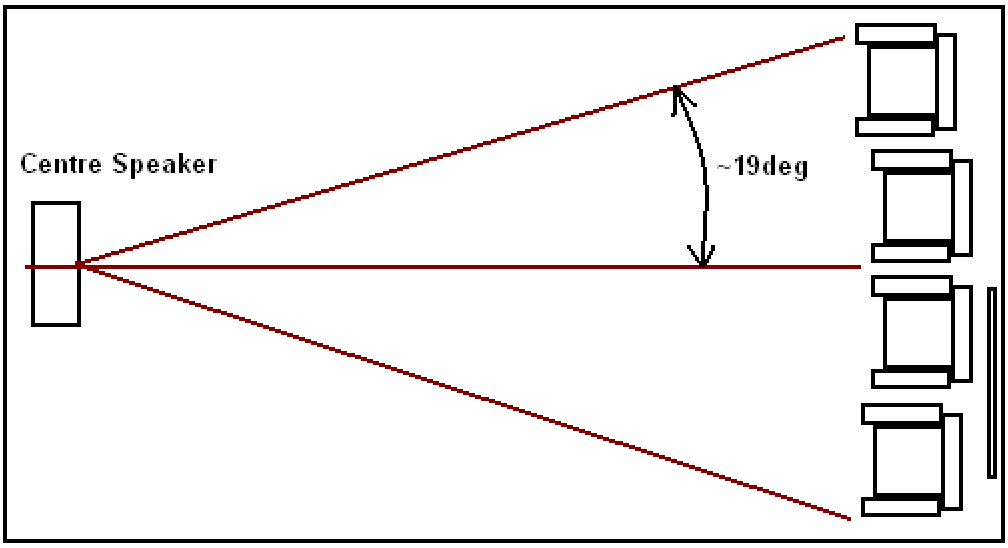
Centre Channel Design

In my system, centre loudspeaker needs to be a horizontally symmetrical device. The easiest way to accomplish this would be to design a standard, vertical TW arrangement, where the tweeter is mounted on the top of the woofer, thus providing symmetrical horizontal design. However, a flatter loudspeaker (one that can fit comfortably under the TV screen) can be designed if the single woofer is replaced by two smaller units and the tweeter mounted between them. Unfortunately this arrangement may create a lobbing problem between the two woofers.

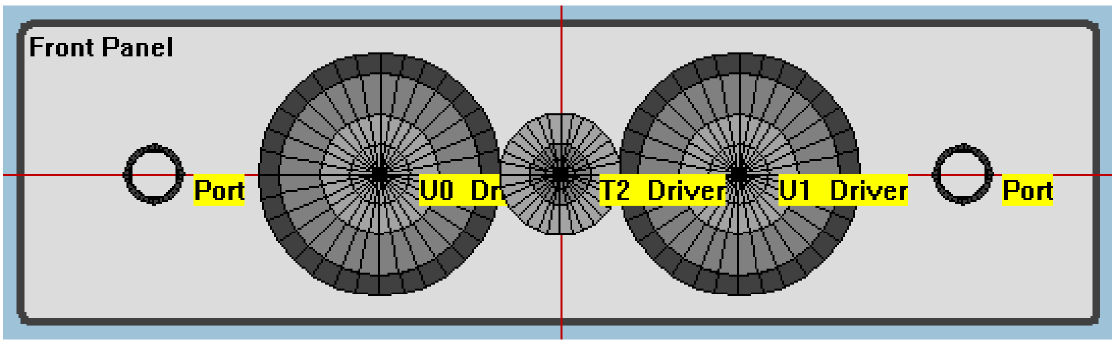
How severe is the lobbing problem? Can it be dealt with?.

