

## Design considerations for the mid range section of a co-axial slot mid/hi horn

The following diagrams show the effects of changing different aspects of the mid range horn and have been modelled using the software hornresponse. Due to the layout of the horn the software warns that some aspects of the prediction might not be accurate, but comparisons with real measurements indicate that the results should be of some value. It should be remembered that the software doesn't take into consideration the height width ratio of the horn cross section and this might affect the results.

**Hornresp - Input Parameters**

File Tools Window Help

ANG:  VEL:  DEN:  FTA:

S1:  S2:  CON:  F12:

S2:  S3:  CON:  F23:

S3:  S4:  CON:  F34:

S4:  S5:  L45:  F45:

---

SD:  CMS:  MMD:  RE:

BL:  RMS:  LE:  ES:

VRC:  FR:  VTC:  **CAUTION:**

LRC:  TAL:  ATC:  **CIR > 1 for S3**

Comment:

Previous Next Edit Add Delete Record 2 of 3 Calculate

In the above:

ANG = radiating space 4pi is free space

VEL = speed of sound

DEN = air density

FTA = Conical Mouth flare angle

S1-5 = The throat and mouth areas of the horn. The four rows allows multiple segment horns.

CON = The segment of the horn has a conical expansion rate the value in the box gives the length (cm)

The two rows below the line give the driver parameters in this case 2 Eminence Alpha 6"s in parallel

VRC = volume of chamber behind the drive unit

LCR = The average depth of the rear chamber

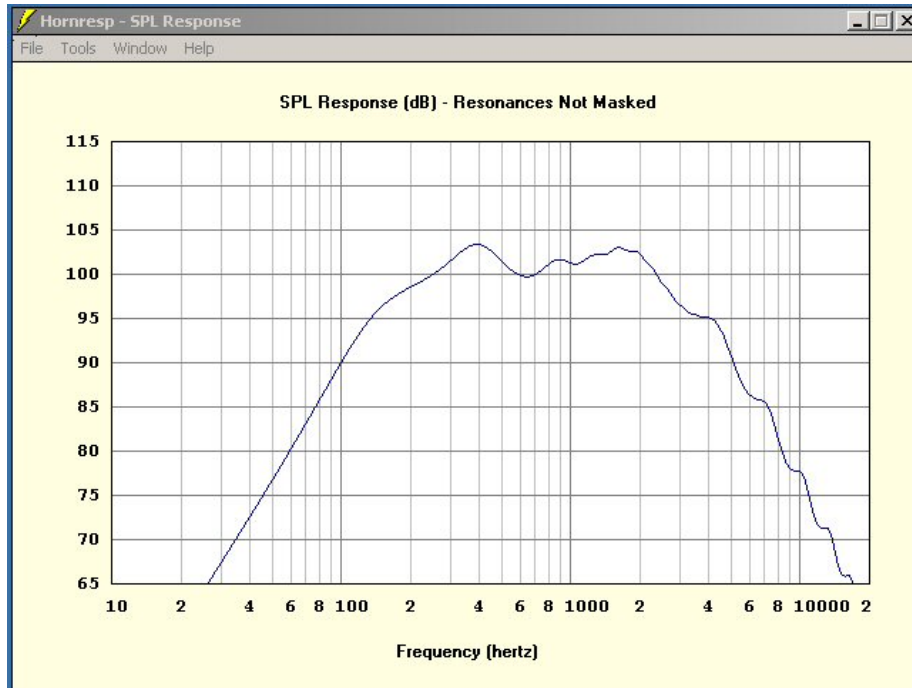
FR = airflow resistivity of any acoustic lining

TAL = thickness of the above lining

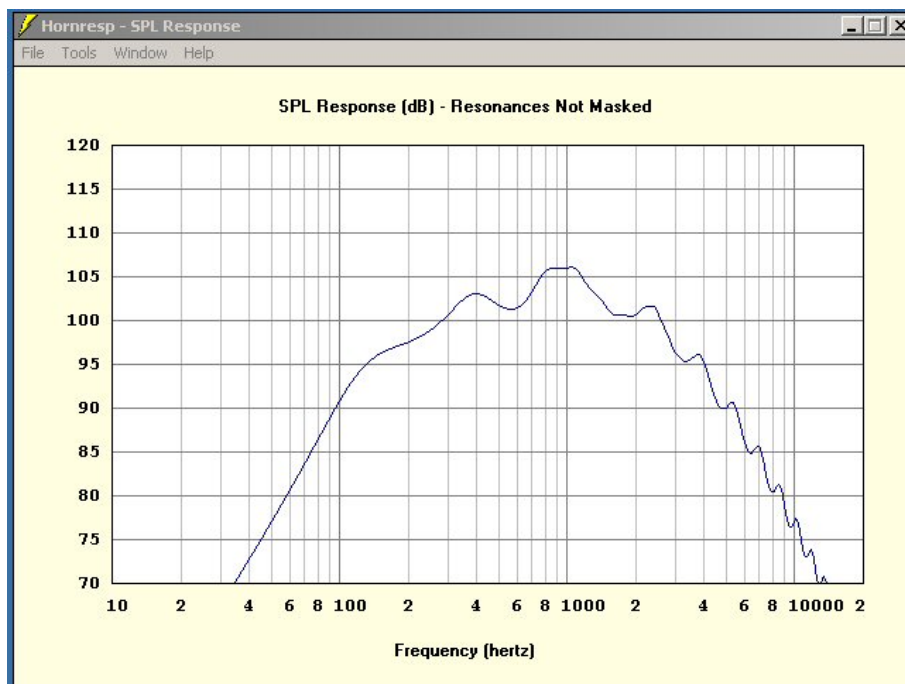
VTC = volume of chamber between the drive unit and throat

