HORNRESP TUTORIAL

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Version	Date	Notes
1.0	2-3-25	Initial release
2.0	2-6-25	Added tapered TL example.

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Genesis:

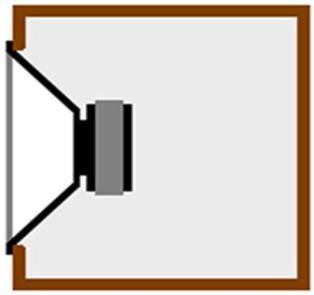
Several recent discussions on https://diy.midwestaudio.club/ revolved around Transmission Lines and modeling and simulation applications, notable Hornresp by David McBean. I offered to create a tutorial focused on high fidelity (not professional sound reinforcement) designs. More on those differences somewhat later in this document.

Scope and Focus of this Tutorial

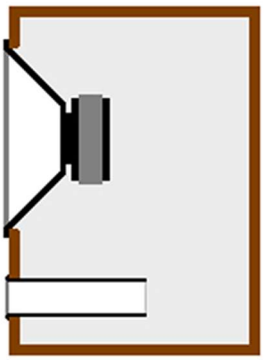
This document will attempt to show how to use Hornresp to model various types of loudspeaker enclosures with specific emphasis on types of transmission lines that are usually used in high fidelity applications. Specifically, one particular mid woofer will be modeled in several different enclosures and simulation results will be studied in depth.

“Legacy” types of loudspeaker enclosures”

Sealed or closed box:



Bass Reflex or Ported:

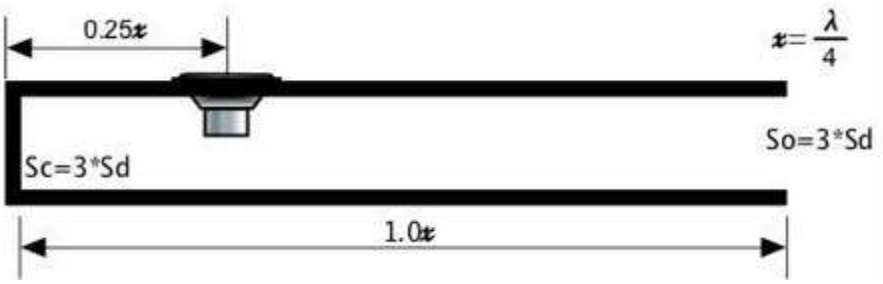


“Transmission Lines” types of loudspeaker enclosures”

Pay little attention to the parameters and equations below.
These are historical “best practices” and “rules of thumb”, but are no longer used since there are very good modeling programs that can optimize or modify any of these parameters.

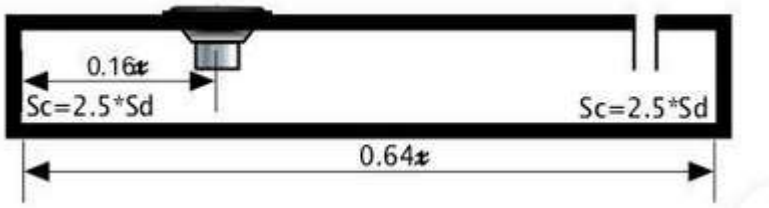
“Straight” Offset Driver Quarter Wave Transmission Line

Exit dimensions are the same as the “origin” of the line.



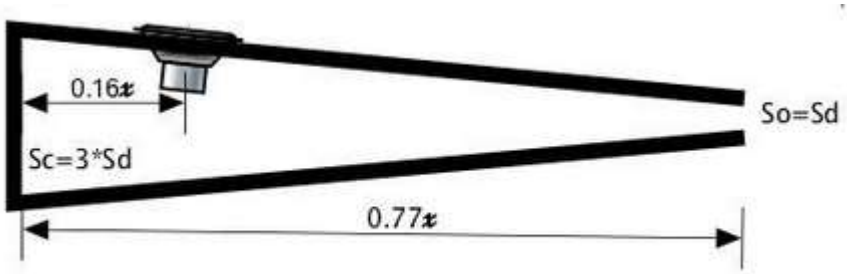
“Mass loaded” Offset Driver Quarter Wave Transmission Line

The design is mass loaded by the volume of air contained in the port.



“Negative Taper” Offset Driver Quarter Wave Transmission Line

Exit dimensions are smaller than the “origin” of the line. Often a 10:1 ratio is recommended.



There are many, many other types of horns, but I am not an expert at designing or using them. You can find different types in Hornresp if you want to play with them.

Other sources of Hornresp and/or TL information:

Home Theatre Shack Hornresp for Dummies

The posts that got me “over the hump” into productive use. Highly recommended!

https://forum.speakerplans.com/guide-to-winisd-pro-and-hornresp_topic1314_page1.html

Brian Steele – Subwoofer guru. Explains and models Bandpass, tapped Horn and other designs and alignments. Also has an Excel spreadsheet to optimize folded TLs and Horns.

http://www.diysubwoofers.org/

Very good explanation of many or all of the fields in Hornresp
In some cases the information is no longer correct for current versions of Hornresp

https://www.hometheatershack.com/threads/hornresp-for-dum-hmm-everyone.36532/

Wayback Machine Voight Pipe designs

Much of this was determined empirically, not via modeling and simulation.
Some of Bob Brines designs is shown – he had some success with his designs, and used MJK's Mathcad worksheets.
Wayback Voight Pipe

SpicyTL web pages

Quite technical discussion of various aspects of TLs, along with his SPICE model. If you are a SPICE person, this could be a great resource.

HORNRESP "GOTCHAS"

A continuing source of confusion is that many of the input fields in Hornresp can change units or function when single-clicked, double-clicked or with a keyboard character when the field has the focus. Here is an excerpt from "Dummies":

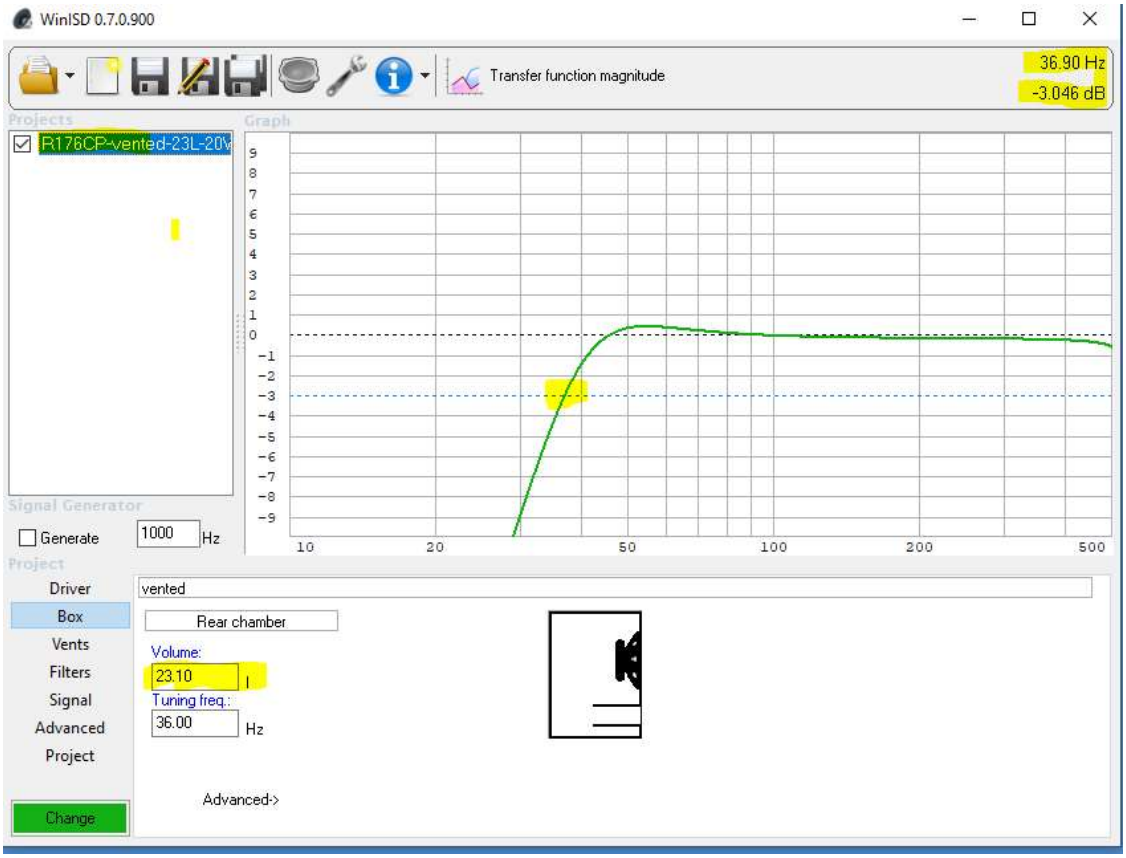
"….almost everything on this screen can be double clicked to alter it, or pull up another window to input options. Text, and input blocks alike. ……you will want to play with this some to see what is there.