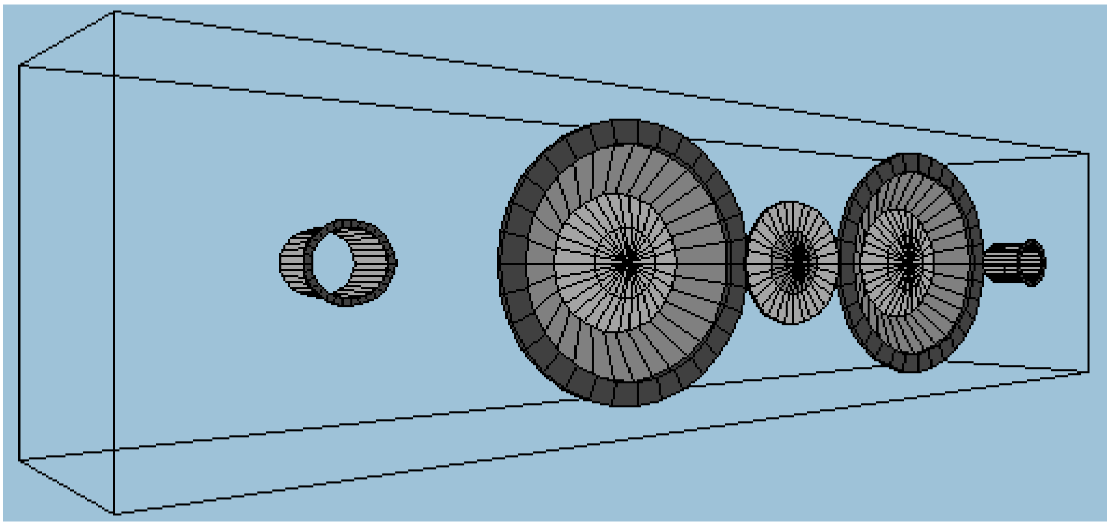
Shown below is a sitting arrangement in my AV room. From the dimensions of the room, I can calculate the maximum off-centre angle to be 19deg, and realistically (if you take into account the location of the head of the listener) to be about 17deg. Here is the aerial view of the AV room.

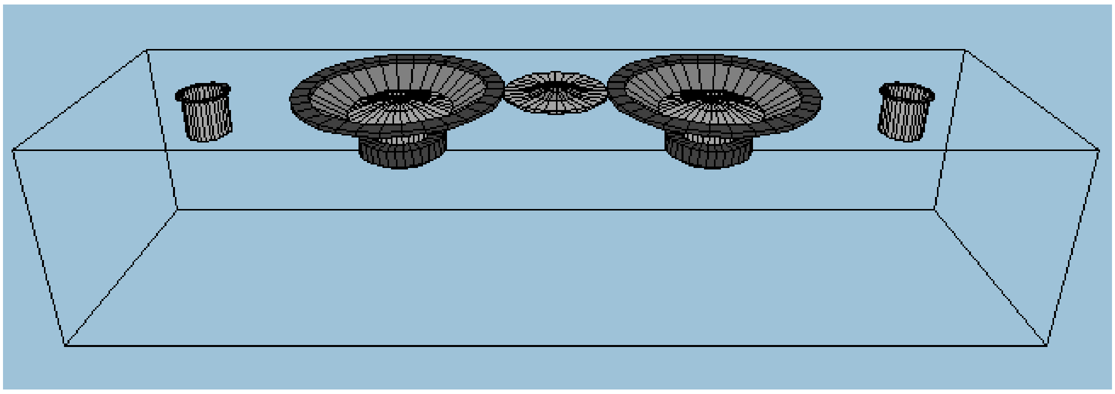


Proposed configuration of the drivers on the front panel is shown below.