ATC is the average area of the above volume.

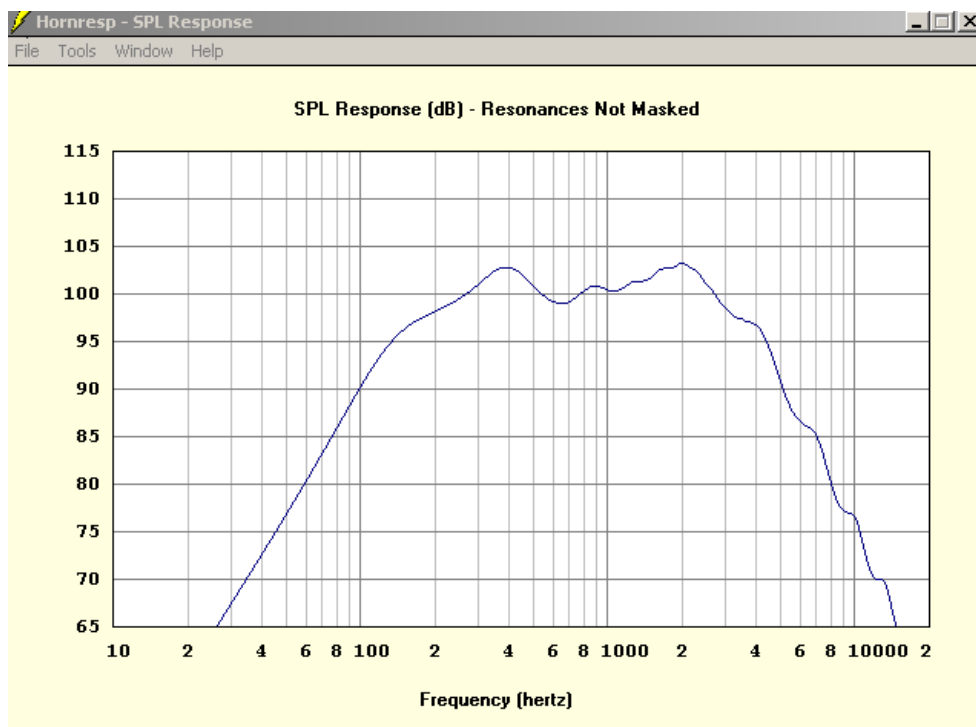
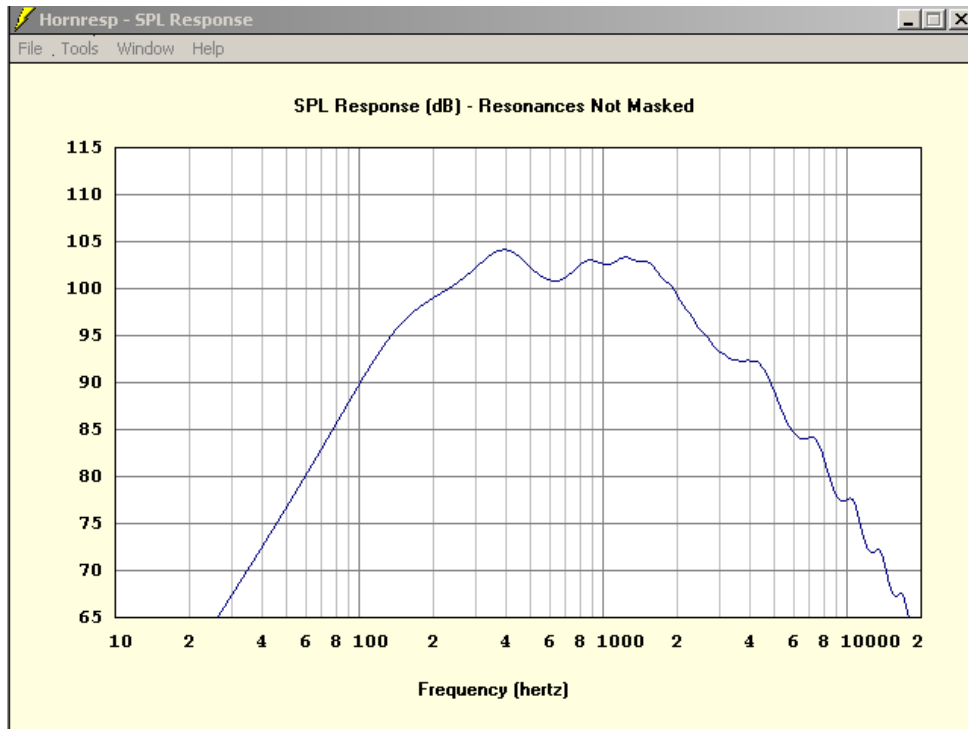
CIR = exponential horn mouth circumference in flare cut off frequency wavelengths.



