you can see they don't have the same response as the CSS does.

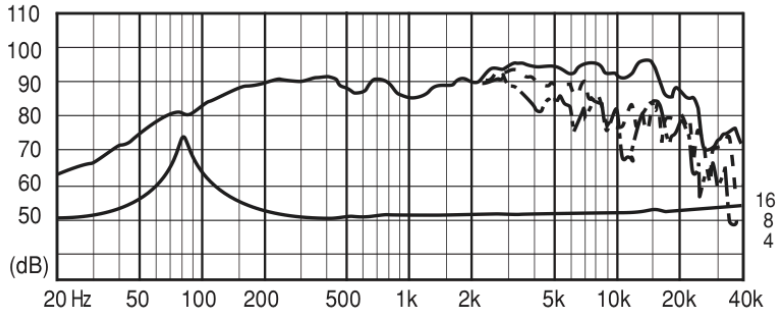

Figure 5: Fostex FE108E

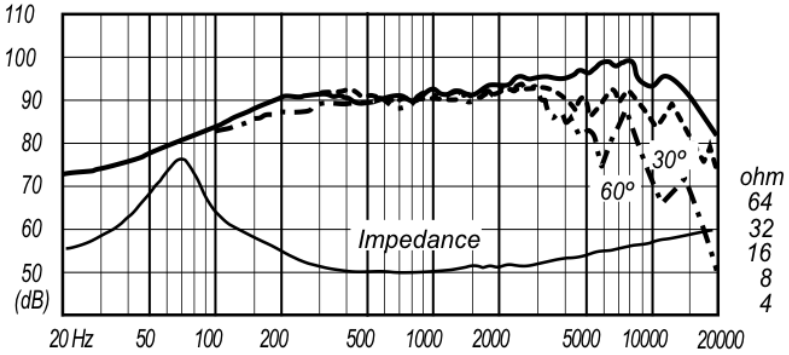

Figure 6: Fostex FF125K

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[8] *Creative Sound Solutions*, http://www.creativesound.ca/details.php?model=FR125SR (accessed September 24, 2009)
[9] *Plummer, SPL Cheat Sheet,* (January 11, 2010)
[10] *Fostex Speaker Components,* http://www.fostexinternational.com/docs/speaker_comp/FE-E-Sigma-Series.shtml (Accessed February 20, 2010)
[11] *Fostex Speaker Components,* http://www.fostexinternational.com/docs/speaker_comp/FF-Series.shtml (Accessed February 20, 2010)