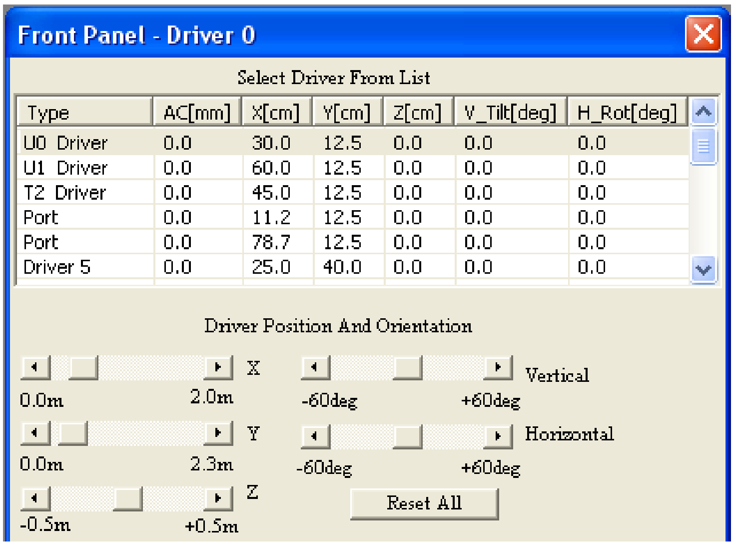
U0 Driver dia = 20.40 cm
U1 Driver dia = 20.40 cm
T2 Driver dia = 10.20 cm
Port dia = 5.00 cm
Port dia = 5.00 cm





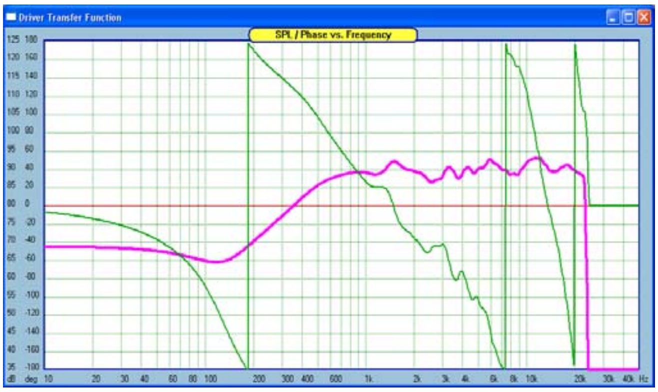


Woofers are 30cm apart, so now, with the help of SoundEasy V18, we can take a look at the lobbying issue. Driver's location is set as shown below.

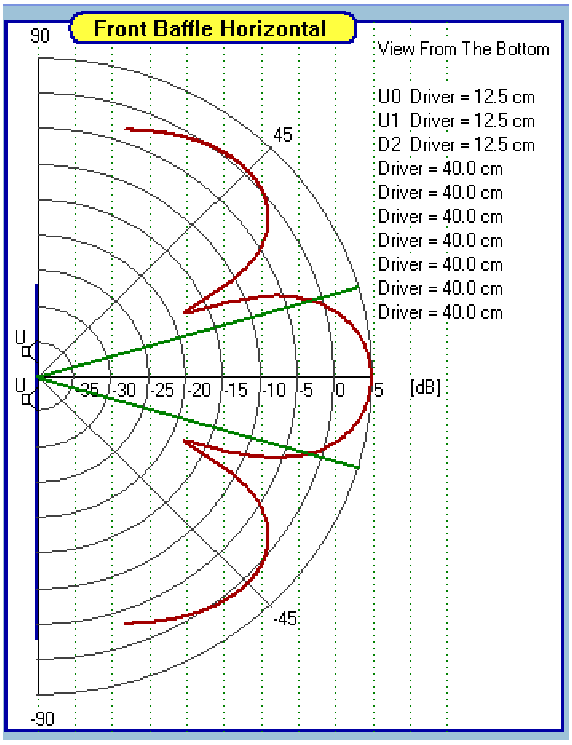


Associated issue is how far can I push my tweeter's crossover frequency towards the low end, without introducing another problem. Tweeter's free air resonance is 850Hz and frequency response is shown below, and it still exhibits reasonably good linearity at 1500Hz.