The diagram above shows the response for the parameters in the previous table and gives a default starting point. The diagram below is basically the same horn as above but the initial slot length has been increased from 5cm to 10cm.

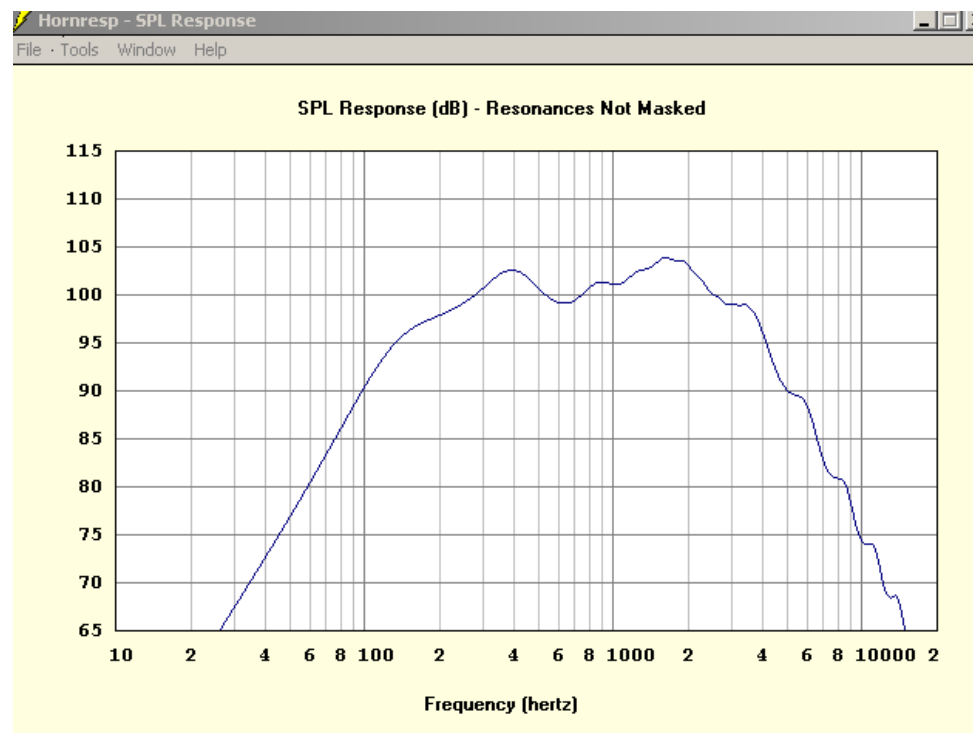
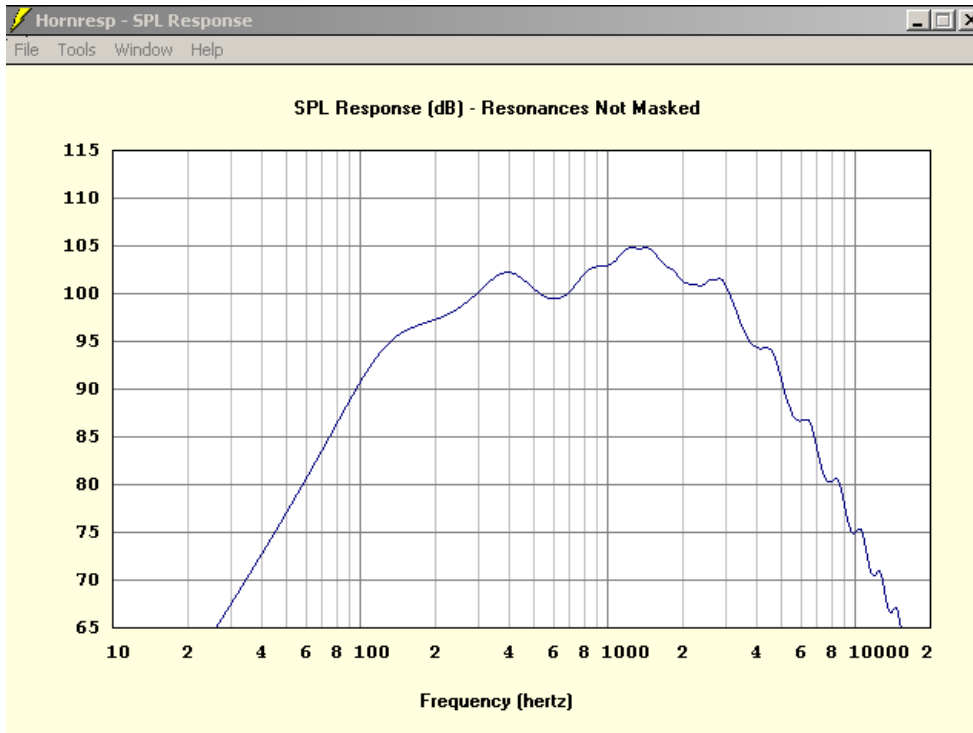