Worked examples

To simplify and normalize all examples, I will use the Rival R176-CP driver.
Thiele/Small specifications:

```
Revc = 6.35 Ohm
Fr   = 34 Hz
Sd   = 132.000 cm²
Vas  = 30 m M³
Cms  = 1.16m M/N
Mms  = 18.6 g
BL   = 8.00 T·M
Qms  = 6.215
Qes  = 0.398
Qts  = 0.374
Le   = 0.134 mH
SPLo = 87 dB
Xmax = 6 mm
Continous Power = 75w (IEC 268-5)
```

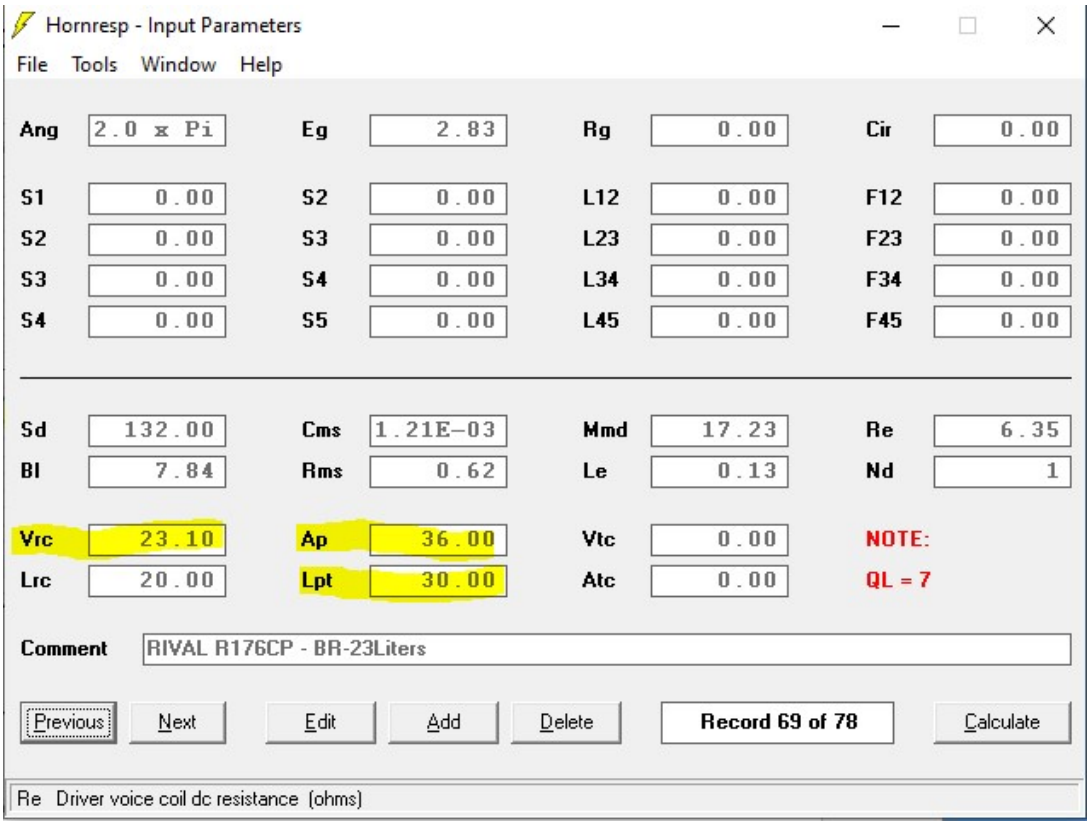
WINISD model for 23 Liter ported box:



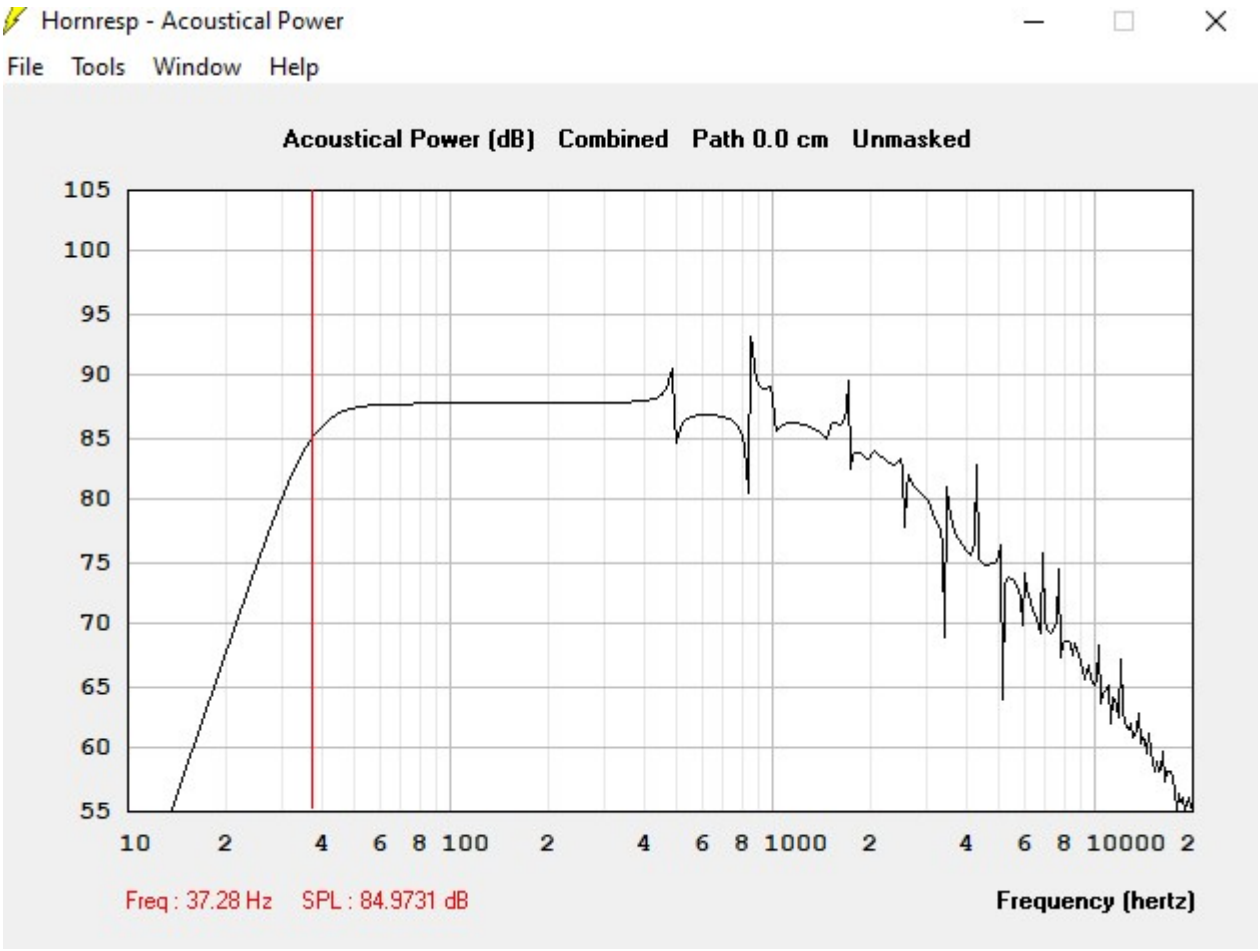
SO: 23 Liters = 37Hz F3

HORNRESP SIMULATION Bass Reflex box

Rival R176CP 23 Liters



Vrc = Volume Rear Chamber = 23.10 Liters
Ap = Area of Port = 36.0 cm^2
Lp = Length of Port = 30.0 cm