Impedance (Ω)	4
Re (Ω)	2.8
Le (mH) @ 10 kHz	0.04
Fs (Hz)	530.9
Qms	2.43
Qes	1.06
Qts	0.58
Mms (g)	
Cms (mm/N)	
Sd (cm²)	6.6
Vd (liters)	
BL (Tm)	
VAS (liters)	
XMAX (mm)	
VC Diameter (mm)	29
SPL (dB@1W/1m)	88.0
RMS Power Handling (W)	100
Usable Frequency Range (Hz)	1200 - 20000



On this polar plot, the green lines show 17deg boundaries. The plots are executed at 1500Hz. This is possibly the lowest crossover frequency I would apply to this tweeter, with +24dB/oct LR crossover.



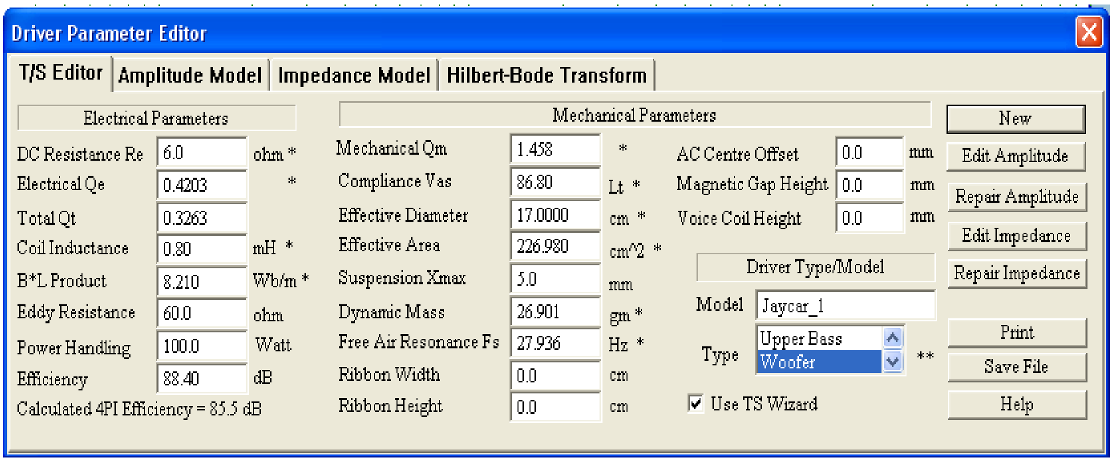
It is observable, that off-centre listeners will not experience lobbying effect. They will experience slight degradation of 4-5dB in overall SPL, but no lobbying. With the residual lobbying null pattern at about 30deg, it may be a good idea to prevent the centre speaker from radiating into the walls and increasing the overall level of reflected sound in the room. I will revisit this issue during listening tests.

The centre channel carry most significant dialogue/vocalist/lead instrumentalist sound information in the movies. Therefore, the design goal followed broadly the 5.1 system recommendations (Ref 1, Chapter 4.4) and was to obtain maximum frequency response extension, say 40Hz-20000Hz from a medium-size box. Aesthetically, I was able to accept a wide, flat box with internal volume of about 50Lt.

Conceptually, the front loudspeaker is a 2-way, vented system with two 8”/90Wrms woofers and 1.125”/100Wrms silk dome Dayton shown below (selected over Vifa tweeter), and making it quite a robust, medium-sized loudspeaker.