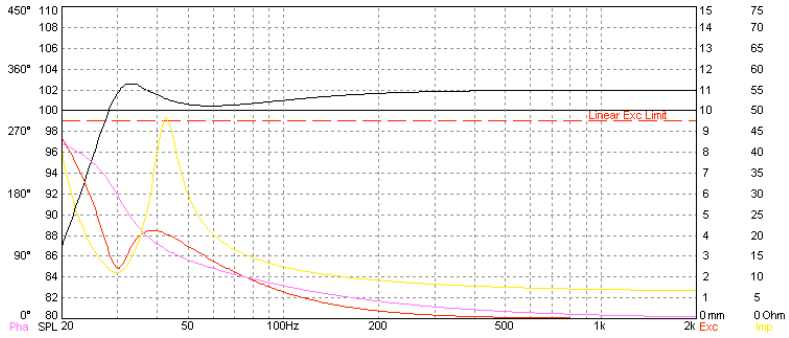

Figure 7: Tangband WT-1427G

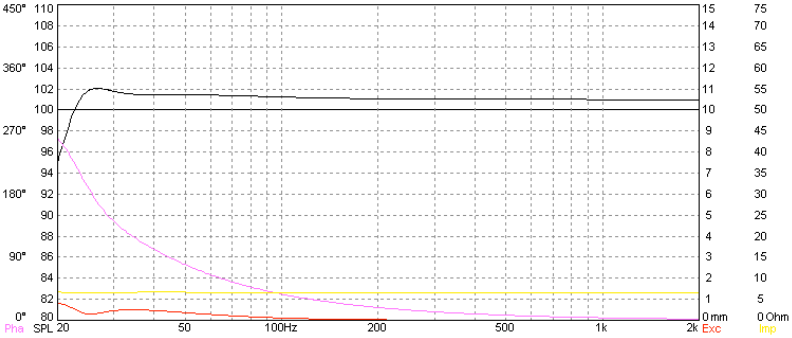

Figure 8: HiVi SP10

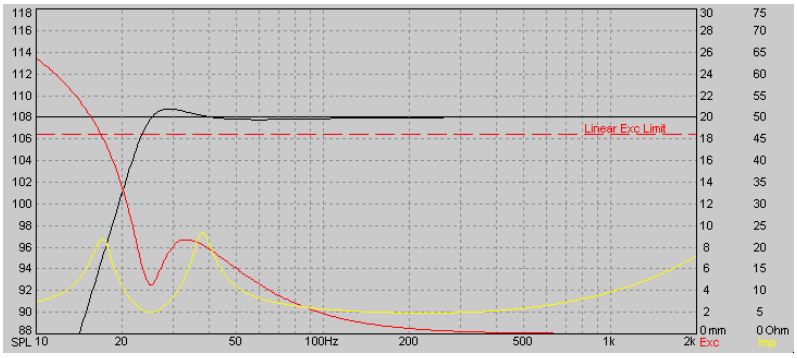

Figure 9: CSS SDX10

Subwoofer:

For the subwoofer I decided to look into 10 inch woofers because they have excellent bass response with out the cost of a 12 or 15 inch woofer. I looked into many woofers, including the Tangband WT-1427G had a decent extended shelf response with an f3 below 30 Hz, see figure 7. The HiVi SP10 on the other hand had a very smooth response down to its f3 which is around 21 or 22 Hz, see figure 8, but it costs almost $200. I ended up choosing to go with a Creative Sound Solutions SDX10 which is a subduction woofer specifically designed to work well in small enclosures. With a 3 cubic foot vented enclosure it has an f3 of about 22 or 23 Hz. As you can see in figure 9 it has a much better response than the Tangband or HiVi woofers. The red line in figure 9 is the excursion line for the driver, you can see that it gets pretty high and but as you can see its linear excursion limit is also quite high just above 18 mm. this graph is simulating putting 200 watts through this woofer and as you can see it handles that power very well

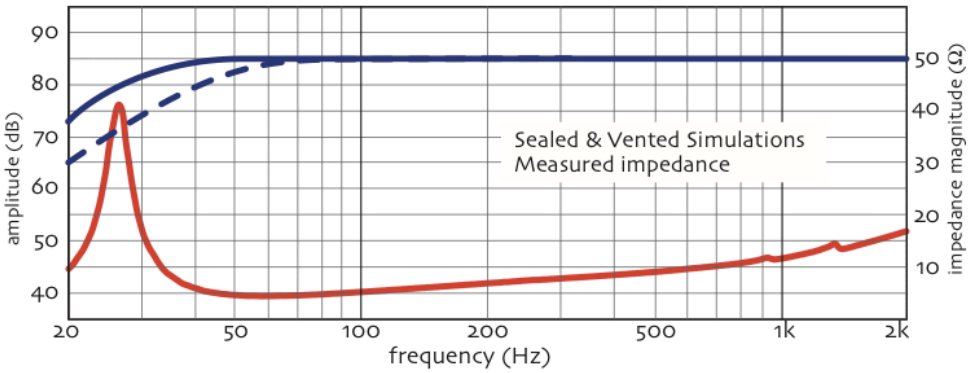

Figure 10

even down below 20 Hz. According to the model with 200 watts powering it the model shows it can hit around 108 dB which is more than than the 105 I need. Figure 10[12] shows the factory modeled response of the SDX10, as you can see it is quite similar to figure 9 so it is hard to tell how accurate it actually is. But as you compare it to the model they both end up smooth to over 300 Hz so if you combine this woofer with the FR125SR midrange driver I have chosen it gives me plenty of room for the crossover. Especially to avoid the breakup mode of the SDX10 because it is currently unknown until I can test it for myself.

Enclosure:

I chose to build an open baffle speaker because it is different and not many people do it. It will give an open sound because it is a dipole speaker, meaning it will put out as much sound in front as it does behind. Which gives you greater image depth and width but you lose much of your bass[13], coupling them with two bass reflex ten inch subwoofers will address the bass aspect. Since I am using them in small apartments a large image will be useful so the sound won't change much if you walk into the adjoining room or listen to music while doing dishes. The idea is that you won't hear a drastic change in

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[12] *Creative Sound Solutions*, http://www.creativesound.ca/details.php?model=SDX10 (accessed September 24, 2009)
[13] *Decware Audiophile Speaker Designs,* http://www.decware.com/paper92.htm (accessed September 30, 2009)

the sound as you walk from one side of the room to the other.

Because I am going with a dipole design that adds in some extra complications that need to be accounted for. For example because it is a dipole system it creates a first oder highpass filter at a frequency dependent on the size of your front baffle. To find this frequency we have this equation $F_D=565/W_D$[14] where W_D is the width of your baffle in feet. For my speakers I am planning on a front baffle of about 21 3/4 inches which when you plug that into the equation gives you a F_D of 311.72 Hz, which means that the midrange will start a first order rolloff at that point. Which I am going to use to my advantage so I don't have to make a low rolloff for my midrange. I plan on using this first order rolloff in combination with the baffle step and woofer crossover to help create a smooth flat frequency response.