The diagram below returns the first section back to 5cm length but this time increases the throat area  $t$  from 40 cm square to 80 square cm . The main effect is that the high frequencies roll off slightly sooner. Just to see what effect reducing the throat area has. The second diagram below reduces the throat area down to 25 square cm.

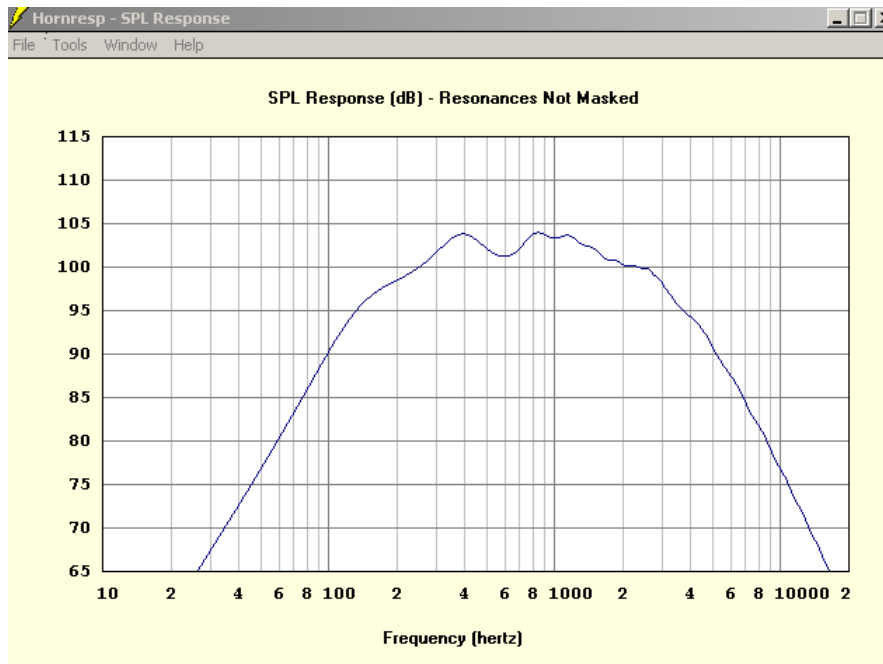


With a reduced throat are the frequency response is extended at the upper end but with a slight loss in the middle of its pass band.

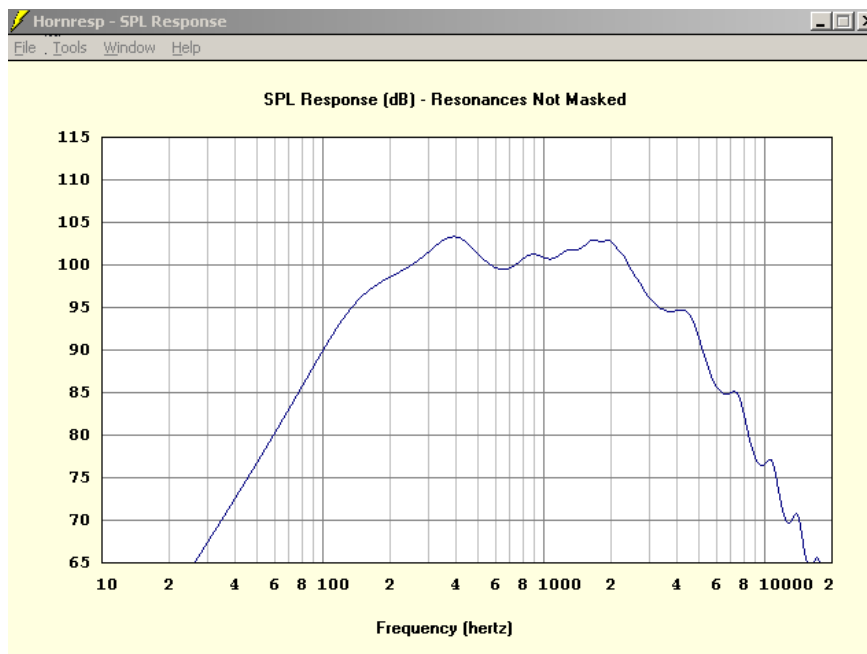
We saw that increasing the length of the initial section of the horn or slot put a peak in the response between 1-2KHz. Incorporating a slightly longer slot with a smaller throat might flatten off the rising response shown in the previous diagram. Below is the plot for the same horn as before (25sq cm throat) with an 8cm slot length. The peak is a little too much so the second graph shows the response with a 6cm slot length.