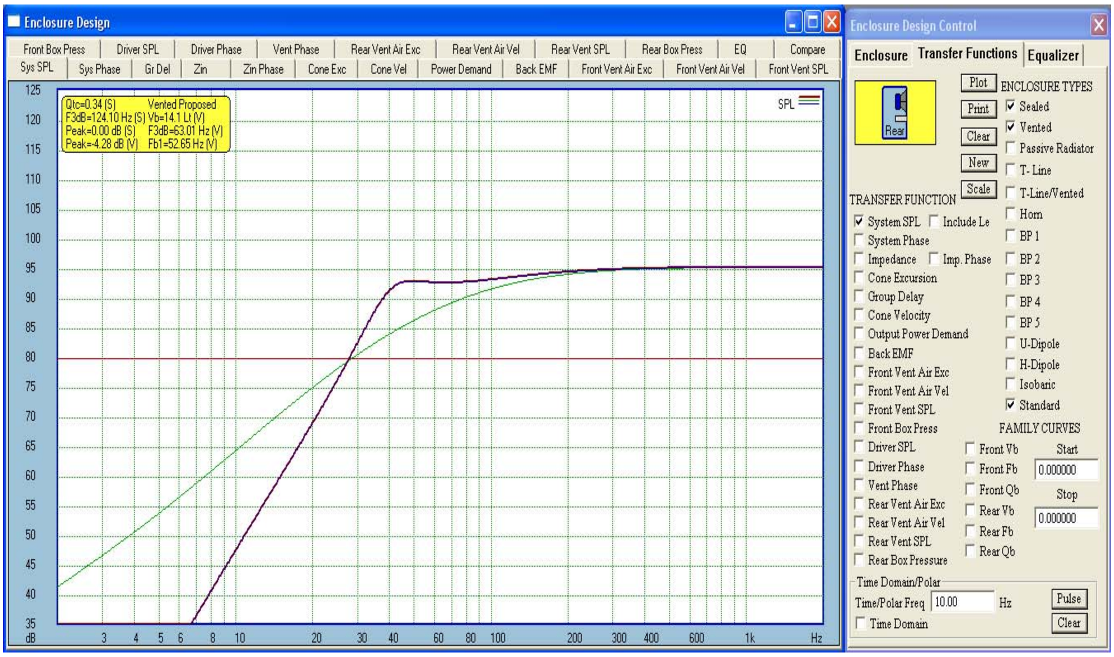
Enclosure design was carried out using SoundEasy V18. Based on TS parameters, I calculated all enclosure data, necessary to assemble the box and the measure drivers’ SPL/phase performance.

