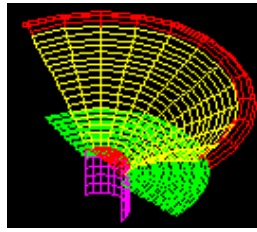


# FINECone™



Acoustic Finite Element Dome/Cone  
Simulation Program

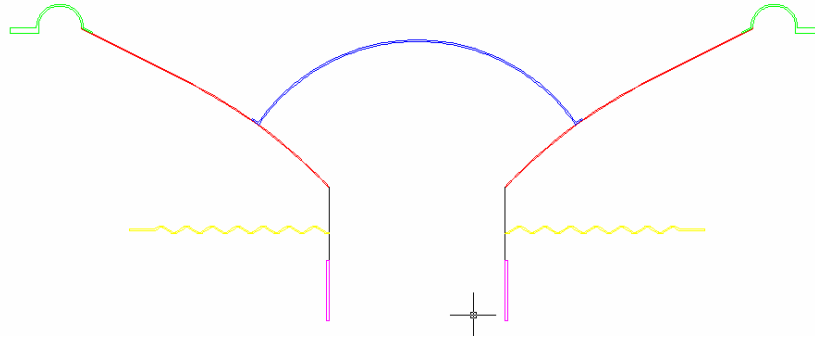
## TUTORIAL



# FINECone example1: 6.5 inch Woofer

We will verify a FINECone model compared to a real driver to see the accuracy. The FINECone model can then be used to simulate new materials, cone shapes and many other things.

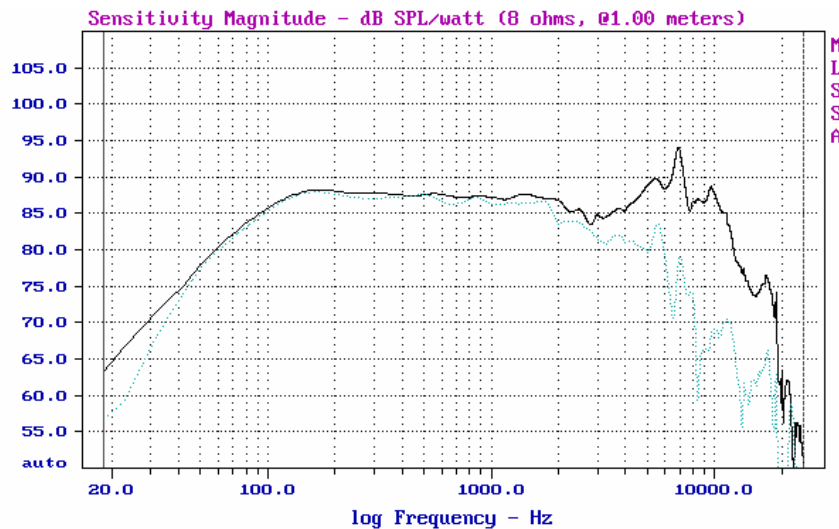
The actual driver is a 6.5-inch woofer in a plastic frame with a 90mm ceramic magnet and 33mm voice coil. It has a curved aluminium cone with a rubber surround and a large plastic dust cap.



**Figure 1. The main geometry of the acoustical components**

Thiele/Small parameters:

Fs	47	Hz	
Re	5.50	ohms	
Qms	4.93		
Qes	0.49		
Qts	0.44		
Le1	0.22	mH	
Le2	0.47	mH	
Rp	4.91	ohms	
Vas	23.93	ltrs	
Mms		12.64	g
Cms	907	m/N	
Bl	5.65	Tm	




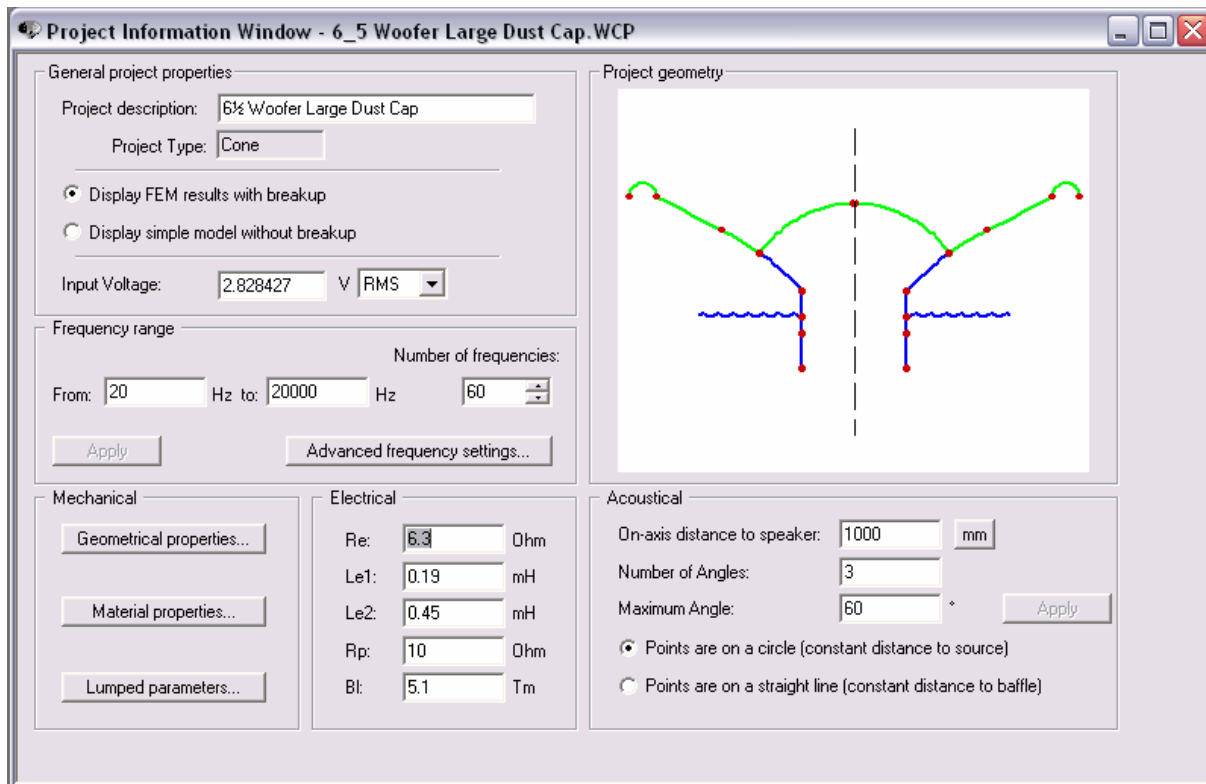
**Figure 2. The (0/30deg) response is measured using MLSSA. The on-axis curve is imported in FINECone**

## FINECone FEM (Finite Element Modelling)

The following is a short description showing how the 6.5 inch woofer was modelled in FINECone.