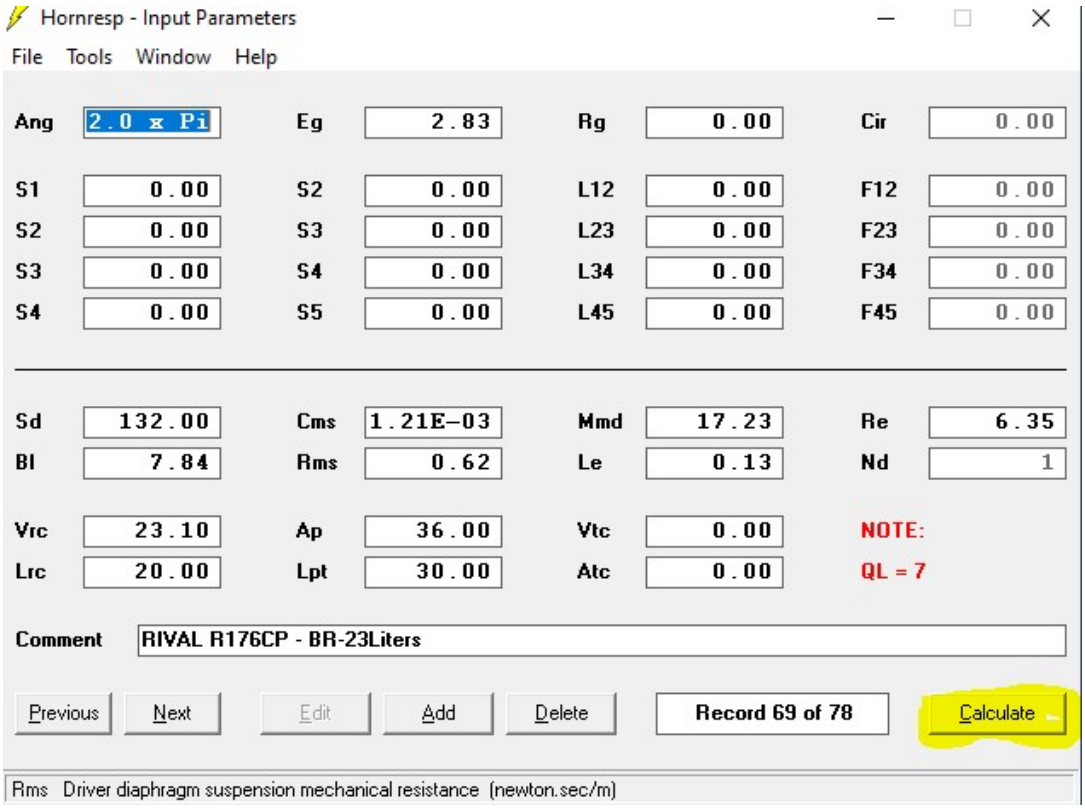


Looks like F3 is about 37Hz

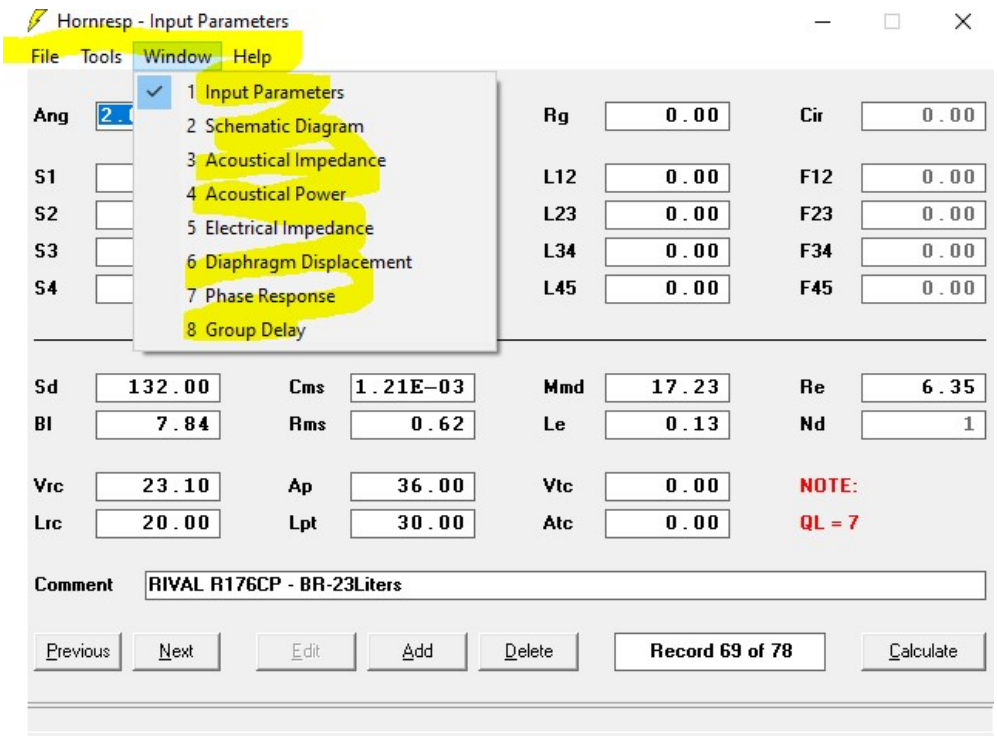
As it should, since they are both Bass Reflex models.

More Hornresp tips

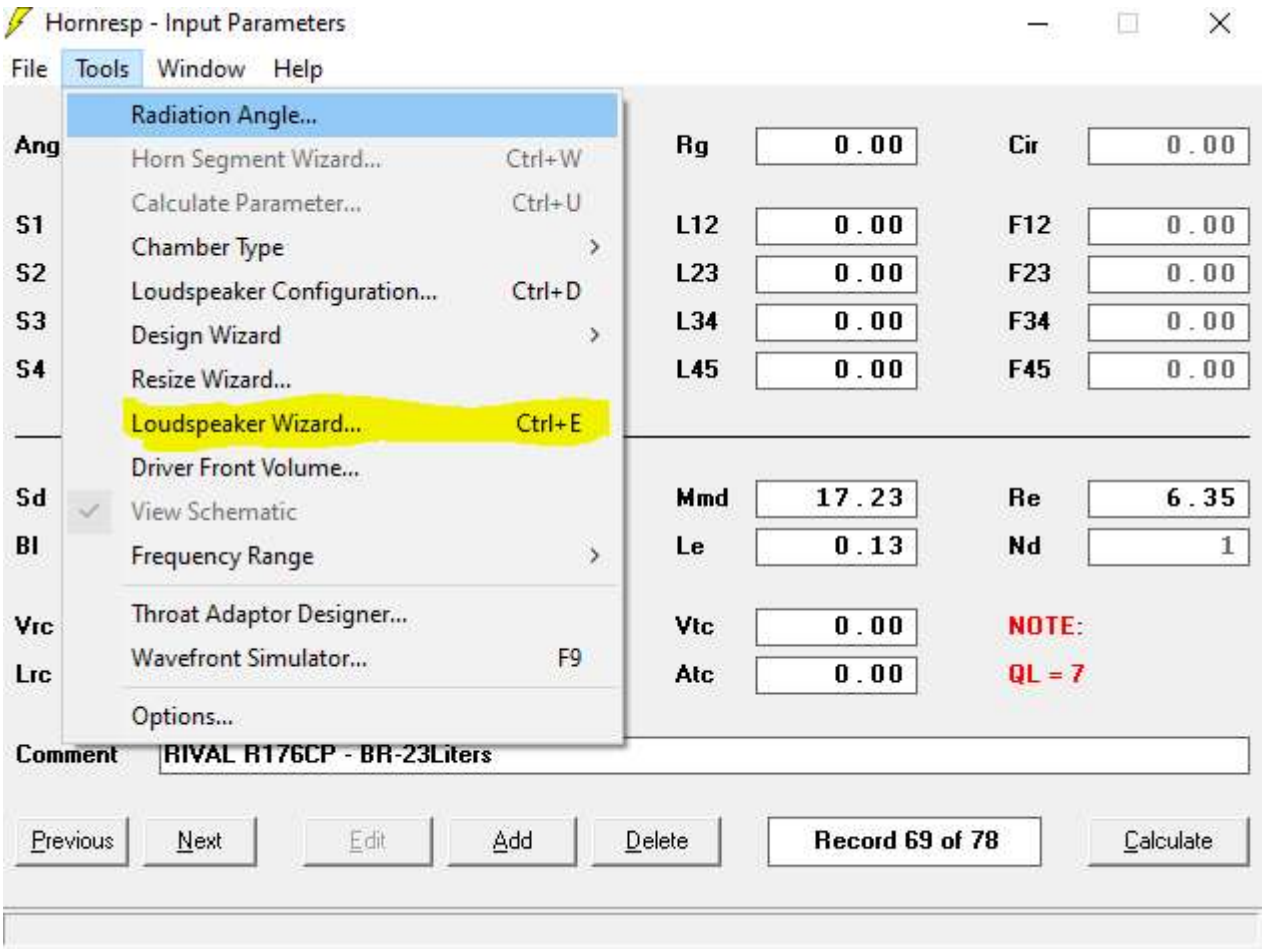
To be able to do most anything, you need to press “Edit” and then press “Calculate”



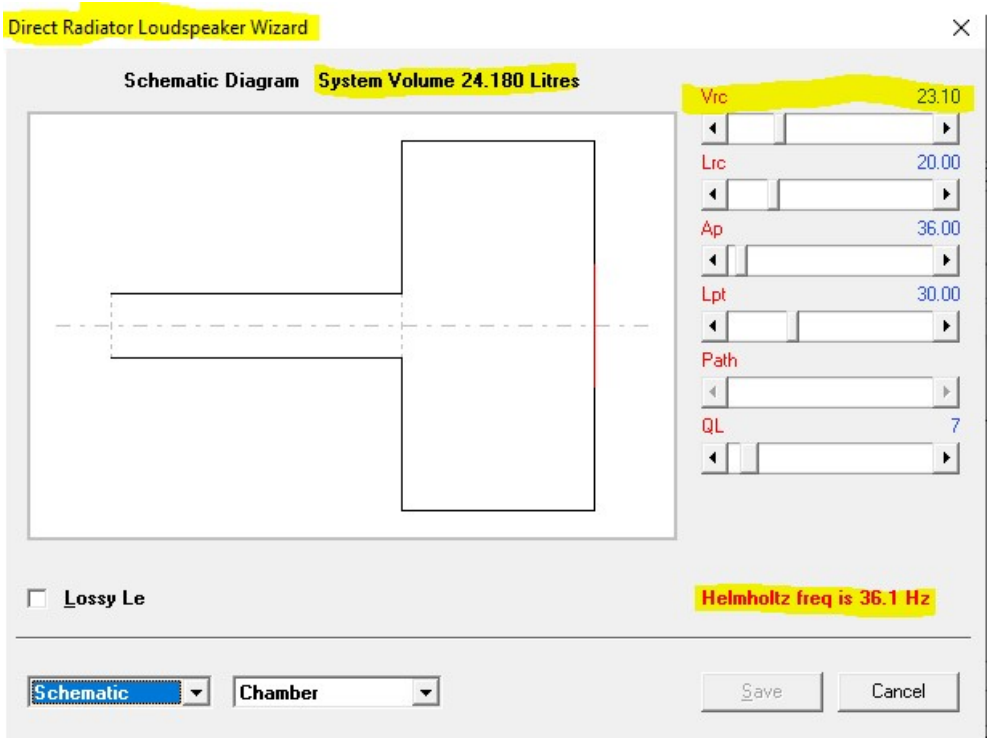
From the Input Parameters screen, after you Calculate, you can get panels with useful graphs and numbers.



From the Input Parameters screen, after you Calculate, you can get to a panel titled Loudspeaker Wizard. NOTE: it seems like you can ONLY launch the Loudspeaker Wizard from the Input Parameters panel.