Woofer’s T/S Parameters



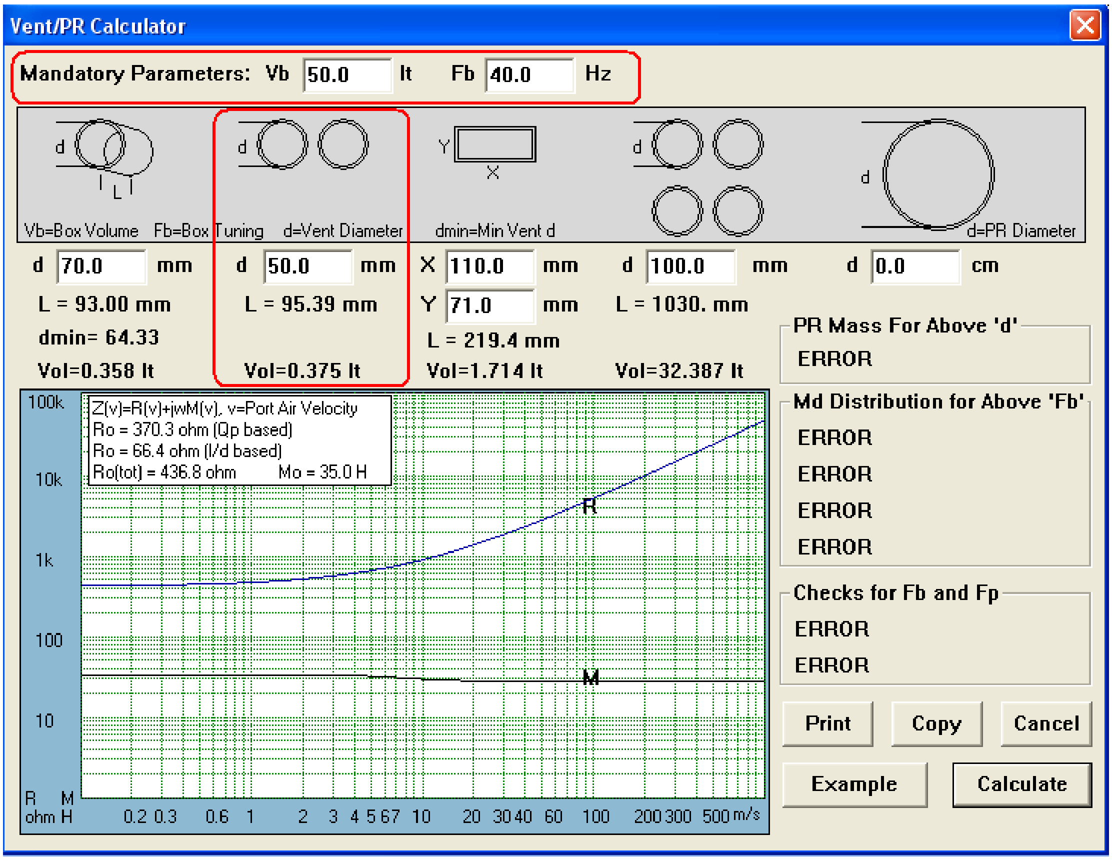
Enclosure Design

There are basically two options for the rear enclosure. I opted for vented system, because with ~5dB of available equalization, I will be able to obtain -3dB cut-off frequency of 35Hz, with satisfactory cone excursions. This is quite reasonable output from such small enclosure. The same equalization for sealed enclosure would result in the -3dB cut-off frequency of around 42Hz. The box is lightly padded with enclosure filling material, resulting in estimated Qb of 10.



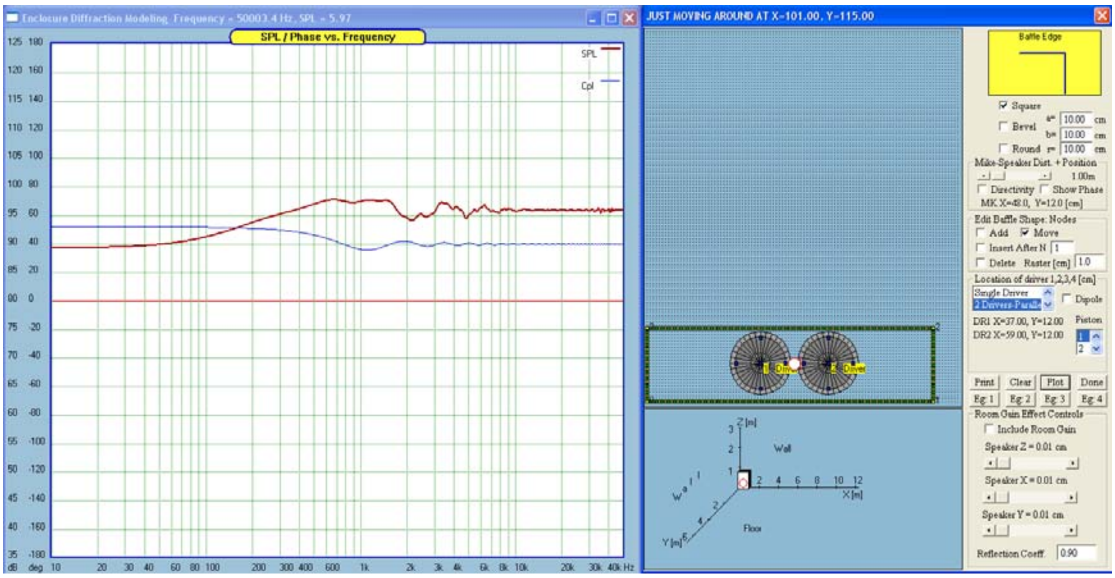
Vent Design

For the 50Lt enclosure, tuned to 40Hz, the vent must be rather small in diameter, otherwise, it’s length is excessive and will not fit comfortably into the enclosure depth of 30cm. For the two 50mm diameter vents, the expected length is 95mm.