These are the steps in FINECone FEM:

- Define Geometry by importing DXF file
- Define Material Properties of speaker components using material database
- Define Electrical Parameters and import  FINEMotor data if available



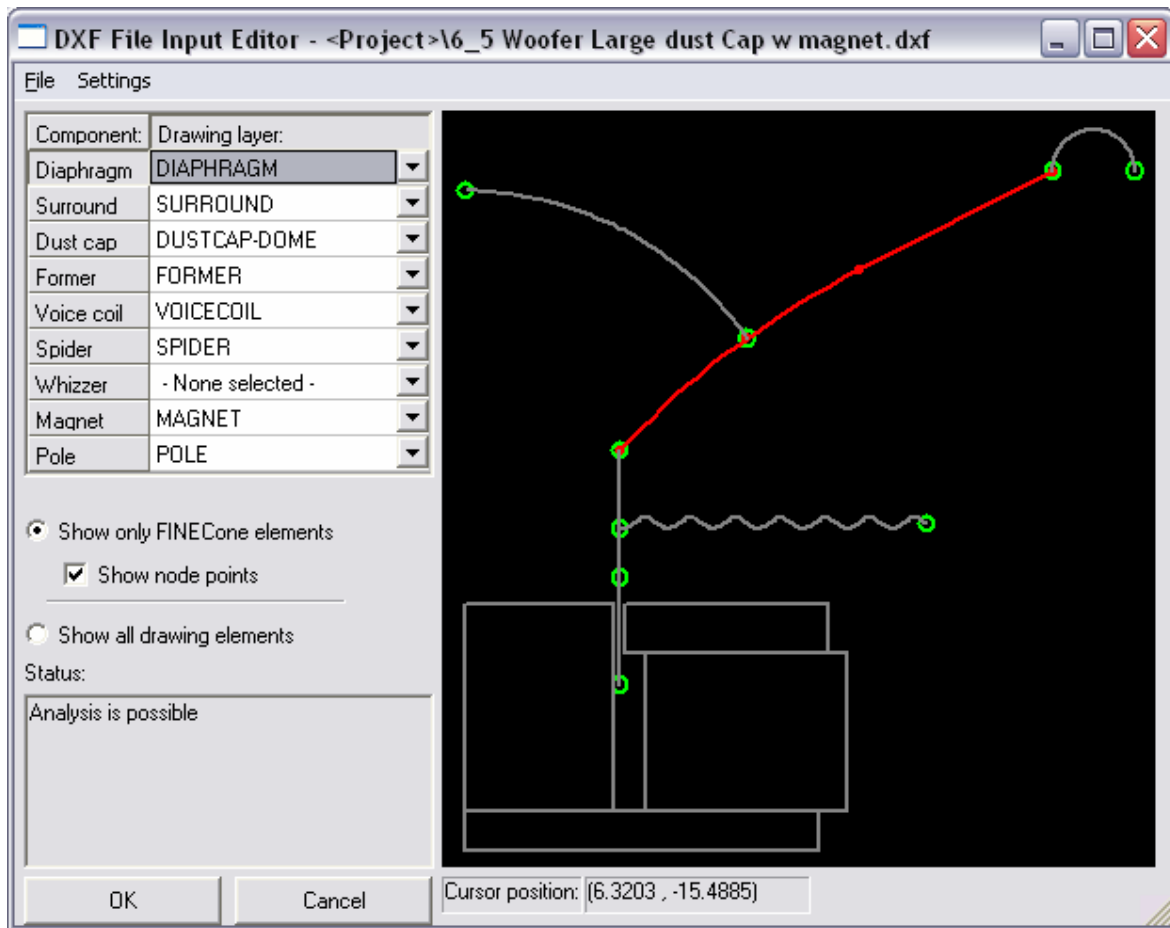
**Figure 3. FINECone Main Window**

Since all meshing, number of elements, DOF (Degrees of Freedom) and Constraints etc. are done automatically by the Program, we will just make a sketch of the geometry in AutoCAD and import the DXF file into FINECONE.

The model must be axi-symmetric, and only the right half is used. This implies that the coordinate of the leftmost point is on the symmetry axis where  $X=0$ . Usually this is the midpoint of the dust cap. The DXF-drawing is shown in Fig. 4

## DXF-Import

The imported DXF geometry is shown here (Diaphragm (Cone) layer chosen):



**Figure 4. DXF Import and Automatic Error Checking**

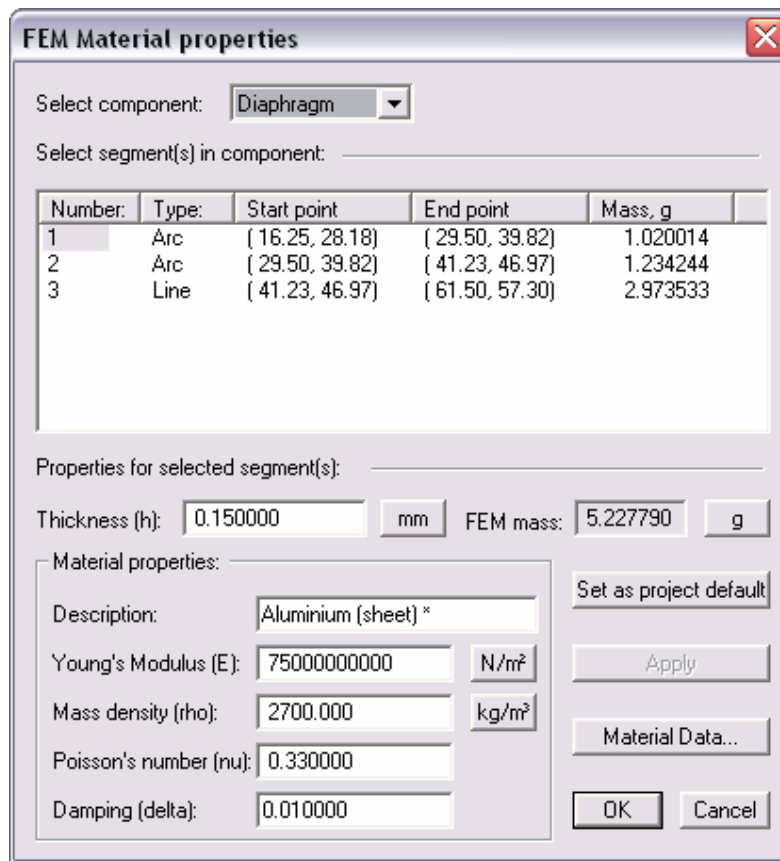
We have used the default names for the layers, and the entire drawing will be imported directly!

*Note. You can change the default layer names in Tools/Program Options/DXF Layers*

The Status window reports: Analysis is possible. This means that the DXF error checking has analyzed the DXF file and found no errors. See also the FINECone Reference Manual, which gives many more details.

FINECone will now start the calculation using default parameters. These must be changed to give meaningful results in this case.