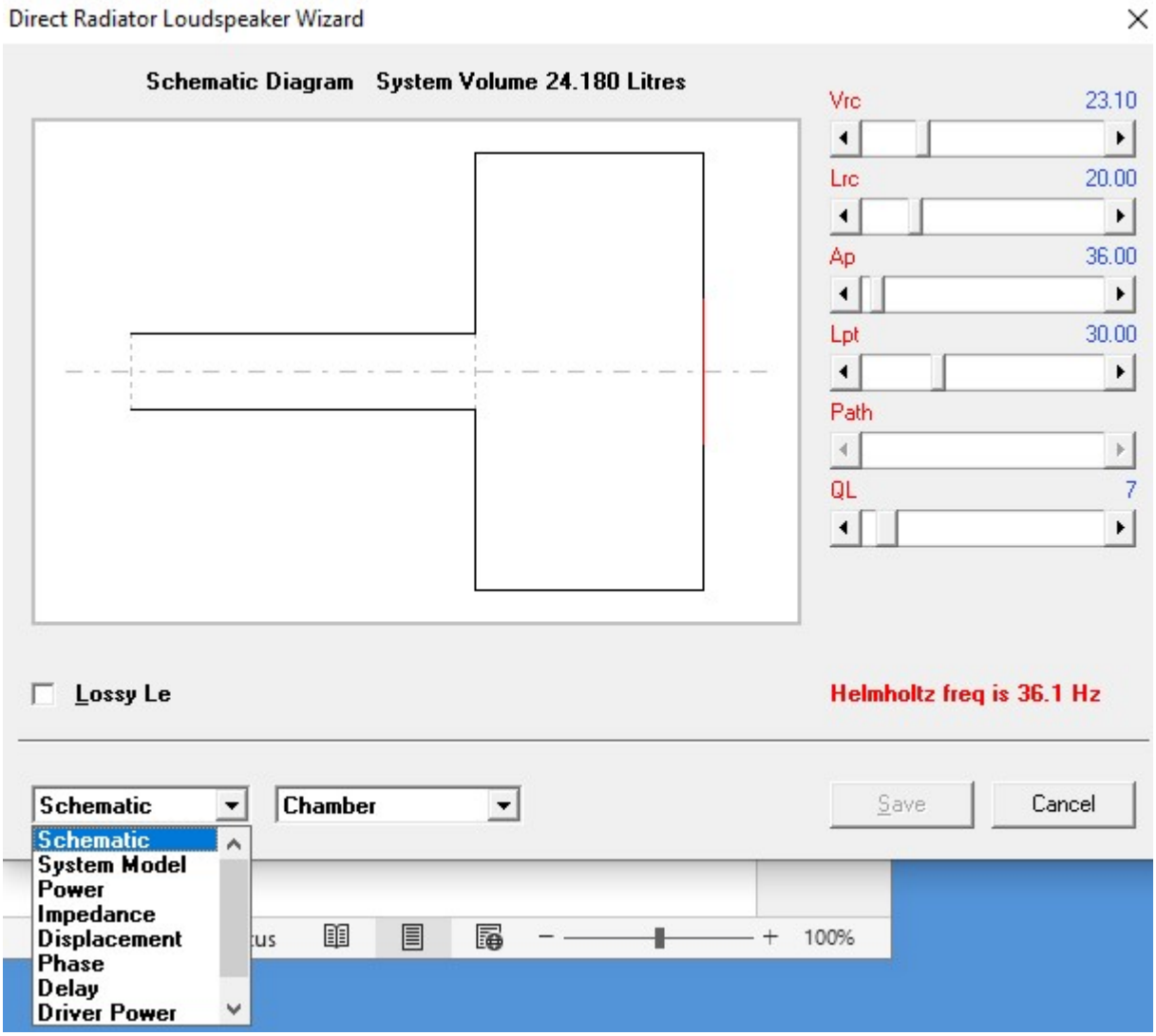


You will do a lot of your work in this panel

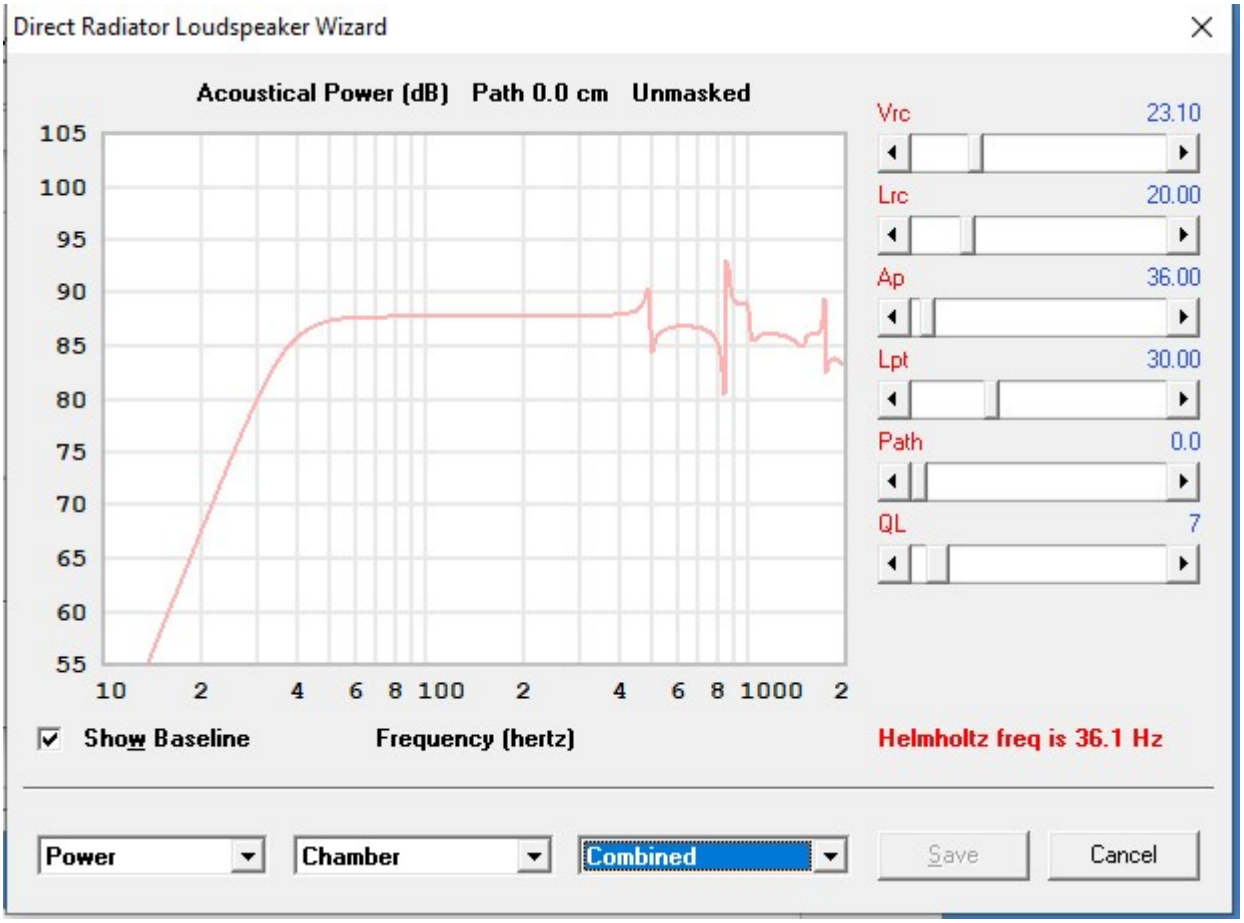


So here we see that the VRC is still 23.1 Liters, but the System Volume is 24.18L
So it is considering the port as part of the total volume.

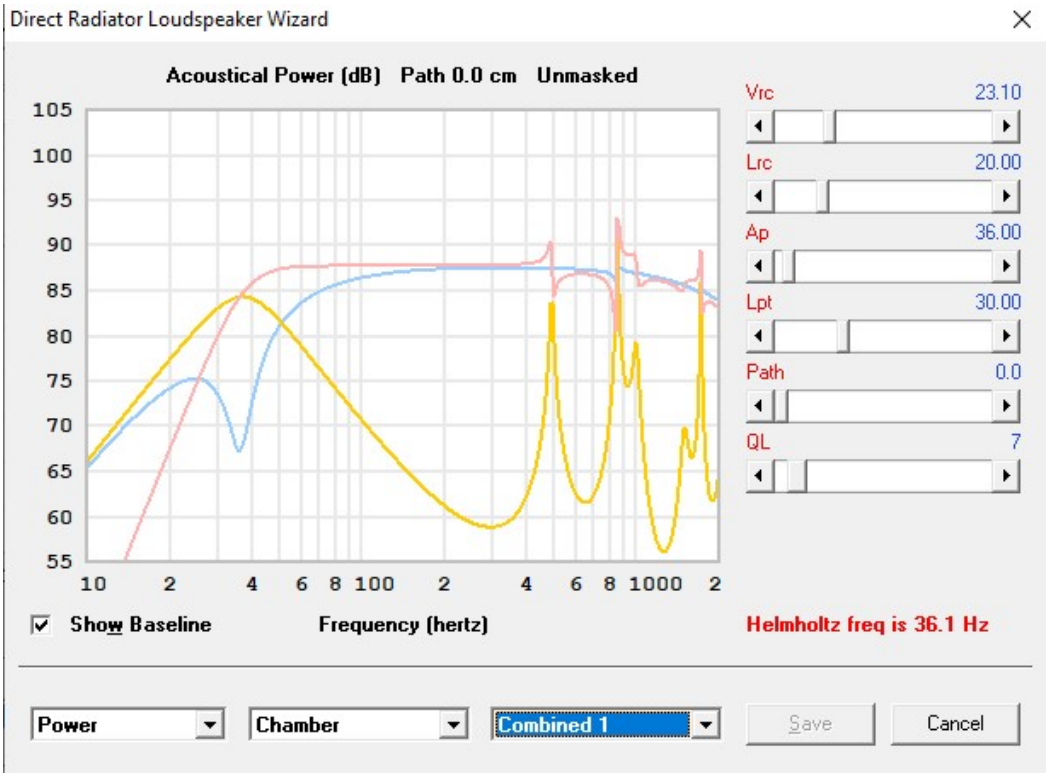
See that dialog box “Schematic” in the lower right?
That’s a pulldown chooser for different parts of the Loudspeaker Wizard



Here is the usual “SPL” graph which is called “Power” “Combined”