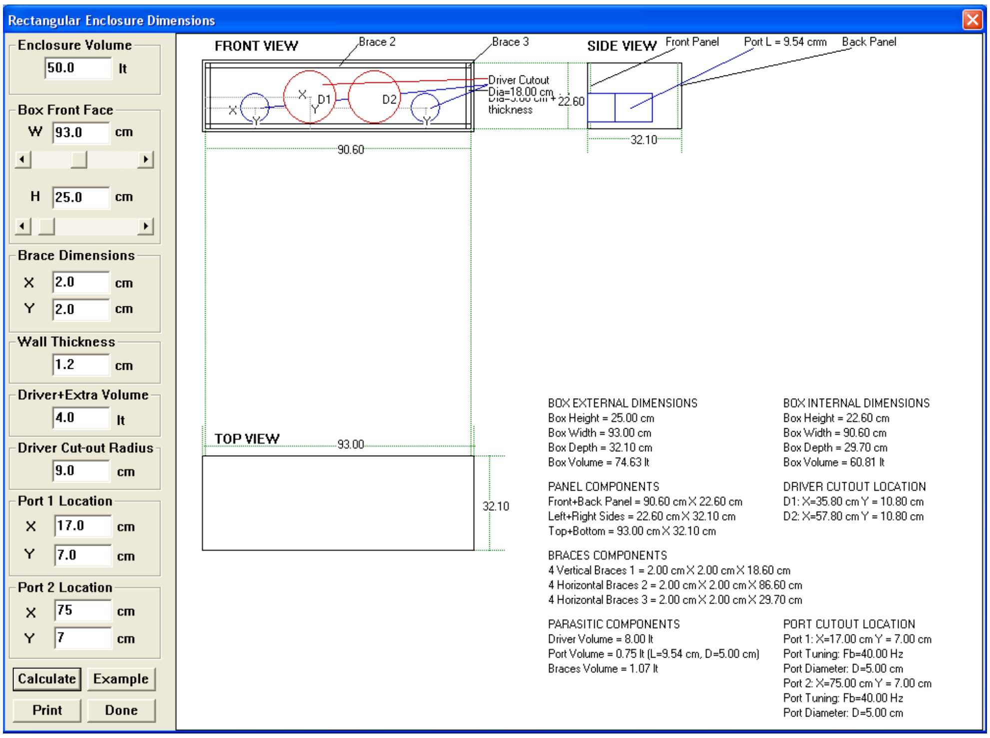
Diffraction

Diffraction curve for square edge type of enclosure is fairly typical. Starts rising from around 100Hz. Diffraction curve will be completely equalized using inverse HBT process.



Rectangular Box

Finally, I am able to visualize the actual box design, even though it does not show tweeter cut out. Enclosure bracing is 20mm x 20mm in cross-section. For the construction, I use 12mm particle board. Joints are glued and all panels are crewed to the braces using suitable wood screws. Finish is very simple. Exterior is smoothed, primed and painted white, to match the rest of the loudspeakers and room décor.



At the back of the box, there are two push connector terminals, one for the woofers and one for the tweeter. The 50mm diameter front ports, are shown to the right.

After assembly, all surface irregularities (screw holes, chipboard edges) are patched with wood-filler, and left to dry for 4 hours. Then the whole exterior of the box is smoothed using two grades of sandpaper.

Finally, the exterior is primed and spray-painted with 4 layers of water-based enamel paint. Total construction time was about 12 hours. Fully assembled centre loudspeaker is shown below. Please note, that tweeter shown below is the old Vifa driver, which was replaced with the Dayton RS28F-4 silk dome tweeter.

As you can see, construction effort was kept to a minimum. The techniques used were simple, bordering on primitive. I did not expect the finish to rival a commercial product, as I do not have woodworking skills to ever accomplish that, but it all worked OK for me.

Since there is no crossover inside the box, it was very important to mark the rear connectors, to indicate which one connects to the woofer and which one connects to the tweeter.

References

1. The Recording Academy's Producers & Engineers Wing Recommendations For Surround Sound Production.
http://www2.grammy.com/PDFs/Recording_Academy/Producers_And_Engineers/5_1_Rec.pdf