Therefore we select FEM Material Properties



**Figure 5. Material Properties Input**

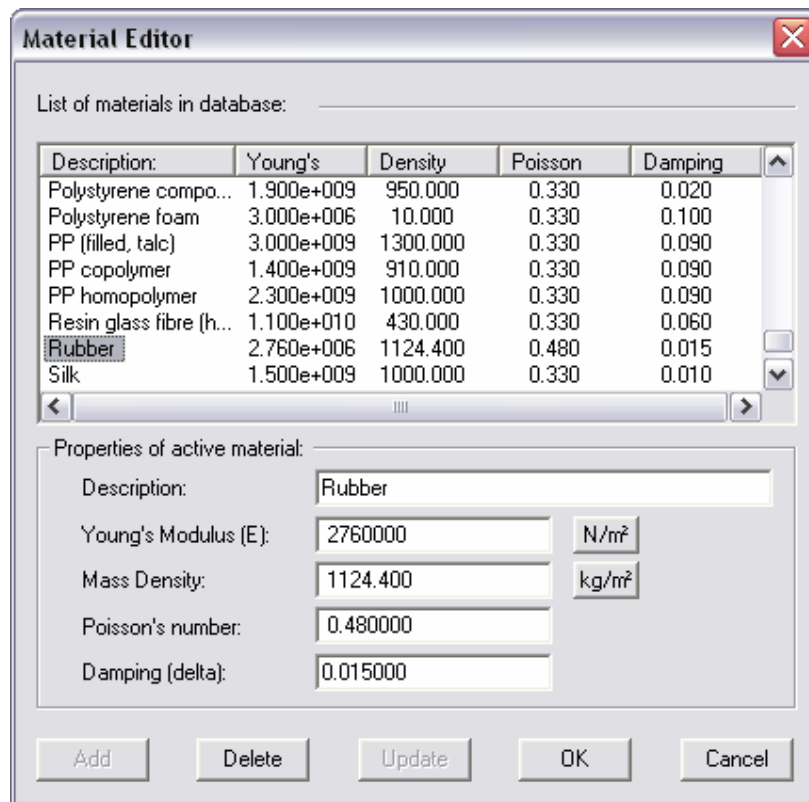
The diaphragm / cone is made in 3 segments. Basically this cone is designed with a large radius (arc) which is connected to a line (see previous fig). The large arc, however, was divided into two arcs both connected to the dust cap.

The cone material is chosen as Aluminium [sheet]. The \* indicates that the material from the database is changed by increasing the damping from 0.05 to 0.1, in order to model the actual speaker material correctly.

The surround material is obtained from the Material Database, selected by the button on the lower right (Fig. 5):

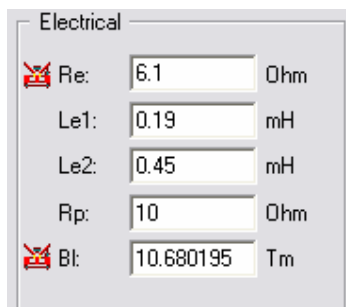
Here is selected "Rubber ", which is a typical surround rubber material.

*Note: you can edit the materials or add new materials in the database at any time.*




**Figure 6. Material Editor**

Now the electrical parameters should be entered. Here the values from MLSSA SPO were used first. To help the user to match an existing impedance curve, a measured impedance curve can be imported by selecting "Advanced Settings"



**Figure 7. Electrical Input with FINEMotor inputs**

If you have a FINEMotor file (\*.FM2) from the latest version, it can be imported directly into FINECone. The parameters in Fig. 7 marked with  are imported From FINEMotor (See also later and the FINECone Reference Manual).

The resulting frequency response is shown in Fig. 8:

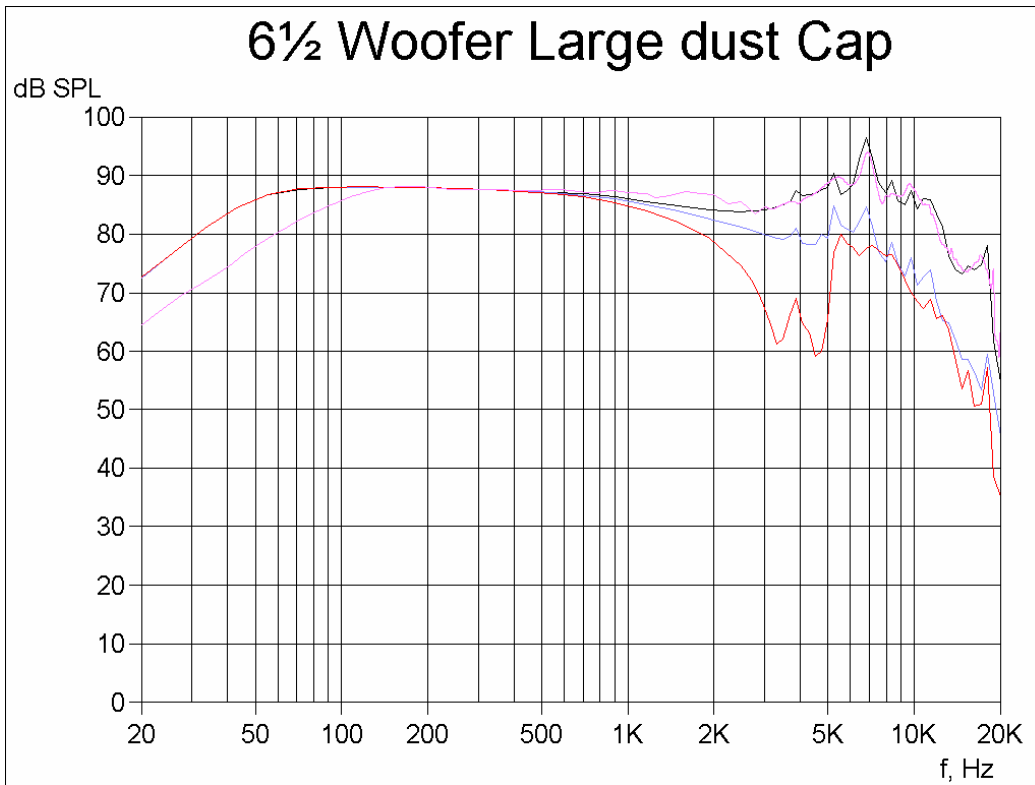


Figure 8. The agreement between the calculated FINECone response (black) versus the measured response (magenta), is remarkable at high frequencies (break-up region)