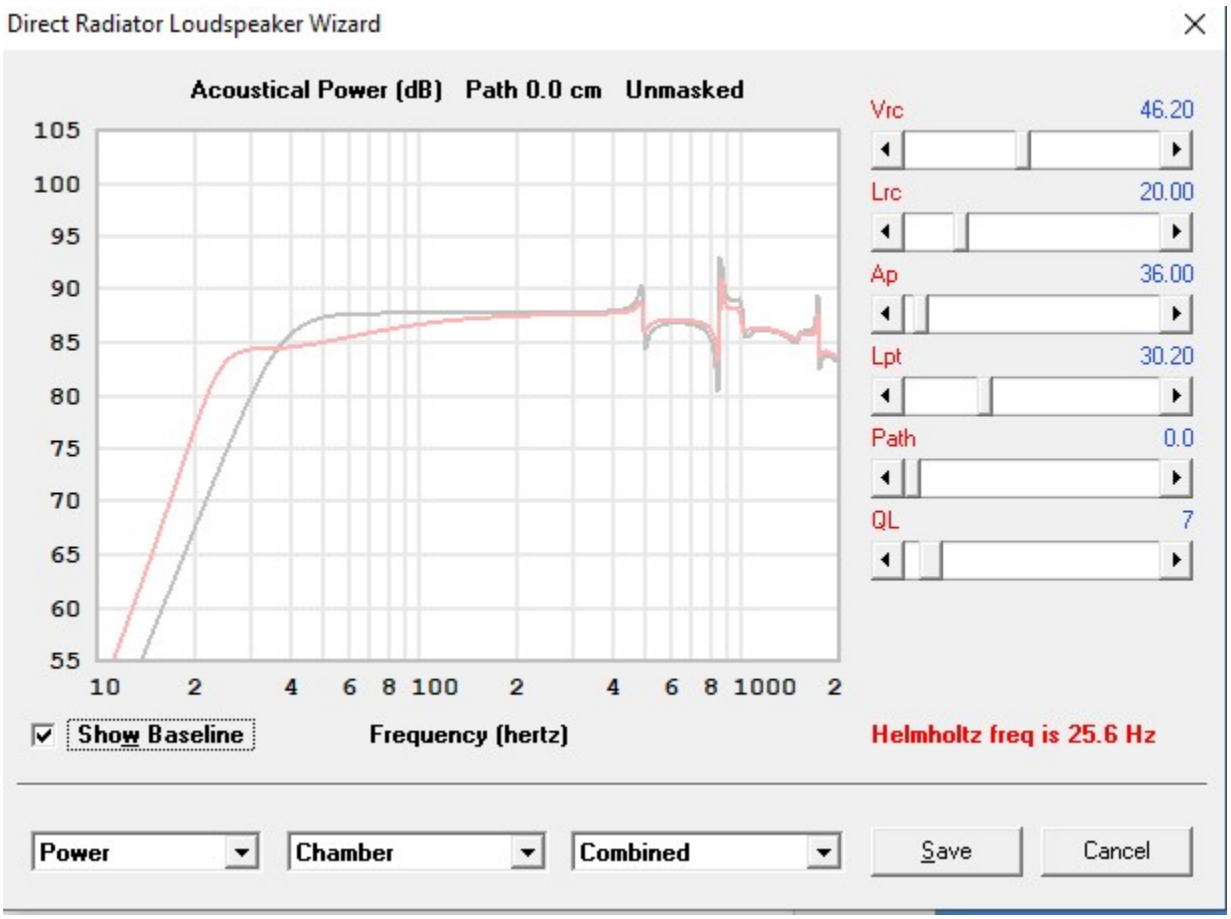


Or you can look at Woofer, Port and System combined:



Here I played with doubling the size of the box to 46 L
More of an EBS alignment.

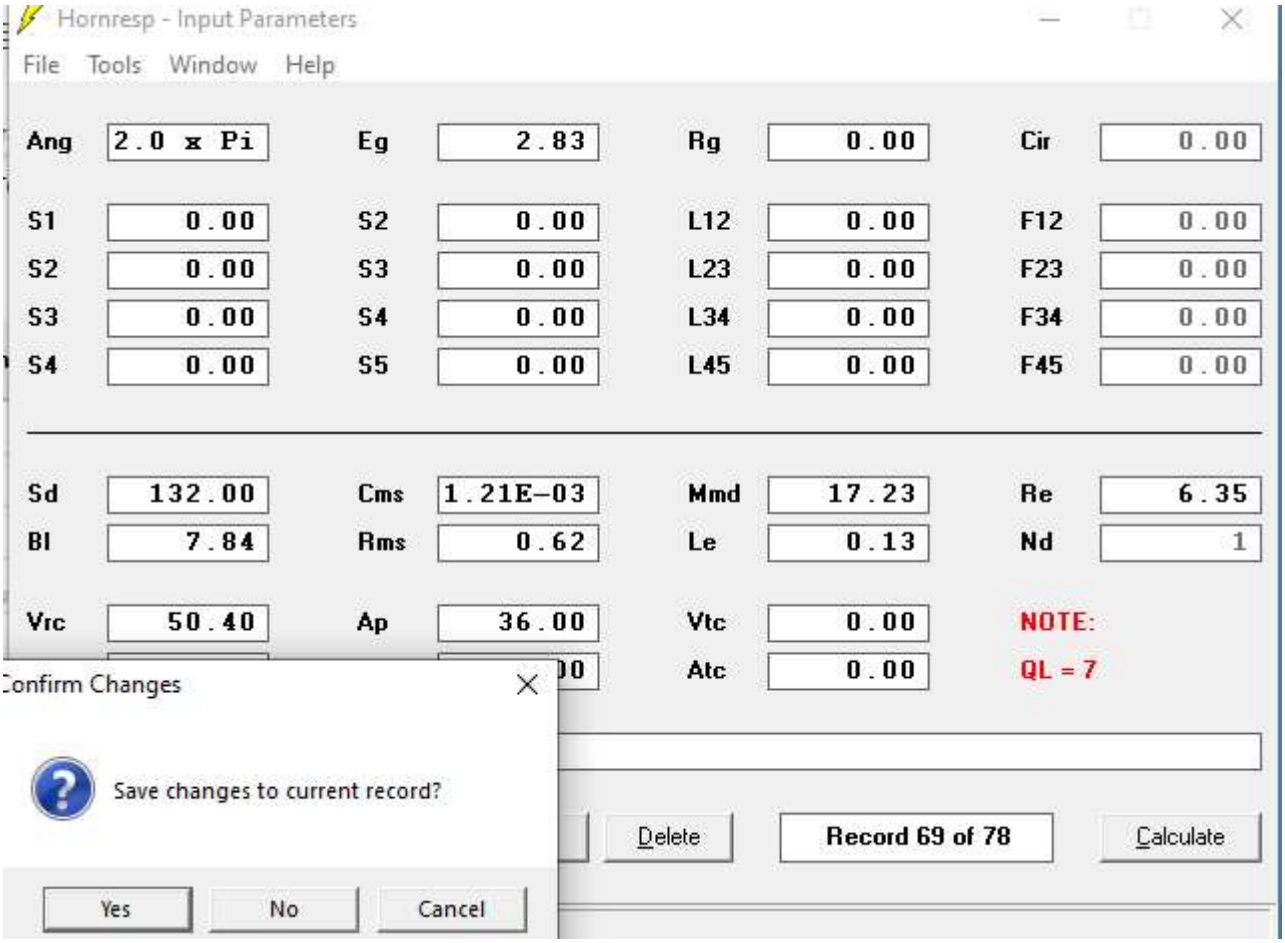
By default, the panel shows the baseline in Grey (before you made any changes), and the current simulated response in Red.



Hitting “Cancel” will immediately lose any work you have done in this wizard.
You must hit “Save” if you want the data.
The panel will disappear, and the data from the Wizard will be now incorporated in the main application, but you must hit “Calculate” to be able to see it.

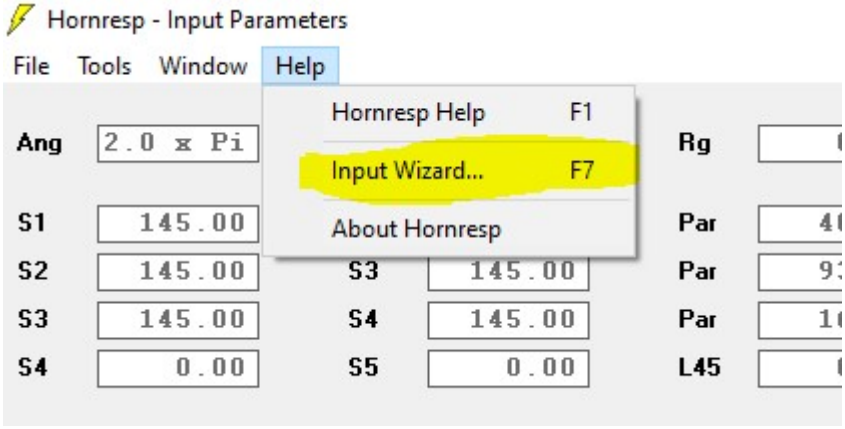
There is no way that I have found in the Hornresp Bass Reflex dialogs to specify wall lining or box stuffing.

If you have made changes, you will be prompted to Save if you try to move to another model

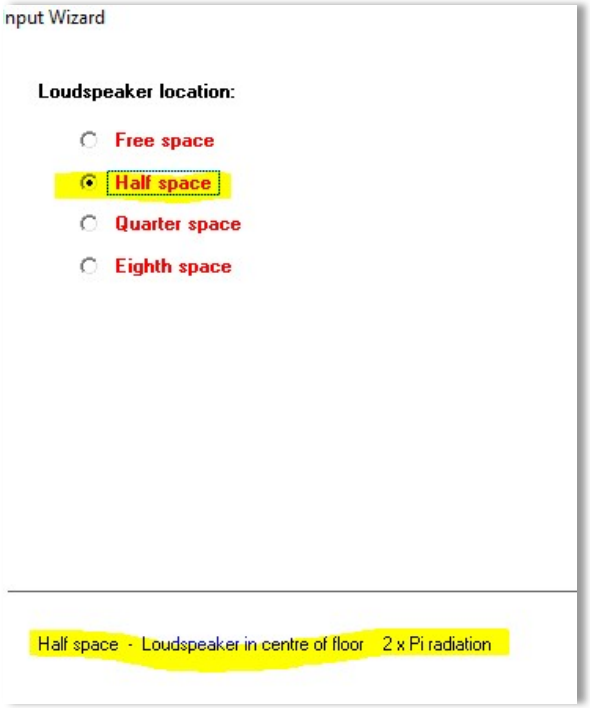


HORNRESP Mass Loaded Transmission Lines

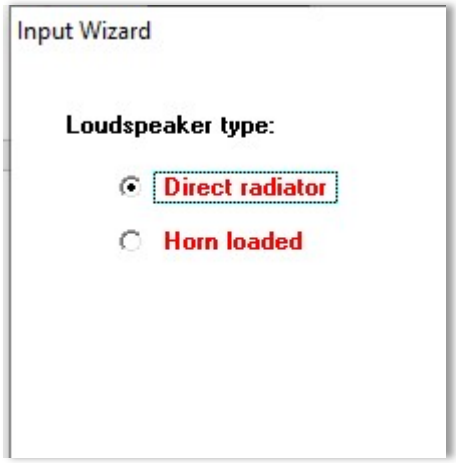
After you have generated a box model in WinISD or other application, it is highly recommended to use the Hornresp “Input Wizard” to make the basic choices.