The slot and throat sections seem to affect the response above 700HZ but has little influence on the lower end of the response.

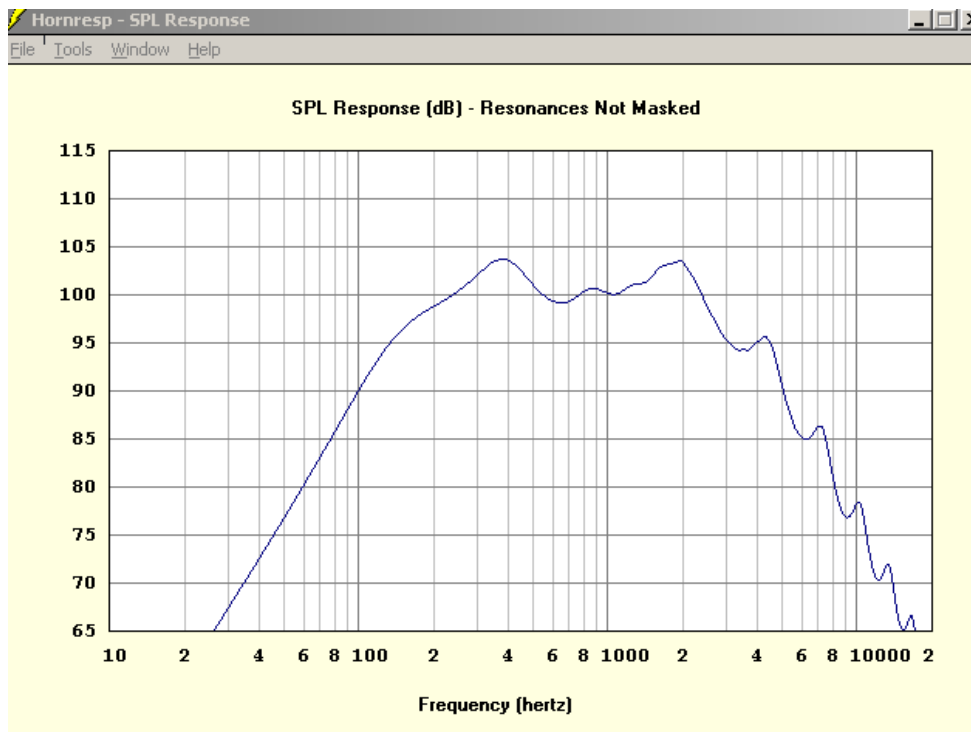


In the diagram above the throat and slot length have been returned to their original values but now the length of the transition region between the slot and the main flare has been lengthened from a nominal 0.5cm to 4cm. This has lifted the response between 400Hz and about 1200Hz, but the high frequency starts to roll off sooner. The diagram below shows a reduction from 0.5cm to 0.1cm.