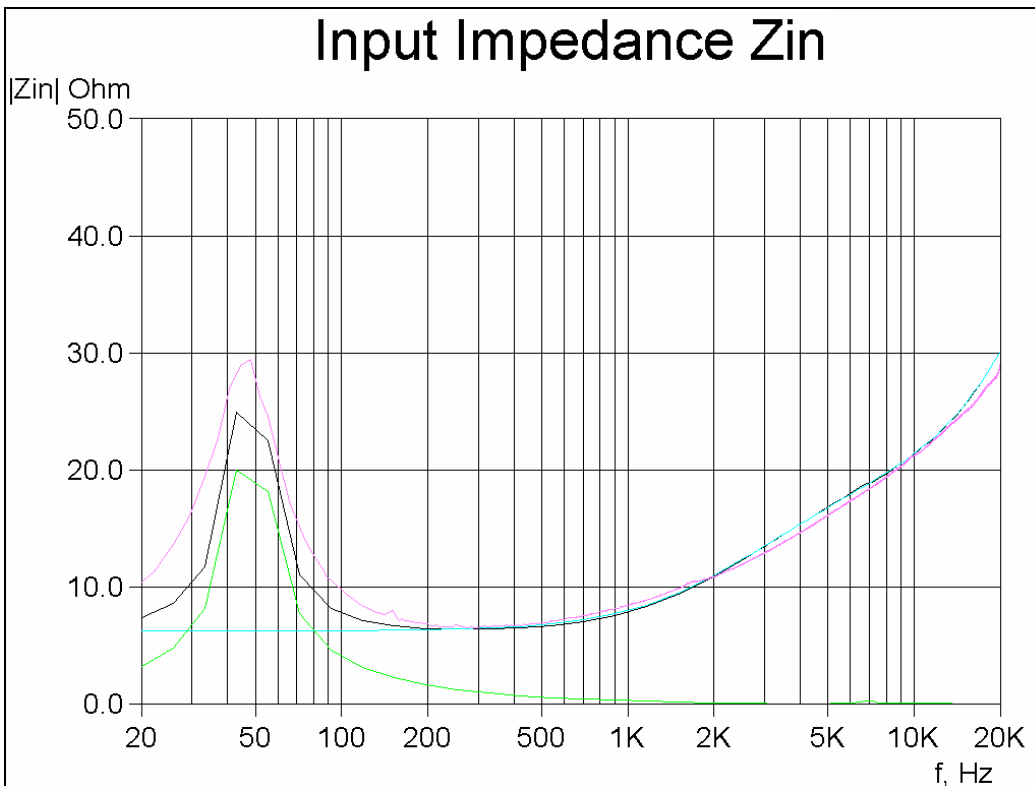
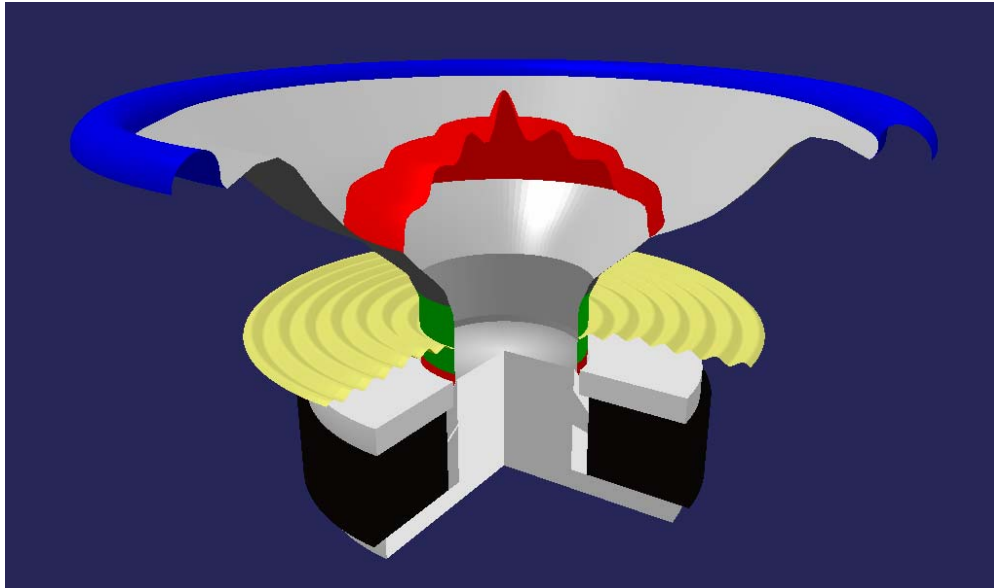
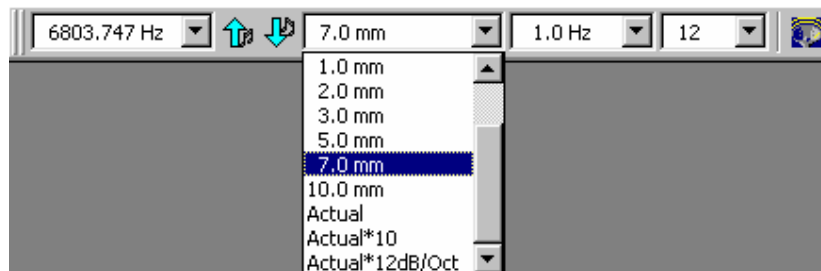


Figure 9. The blue curve is calculated electrical impedance and green is mechanical impedance. The magenta curve is the imported impedance curve for comparison.

## Post processing



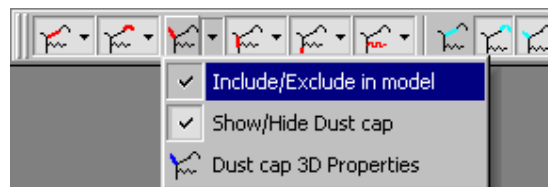
**Figure 10.** This is the 6.5" woofer break-up animated at 7162Hz, which is the frequency of the large peak. Note the heavy break-up in the outer part of the cone.



**Figure 11. 3D Animation Menu**

The 3D animation menu is shown above. The left column is the frequency, which is being animated. Select from the drop-down box or step up/down with the arrows.

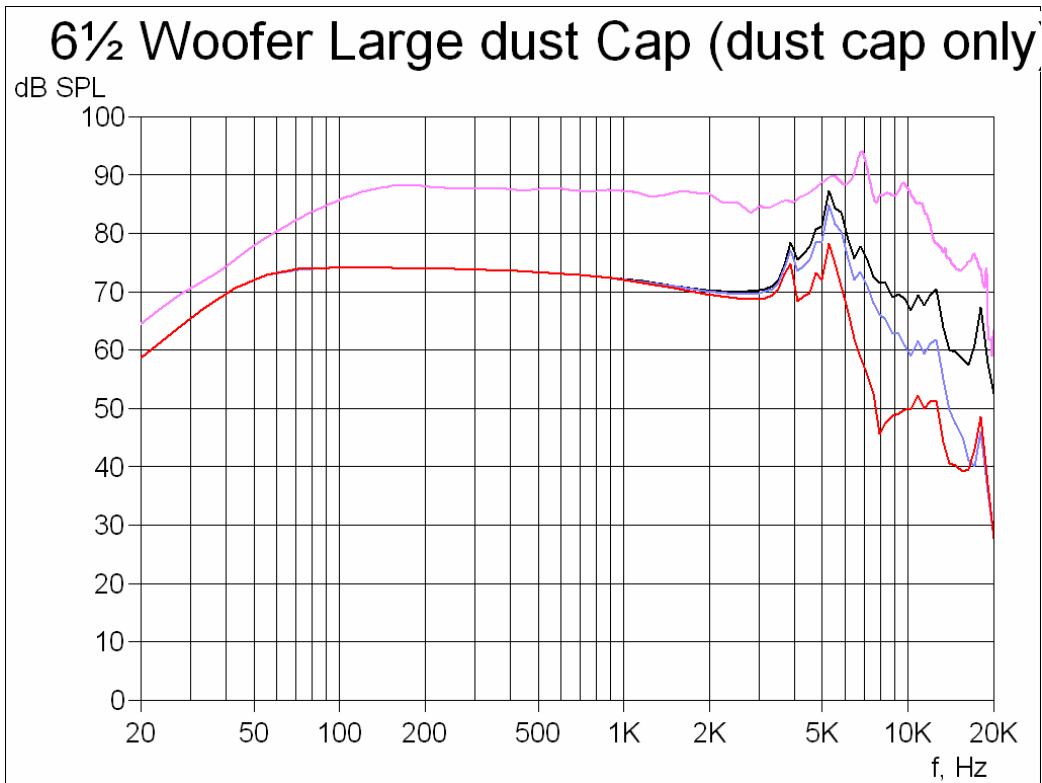
The next column has the amplitude set to 7mm. Under that you can select the actual amplitude. But this is only visible at very low frequencies, being only fractions of a mm above  $F_s$ . Even Actual\*10 is difficult. The last setting: Actual\*12dB/oct increases the amplitude by 12dB/oct above  $F_s$ . This will compensate the real amplitude, which decreases by 12dB/oct above  $F_s$ .