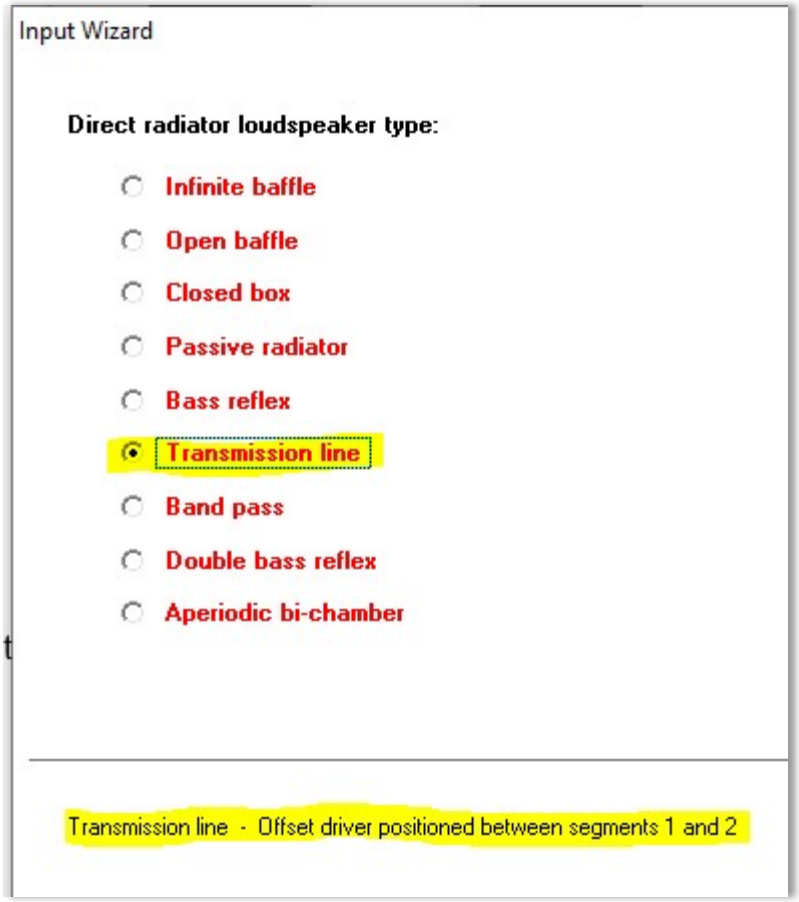
Always choose “Half Space” unless you have a specific need for other positions.



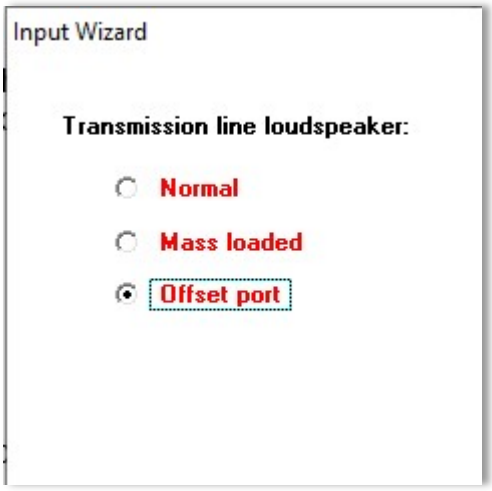
Everything I do is “Direct Radiator”. But you can play with the other choices.



Then

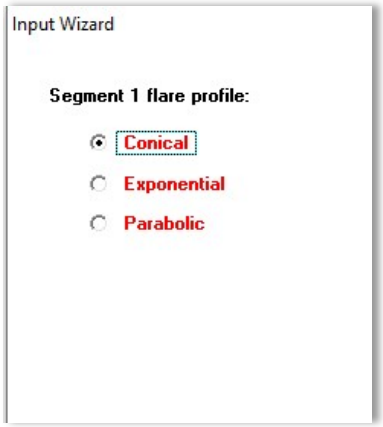


We are going to model a Mass Loaded Transmission Line
(Like a long bass reflex box with a port)

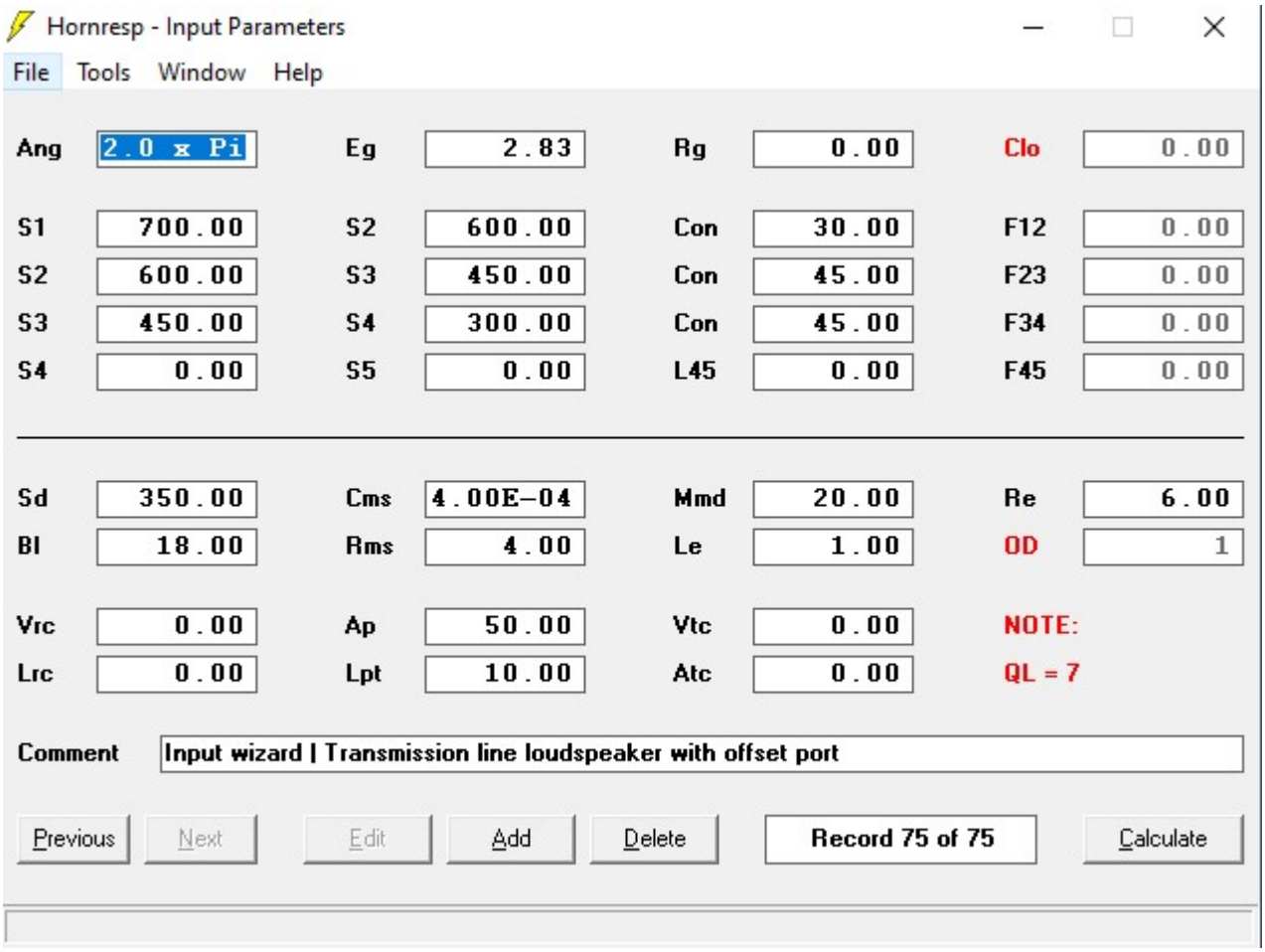


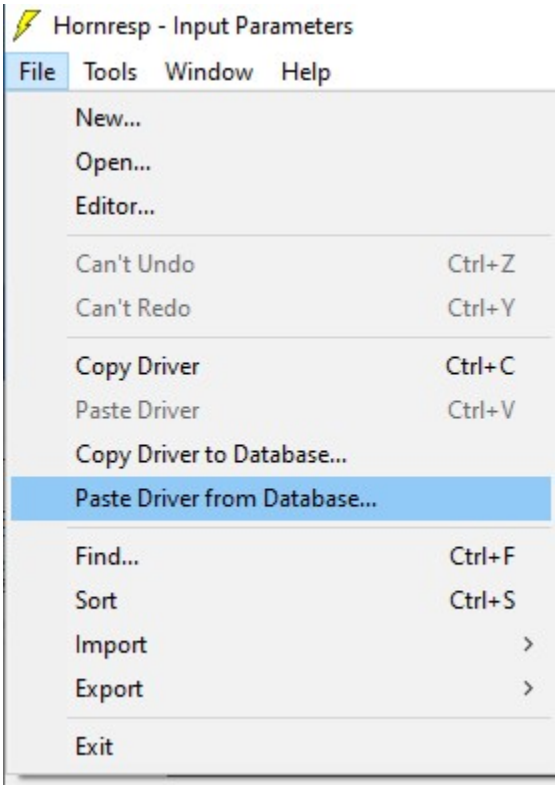
Note, several TL experts have advised that you want to place the port about 3-4 inchs up from the end of the line. For that you would need to choose “Offset Port” in this dialog.