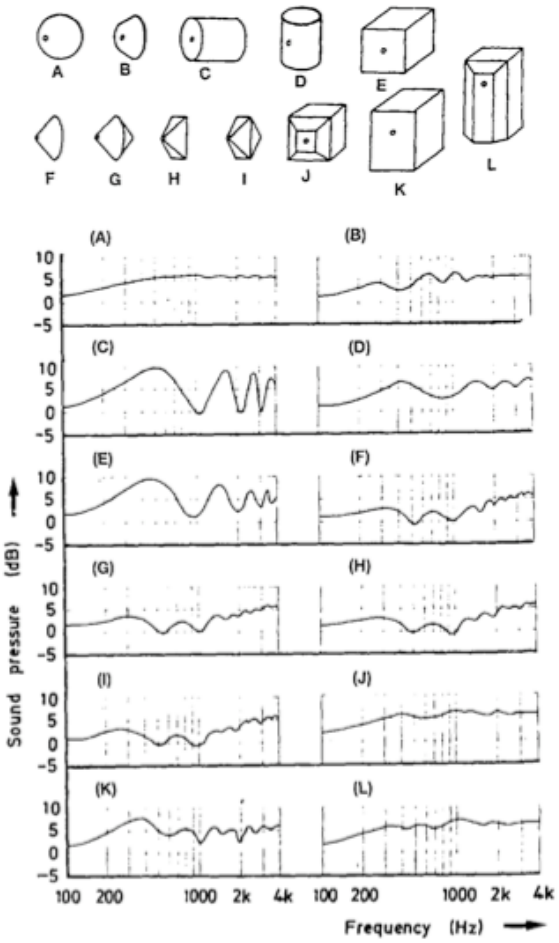


Figure 9

Baffle step is a phenomenon that causes a 3 dB drop at a frequency that is determined by the width of you baffle the equation is $f(3)=380/W(B)$[15] where W(B) is the width of you baffle in feet. For my speakers the baffle will be about 21 3/4 inches which gives me a f(3) of 209.65 Hz. Which is why I am having a subwoofer. The subwoofer

[14] *Murphy Introduction to Loudspeaker Design,* pg. 21 Table 1
[15] *Murphy Introduction to Loudspeaker Design,* pg. 73

cabinet will have an internal volume of 3 cubic feet, which gives it an f3 of around 22 or 23 Hz. The vent will be tuned to about 25 Hz, it will consist of one vent pointing out the top.

Another thing to consider dipole or not is diffraction effects and baffle step. Diffraction is a large problem in the higher frequencies, as you can see from figure 9[16] different shapes have different diffraction losses. As you can see the best Shape for diffraction loss is a spherical enclosure, I however don't have the skills to make a spherical enclosure so I went with a rectangular enclosure (k). As you can see from figure 9 it causes some pretty serious diffraction effects, the way I plan to counter act this is to use a router and round the edges of my baffle.

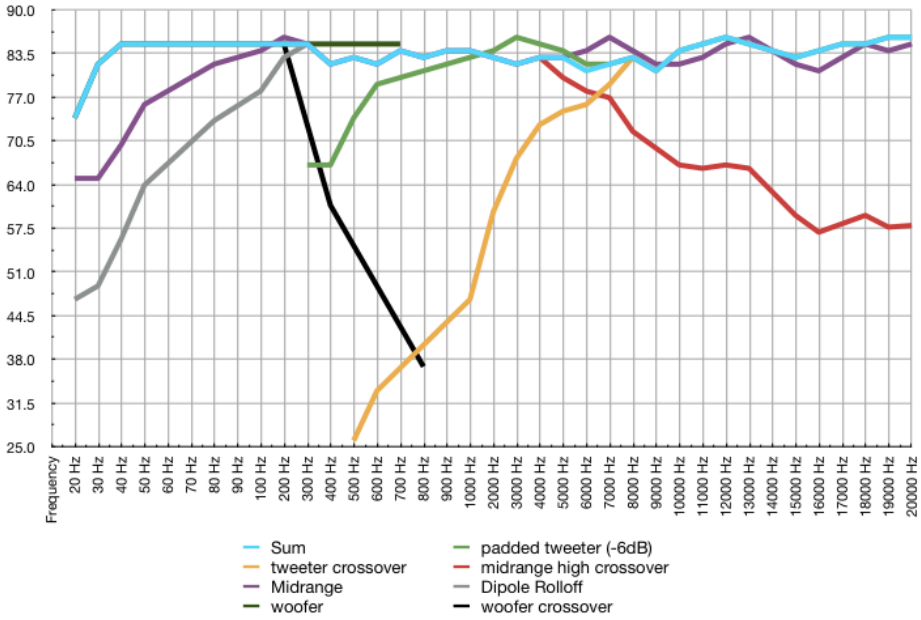


Figure 11

Crossover:

I am doing a three way system that will be bi-amped, which means that I have to have two separate crossover points. I am going to be running the speakers off of my Marantz SR4002 home theater receiver which has preamp outs for all of its 8 channels. For the sub crossover, the signal will come out of the left/right preamp outputs into a dbx

[16] *Newell/Holland,* Loudspeakers for Music Recording and Reproduction, pg. 89 Figure 3.16

223 analog crossover then into my Sunn SA20 power amp then to the woofers. The dbx has a 24 dB/octave Linkwitz-Riley filter with an adjustable frequency. It will start rolling off around 200 Hz. For the mid cross over I am planing on rolling it off around 4 kHz with a second order Linkwitz-Riley filter see figure 11[17]. Figure 11 is a plot of all of my drivers and the proposed crossover points. I padded the tweeter 6dB, and I rolled off the high end of the midrange at around 4 kHz and the tweeter at around 8 kHz. Both crossovers are second order Linkwitz-Riley filters. The low end of the midrange I am not planning on using an electronic crossover, because of the dipole effects in combination with the drivers natural rolloff plus if you add in the baffle step 3 dB drop in combination with the woofer rolloff at 200 Hz. The light blue line is the sum of the drivers, dipole, baffle step, and crossovers. As you can see it is a fairly flat hovering around 83 dB or so. Figure 12[18] is a theoretical map of a second order Linkwitz-Riley filter. For the tweeter we are looking C1=1.24 µF, L1= 0.32 mH. And the woofer which is going to be crossed over at a different frequency will have C2= 2.49 µF, and L2= 0.64 mH. Figure 13 is a map and parts list for a 6 dB pad for the tweeter. Figure 14[19] is a map and parts list for the midrange impedance correction circuit and

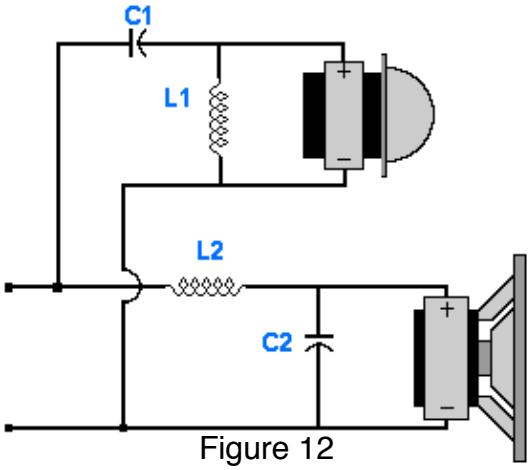
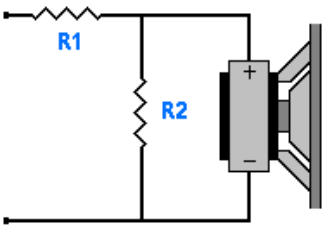


Figure 12



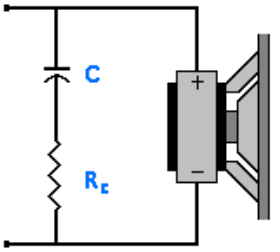
Parts List

Resistors
R1 = 3.99 Ohms
R2 = 8.04 Ohms

Figure 13

[17] *DIYaudioandvideo,* http://www.diyaudioandvideo.com/Calculator/XOver/ (accessed Feb. 12, 2010)
[18] *DIYaudioandvideo,* http://www.diyaudioandvideo.com/Calculator/LPad/ (accessed Feb. 12, 2010)
[19] *DIYaudioandvideo, http://www.diyaudioandvideo.com/Calculator/ImpedEqual/ (accessed Feb. 20, 2010)*

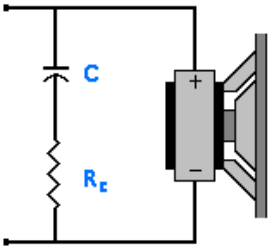
figure 15 is for the tweeter.



Parts List

Capacitor
C = 4.57 uF
Resistor
Rc = 8.75 Ohms

Figure 14



Parts List

Capacitor
C = 2.8 uF
Resistor
Rc = 10 Ohms

Figure 15

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