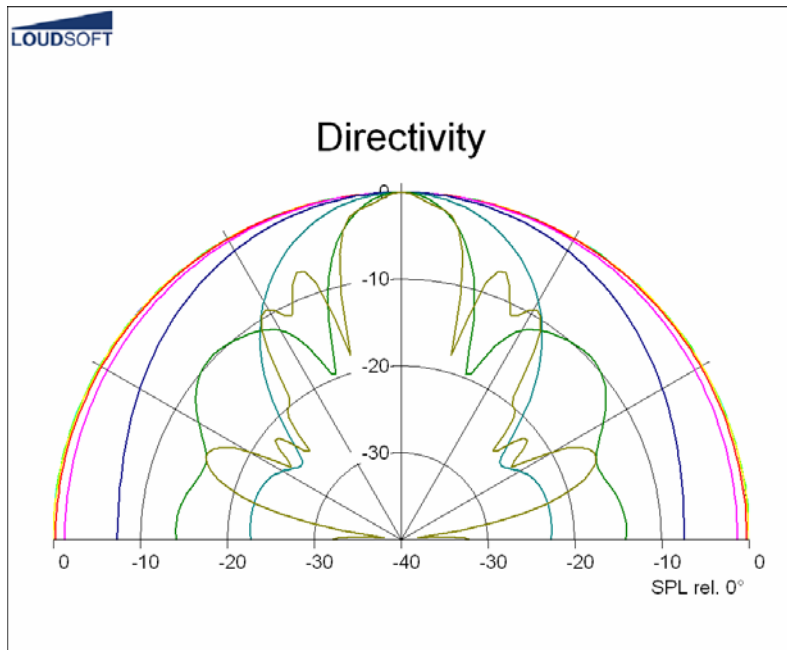
**Figure 12. Include/exclude components**

In this menu you can control the visibility for all components, and the SPL from the acoustic elements can be included or excluded from the total acoustic output. This feature is extremely useful because you can isolate the output from each component, which is not possible with a real driver. For example the response in the next figure has only the dust cap active.





**Figure 13. Response of the large Dust Cap ONLY. The dust cap has a large peak around 5kHz. By going back to the 3D animation this mode can be analysed in detail.**

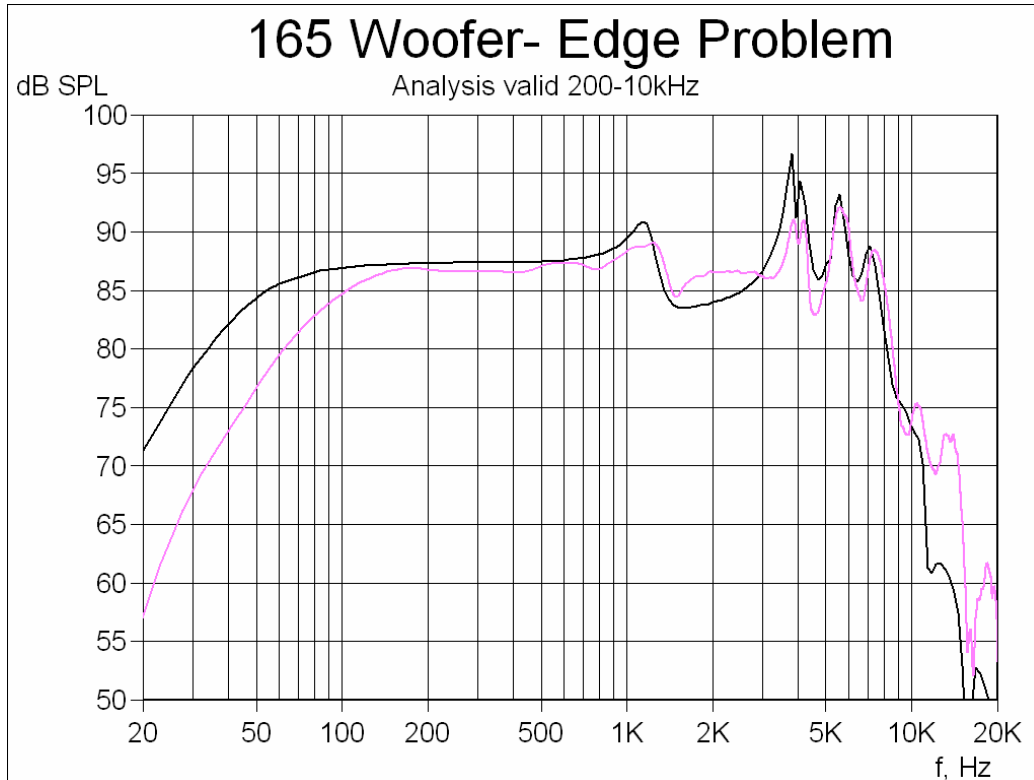


**Figure 14. Directivity at 10 frequencies**

## FINECone example2: 165mm Woofer with 1300Hz problem

In the following example we have modelled a 165mm woofer which has a severe response problem around 1300Hz.

The measured response is imported and shown as the pink response. Note that this analysis is only accurate up to ~10 kHz. The low end measured response is different from the FINECone simulation because the driver was measured in a small baffle, and the response above 10 kHz is not accurate because the FEM analysis was done in Fast Mode (calculation time less than 7 seconds with a 1.5 GHz PC).



**Figure 15. 165 Woofer with edge problem**

The FINECone simulated response in Fig. 15 fits well to the imported measured response. There is much break-up from 3-8 kHz, but we will concentrate about the peak and dip around 1300 Hz, because that is quite annoying and very difficult to handle in the x-over.

The Project Geometry is shown in Fig 16. The red dots indicate intersections between segments. Note that we have split the surround into 5 segments. All 5 segments have the same thickness 0.4mm, which can be seen in the FEM Material properties in Fig. 17.