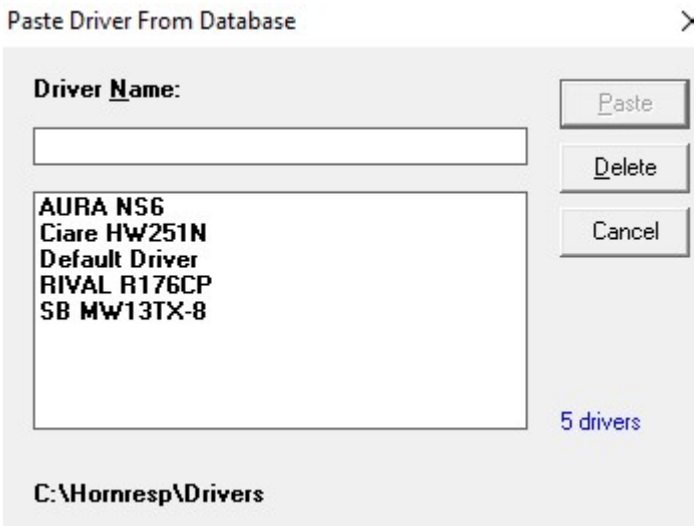
In Hornresp, a “Conical” profile is what you normally want.



So at this point, Hornresp has chosen some kind of wonky subwoofer driver, but we can easily change that.

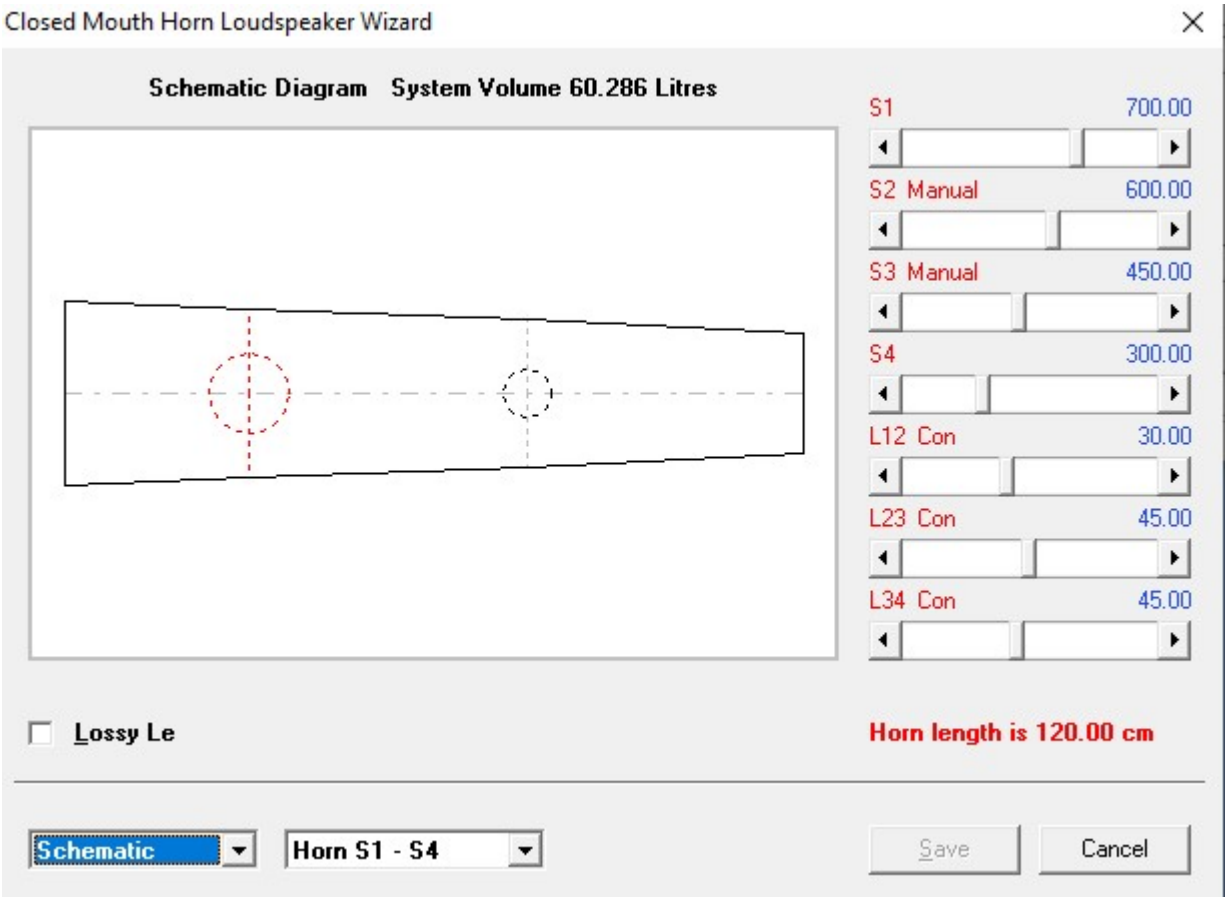






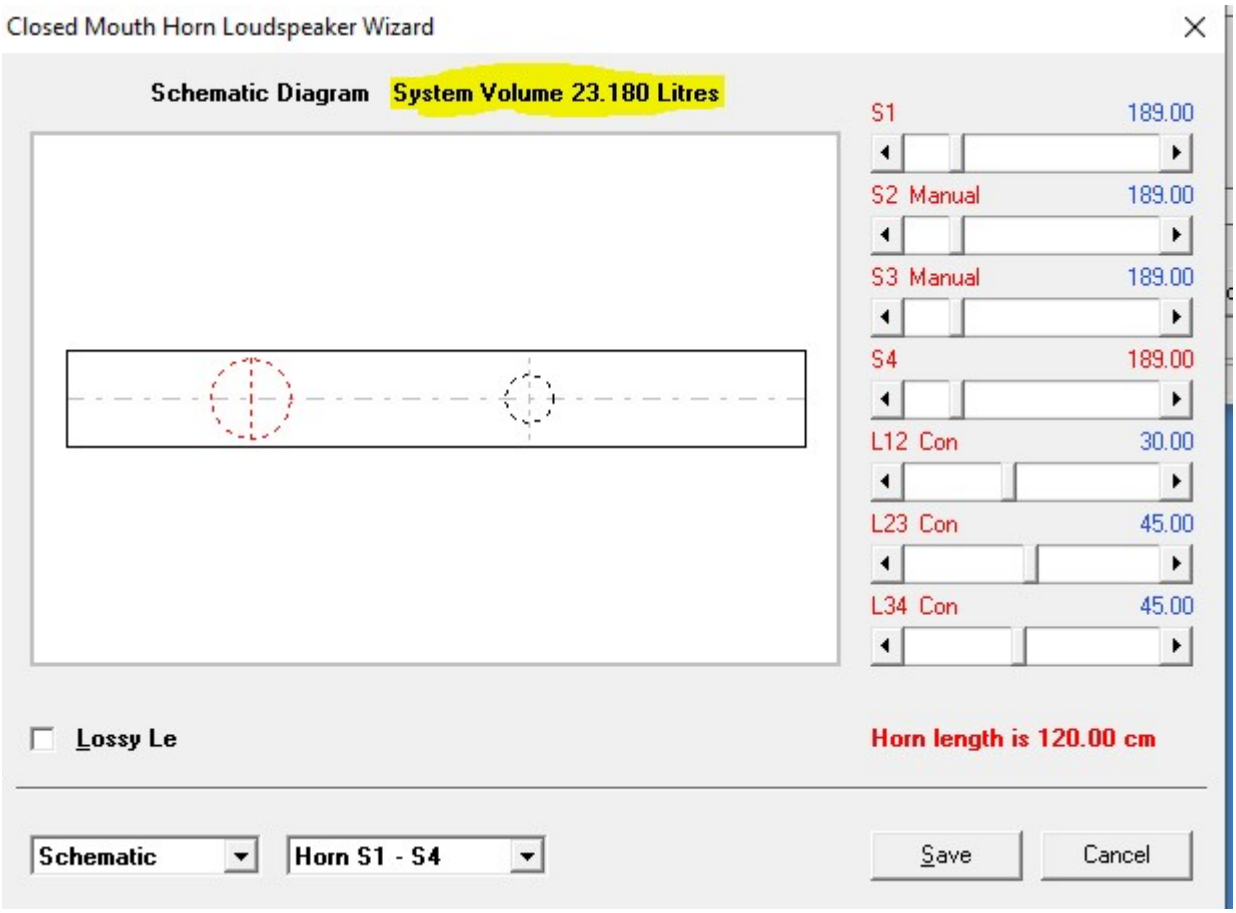
And I will paste in the Rival R176CP

This is what came out of the wizard with the correct driver.
Couple of problems – the box is way too big, and I don't want the taper. Easily fixed in "Loudpeaker Wizard"