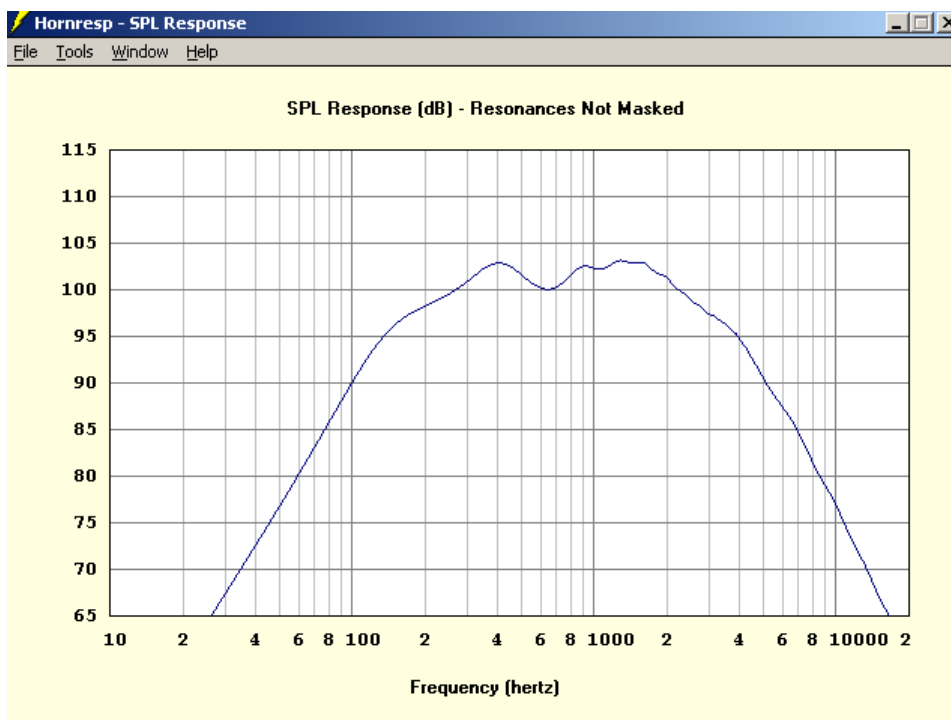


This shows a response almost back to the original

The next thing to try is a change in the size of the combined slot areas which acts as a discontinuity between the slots and the main horn. The original settings assumed that the mouth of each slot was 60sq cm giving a combined mid slot area of 120 and a total including the hi-frequency slot of 180 sq cm. If we add an extra 60sq cm to allow for the dividing wall thickness the throat of the main section goes up to 240sq cm. The result is shown in the plot below

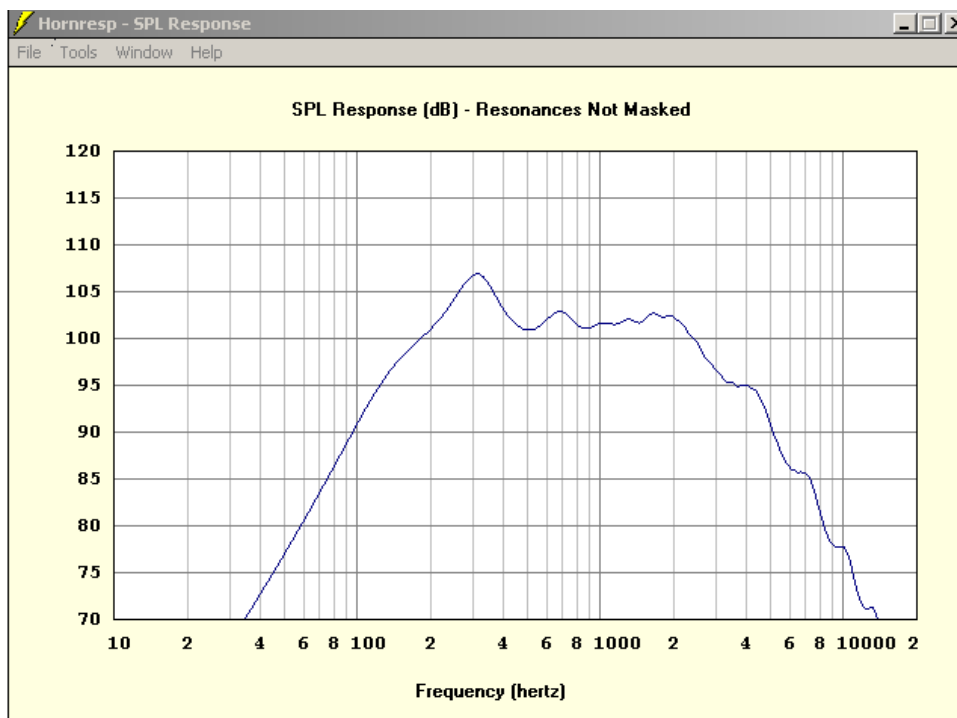


The main effect is a sharpening of the resonance peaks at the upper frequency range. Would these be reduced if the discontinuity at the slot mouths could be reduced. The plot below eliminates the discontinuity altogether.