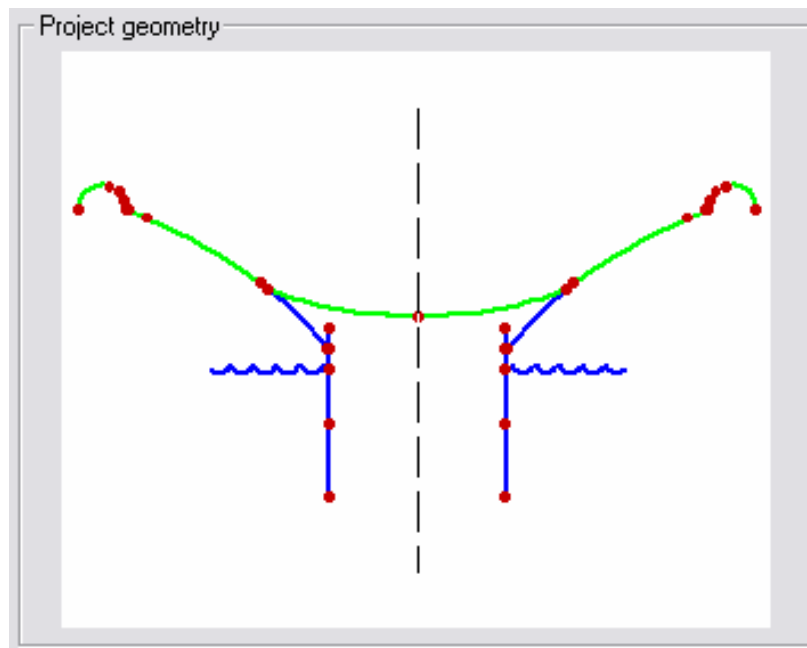


Figure 16. Project Geometry for 165 Woofer with 5 segments in surround

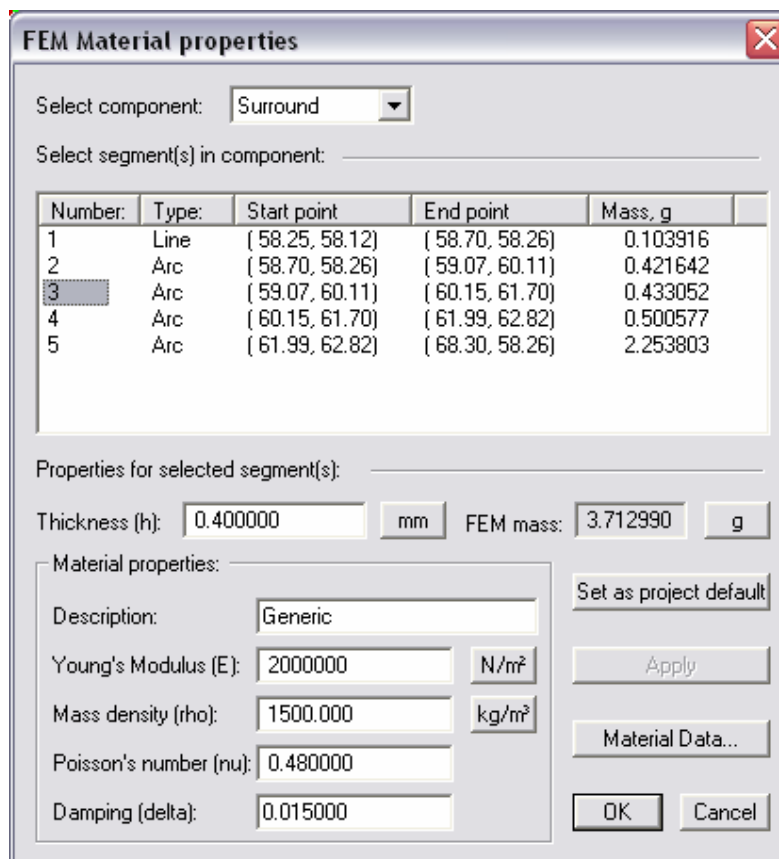
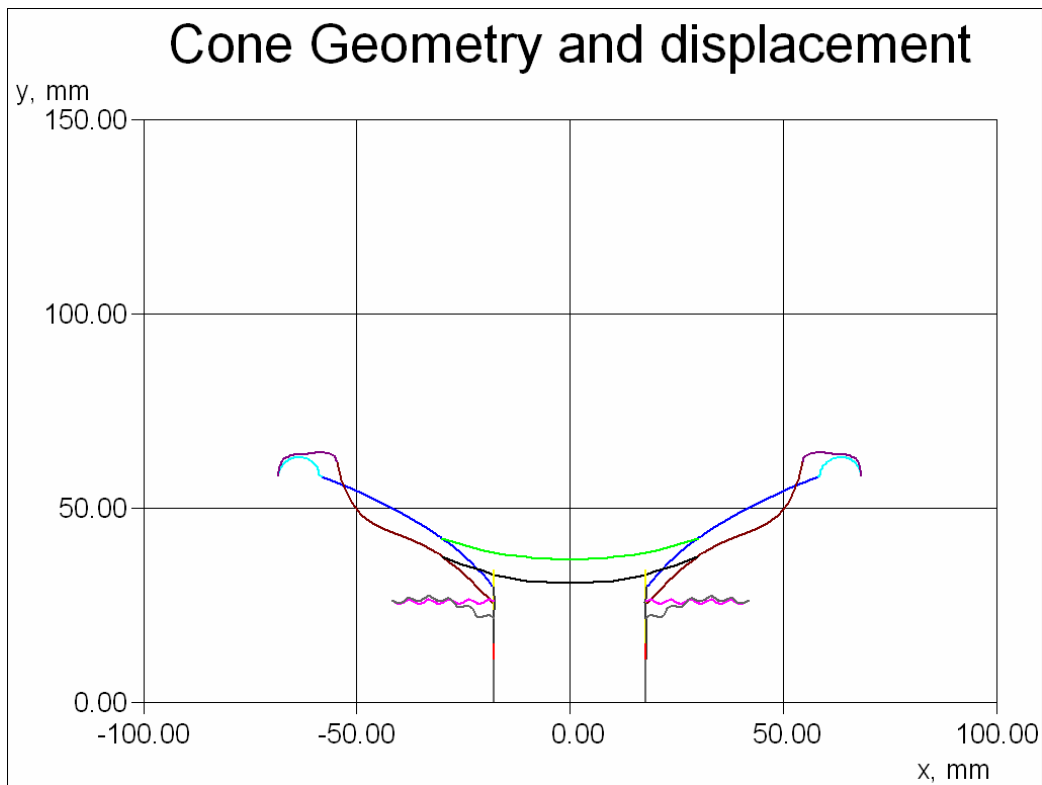


Figure 17. FEM Material properties for 165 surround

In order to find out what is happening around 1300 Hz we have this time used 2D animation, which some times is better to show where the maximum movement of the components is. Fig. 18 shows the cone edge and surround is moving excessively (brown curve).

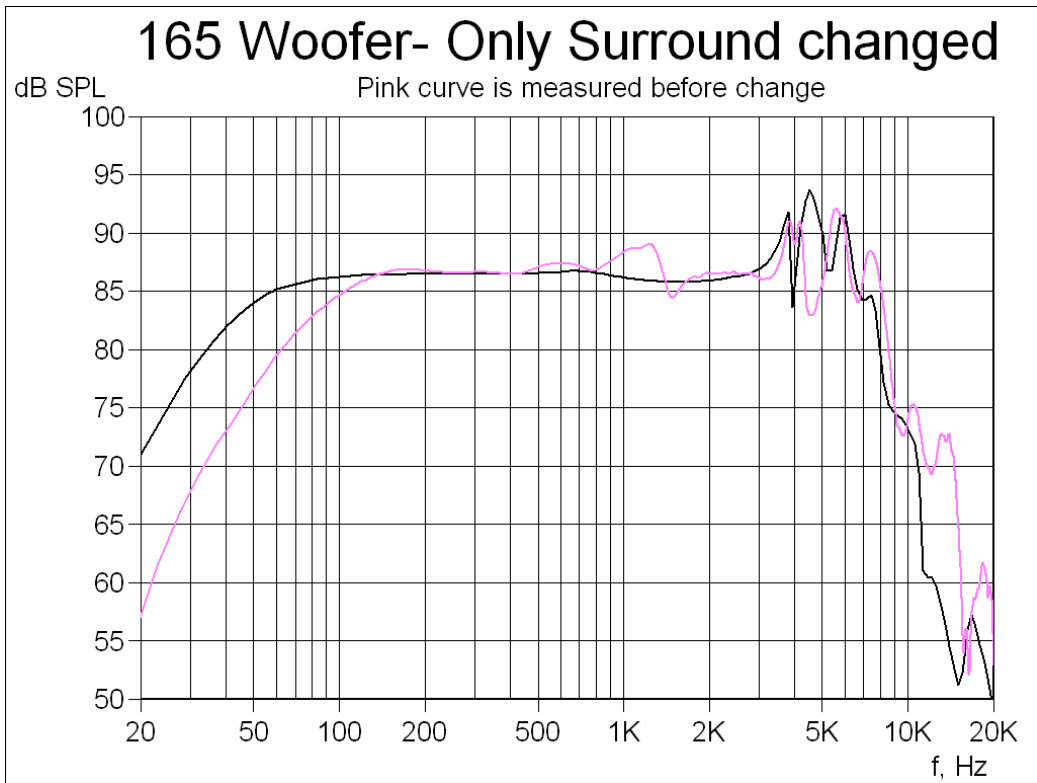


**Figure 18. 165 Woofer Cone displacement (brown), maximum at cone edge.**

There are many ways to correct this problem, for example by changing the cone profile to a large cone angle or change the geometry or thickness of the surround. Here we will change the thickness of the inner part of the surround.

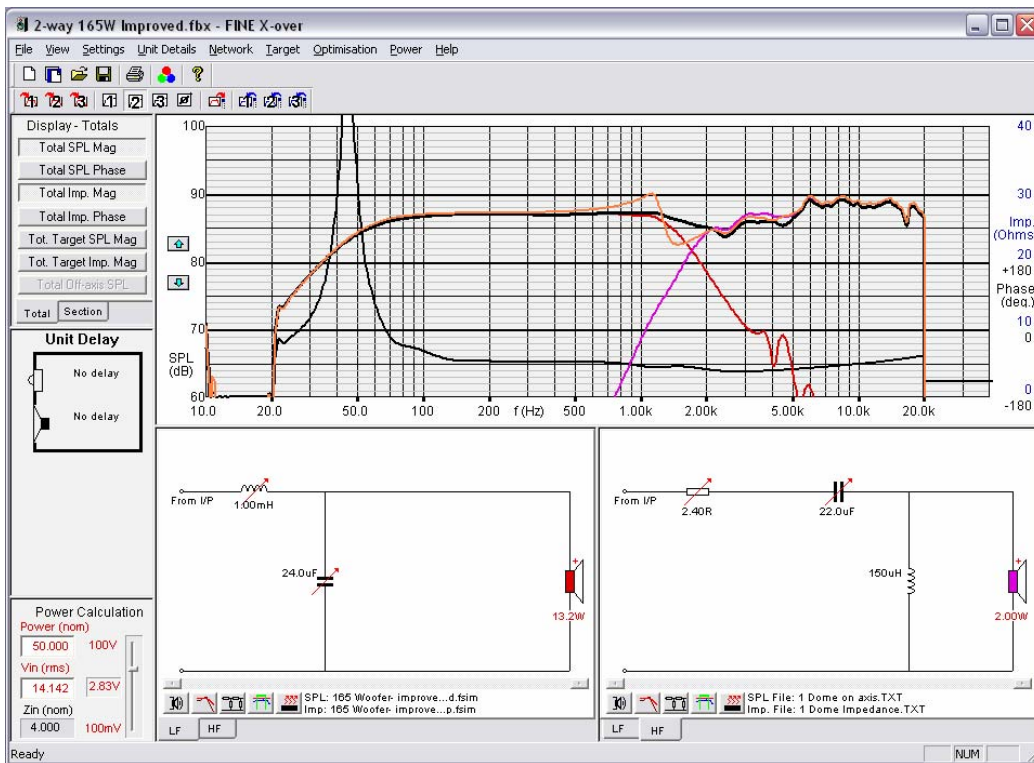
In Material Properties we select segments 1, 2 and 3 and change the thickness to 0.8mm. After Apply and OK the calculation is done automatically.

The new simulation is shown in Fig. 19, and shows a much smoother response around 1300 Hz. The pink curve is showing the response before the change was applied. That response was exported as an FSIM file (see also Fig. 20). This file was then imported after the changed surround was calculated.



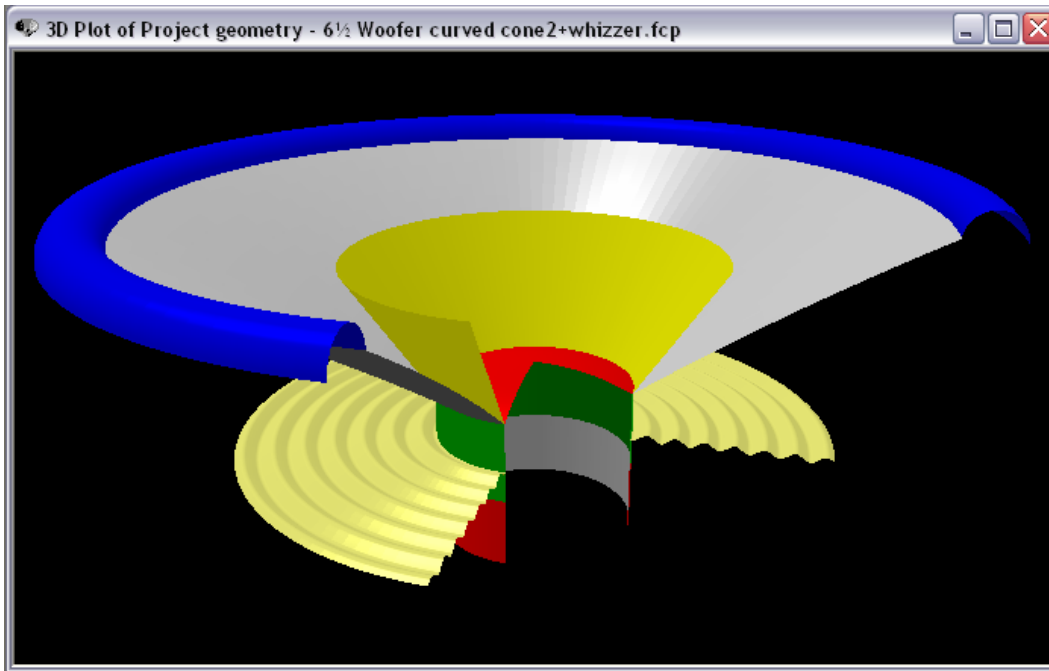
**Figure 19. 165 Woofer with increased thickness of inner surround**

Fig. 20 shows a screen plot from FINE X-over 3, where we have used the exported responses from FINECone as input for the woofer section. The orange response is using the 165W before the simulated change. The final response (black) is much improved. (File: 2-way 165W Improved.fbx).



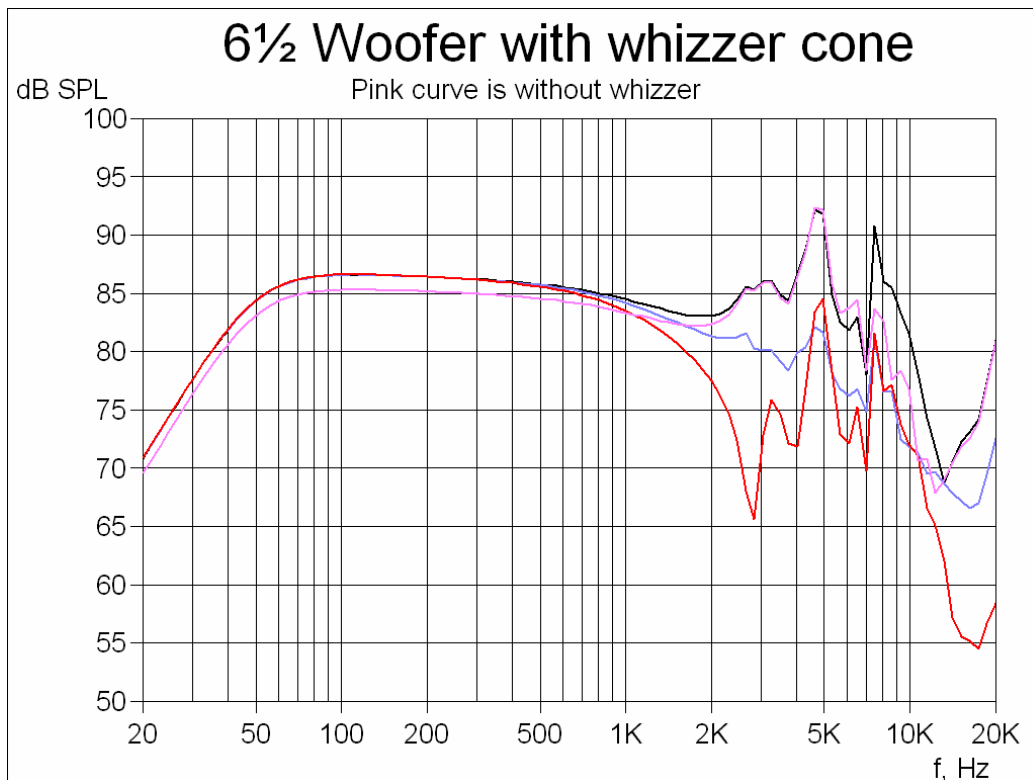
**Figure 20. FINE X-over 3 using 165W exported from FINECone. Orange curve is with the bad woofer**