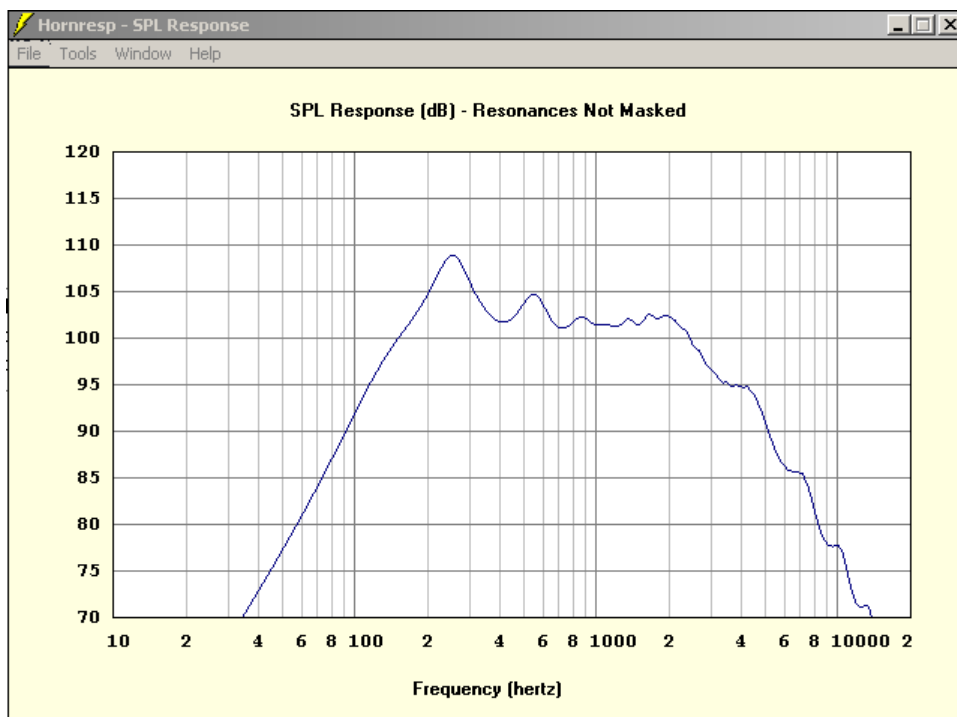


The top end roll off is now smoother but the low frequency response remains the same.

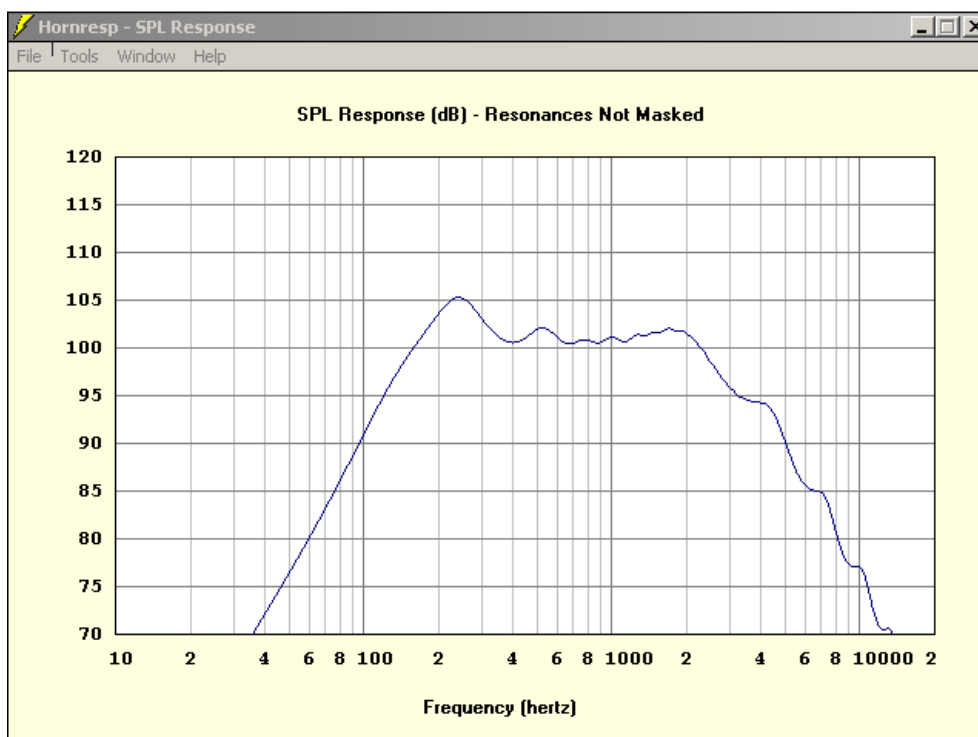
The next thing to do is alter the main flare to see the effects that it has. To start off the length of the horn is increased from 20cm to 30cm.



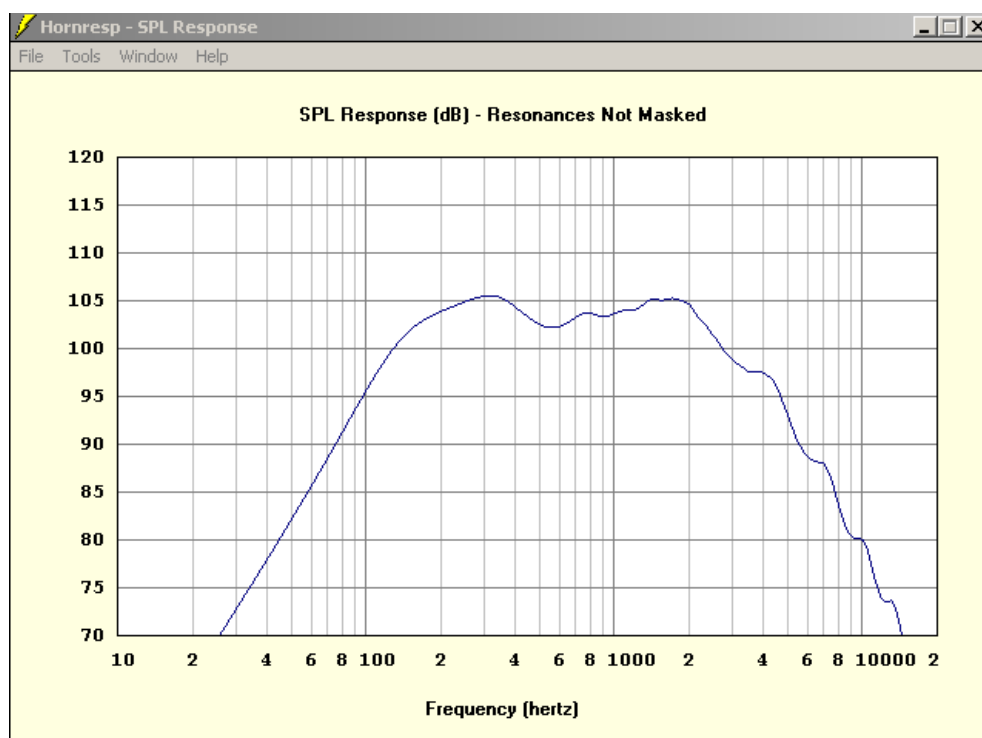
The effect has been to shift the peak in response down from 400Hz to 300Hz and increase the amplitude a few dB. If we continue to increase the length of the horn the peak should move to an even lower frequency. The next plot shows a horn length of 40cm,