# FINECone example3: Woofer with whizzer cone (Dual Cone)



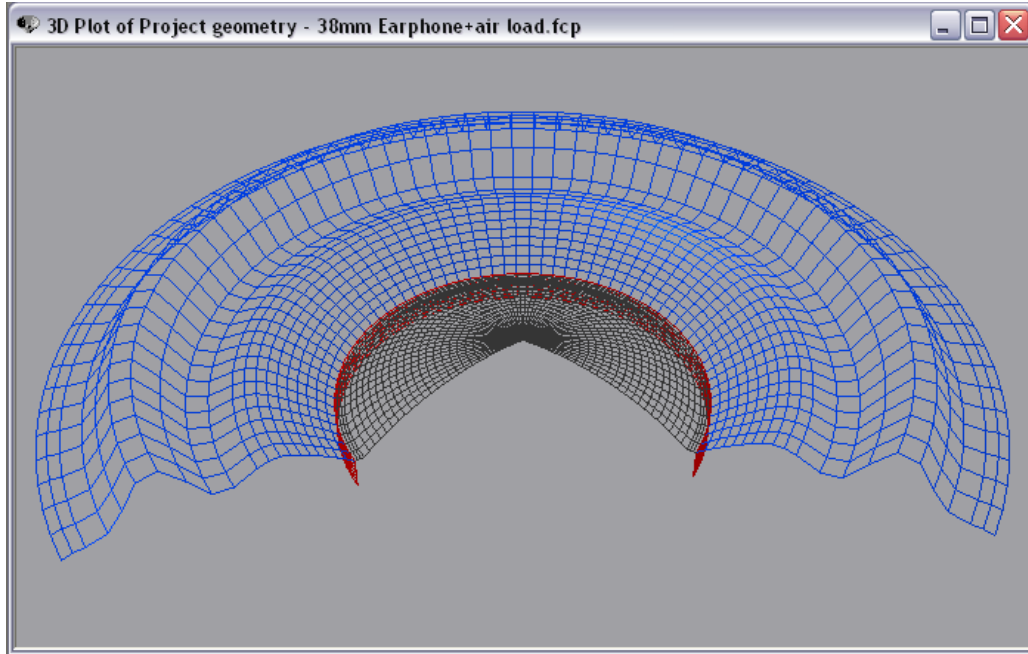
**Figure 21. 6inch woofer with whizzer cone (Dual Cone)**

The whizzer cone (Dual Cone) is quite easy to simulate in FINECone. Now the whizzer cone calculation accuracy is greatly improved. In addition the acoustical output from the whizzer cone can be excluded from the SPL, which is shown as the pink curve in Fig. 22.



**Figure 22. 6 inch Woofer with added Whizzer Cone. Pink curve is without whizzer cone**

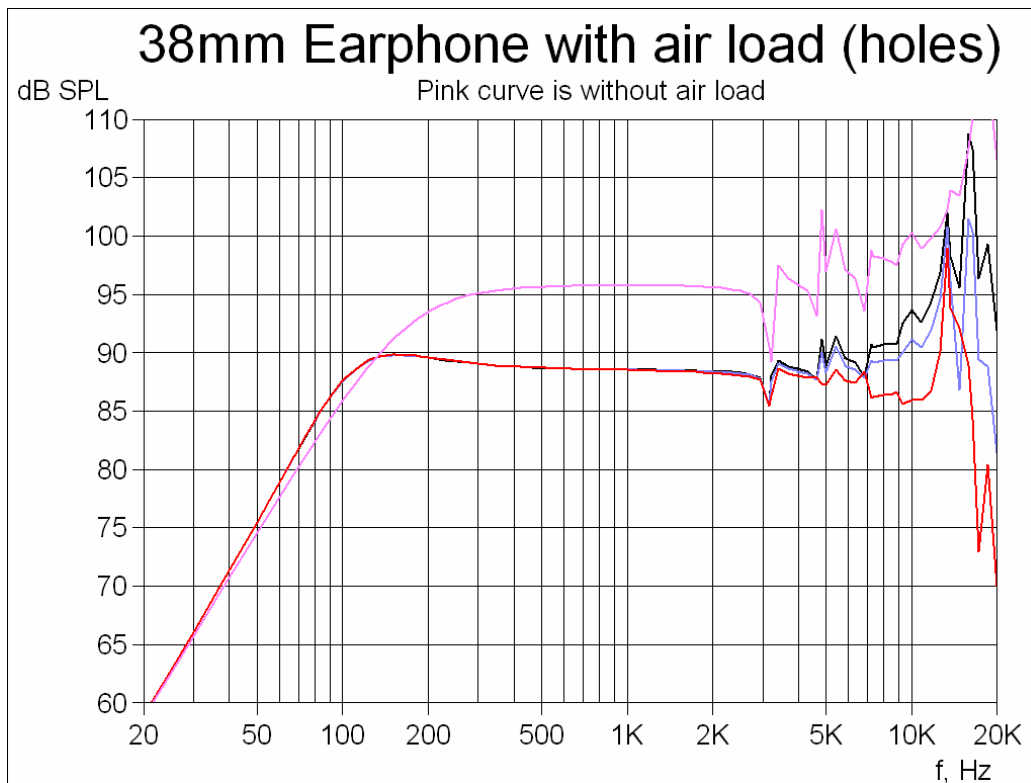
## FINECone example4: 38mm Headphone transducer



**Figure 23. 38mm Headphone transducer simulated in FINECone: Break-up @ 3165 Hz**

The 38mm headphone was first modelled in FINECone with only the main acoustical parts: Diaphragm inside (dome) and diaphragm outside (surround) and voice coil. The diaphragm is 25u PEI which is used for both dome and surround since the diaphragm is made in one piece.

The resulting response is here shown as the pink curve in Fig. 24. There is serious break-up from approximately 3000 Hz and the first mode is shown as 3D animation in Fig. 23. This first break-up mode is showing up in the middle of the outer diaphragm (surround) where it is almost flat.



**Figure 24. A 38mm Headphone simulated frequency response with air load (rear holes)**

The actual transducer has a number of holes behind the outer diaphragm/surround all covered with a cloth acting mainly as damping material. The net effect of this may be calculated as an effective air load mass using the well-known Helmholtz formula. We can incorporate this air load mass in the FINECone simulation by adding it as "Air load" in Lumped Parameters. The main curve in Fig. 24 is showing the resulting response, which is some 7 dB lower in SPL due to the extra load mass.

We also note that the effective  $F_s$  is reduced from approximately 180 Hz down to 100 Hz with the air load mass.