Not only has the main peak shifted downwards and more accentuated, the secondary peak has also increased in amplitude. And a third ripple has become apparent. These ripples in response are obviously related to the length of the horn and thus fixed for a given cabinet size. As the cabinets are designed to be used in an array the combined mouth size will be larger so before reducing the horn length we can see what effect doubling the mouth size has.



The peaks are still there but at a reduced level. The next step is to go back to the original design and simulate the effect of two cabinets. This is done by using the feature to double the number of drive units, keeping all the lengths the same but doubling all the cross sectional areas.



The peak is much reduced and apart from a gentle dip that bottoms out about 2.75dB down between 500–600Hz the graph is pretty flat. The final page shows the input parameters that were used for the above graph, so that if anyone has any comments about how the horns were modelled or any problems with these predictions they have all the details. Also as with the parameters given earlier it is a starting point for those who wish to experiment.

**Hornresp - Input Parameters**

File Tools Window Help

ANG: 4.0 x Pi	VEL: 34400.00	DEN: 0.001205	FTA: 51.32
S1: 80.00	S2: 240.00	CON: 5.00	F12: 0.00
S2: 240.00	S3: 360.00	CON: 0.50	F23: 0.00
S3: 360.00	S4: 4000.00	CON: 20.00	F34: 0.00
S4: 0.00	S5: 0.00	L45: 0.00	F45: 0.00

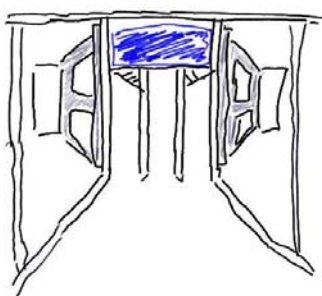
---

SD: 506.80	CMS: 6.50E-05	MMD: 28.00	RE: 1.80
BL: 8.00	RMS: 3.72	LE: 0.05	ES: 2.83

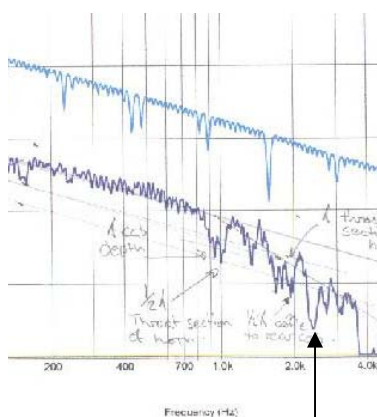
VRC: 16.00	FR: 20.00	VTC: 80.00	<b>CAUTION:</b> CIR > 1 for S3
LRC: 8.00	TAL: 5.00	ATC: 500.00	

Comment: slot2

Looking at the slot in more detail and forgetting the horn we can look at some of the problems that might be expected from this design method.



Each slot can be considered narrow enough to radiate omnidirectionally in the horizontal direction. When the distance between the centre lines of each outer (midrange slot) is equal to one half wavelength of the frequency being radiated the sound from each slot will cancel out with the other. This would normally cause a narrowing of the radiation pattern, but if we consider the radiating slots as different parts of a diaphragm driving the throat of a horn the result would be a dip in response. Using the dimensions of the original horn that I built, the dip in response should occur at 2293Hz.



The graph on the left (shown in more detail on the web page) indicates just such a notch in the response at close enough that frequency. If the high frequency slot is radiating in phase with the mid range at this frequency this notch should not occur. I would consider this point to set the maximum cross over point from mid to high. Using DSP it might be worth experimenting with different roll off rates, frequency overlaps and delays to get the smoothest response through this frequency range.