So I want the volume to be 23.1L, and the line length to be about 140cm

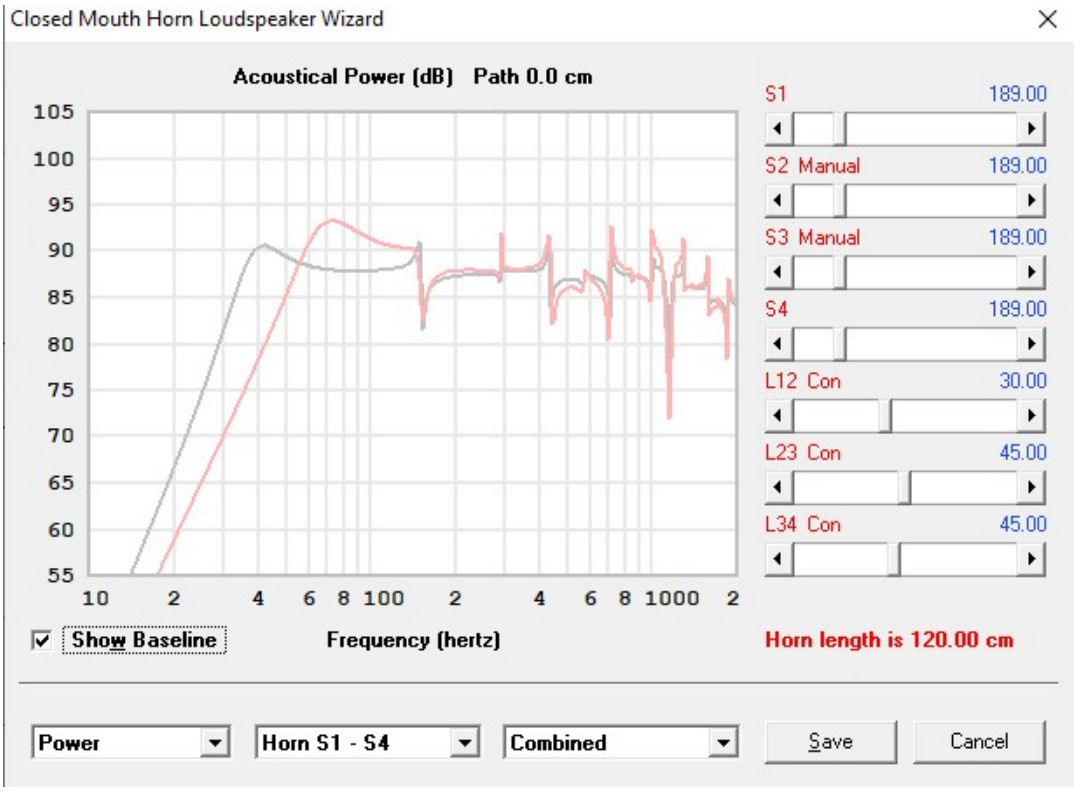
Now the volume is ok, but I want the line length a little longer, and I probably want to move the port lower.



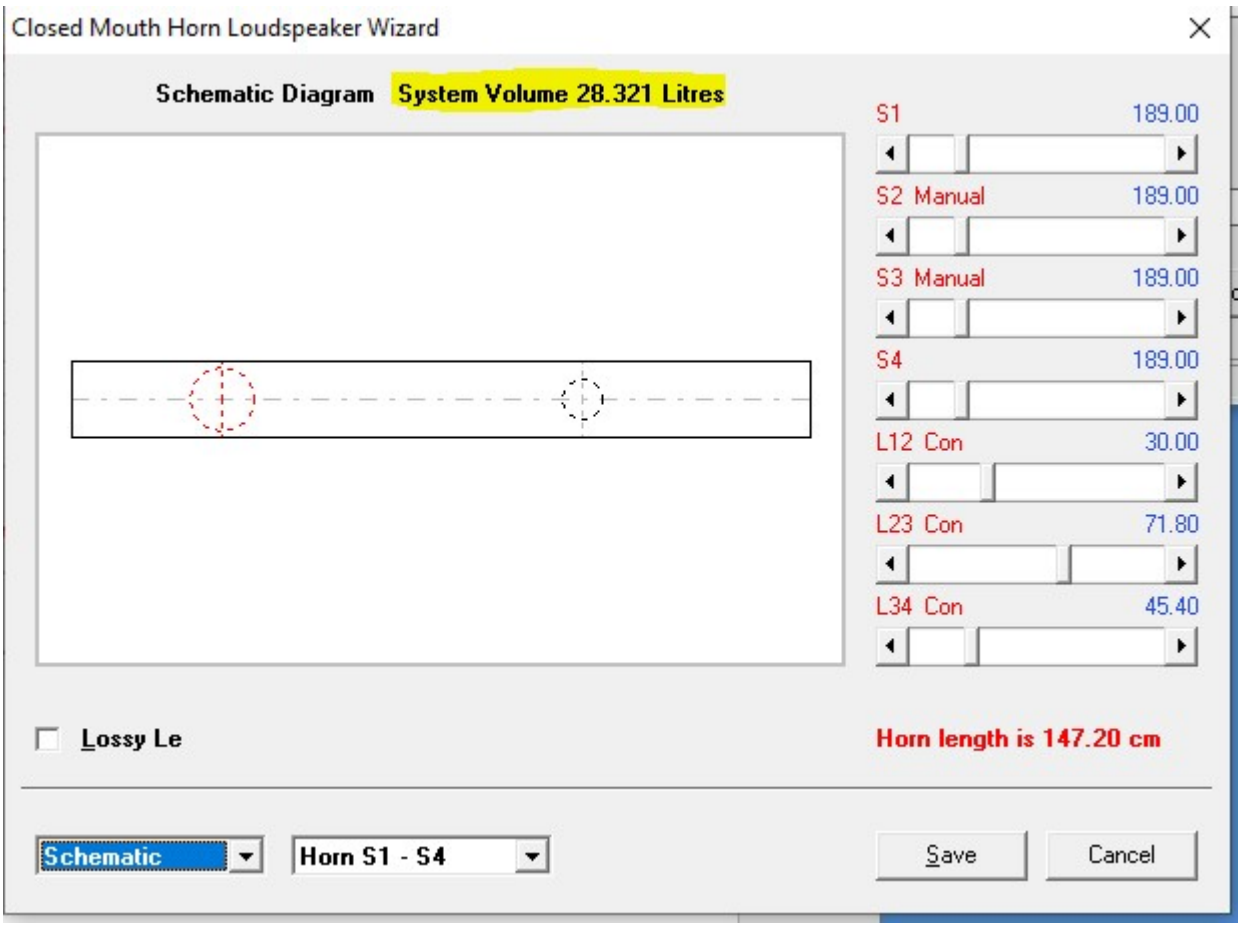
Notice those “L” parameters?
For the TLs I design and build, the center of the woofer is ALWAYS at the boundary of Segment 1 (S1) and Segment 2 (S2). This is controlled by L12 Con (The connector between the closed end of the TL up to Segment 2 (the center of the woofer). We will play with that parameter later.

Similarly, L23 Con is the length of the line between the center of the woofer (start of Segment 2) up to the center of the port.

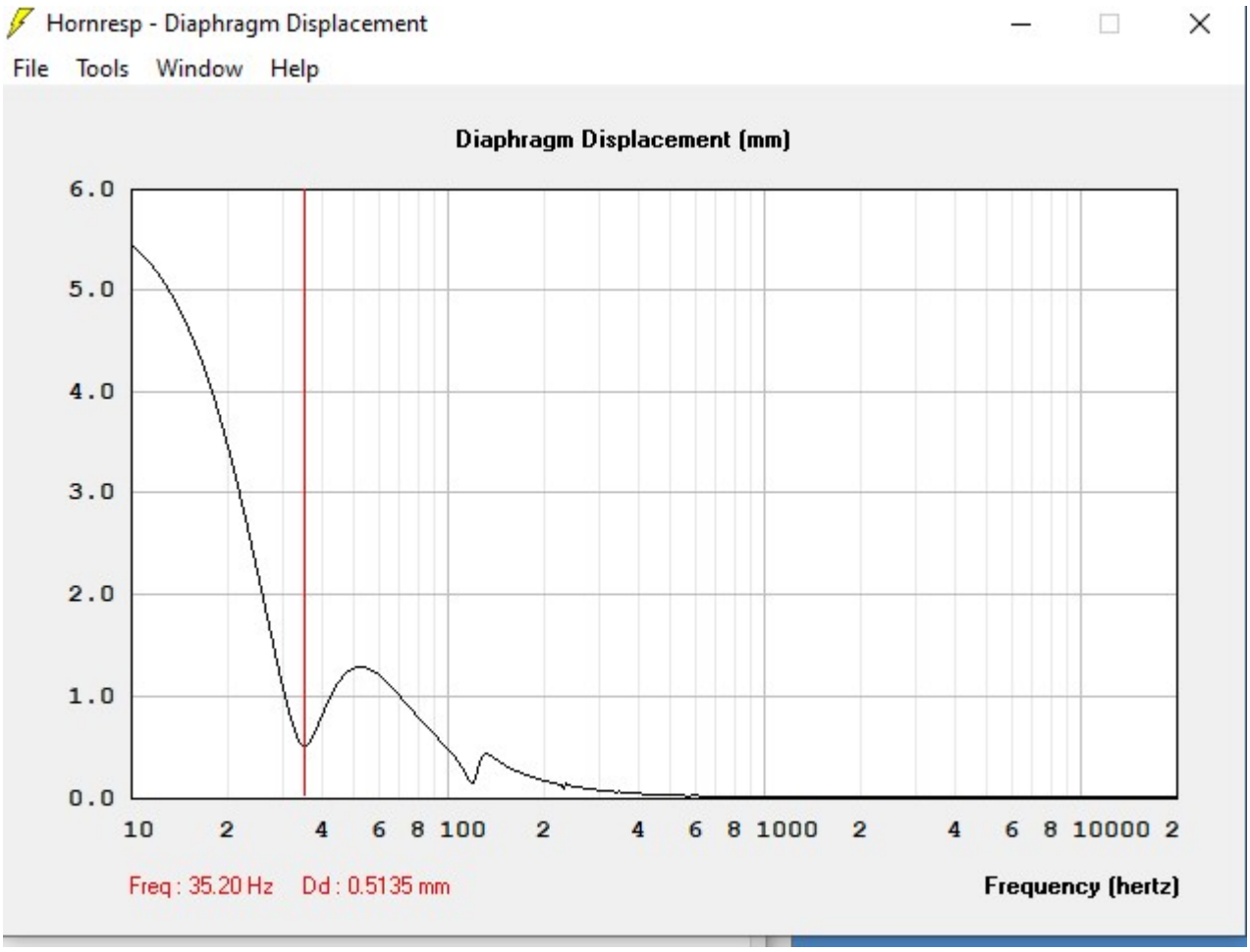
At any time in the wizard, you can toggle over to Power (SPL) or Excursion, or other graphs.
In this case, since I reduced the volume, I have less low end and bump in the base. We can fix that.



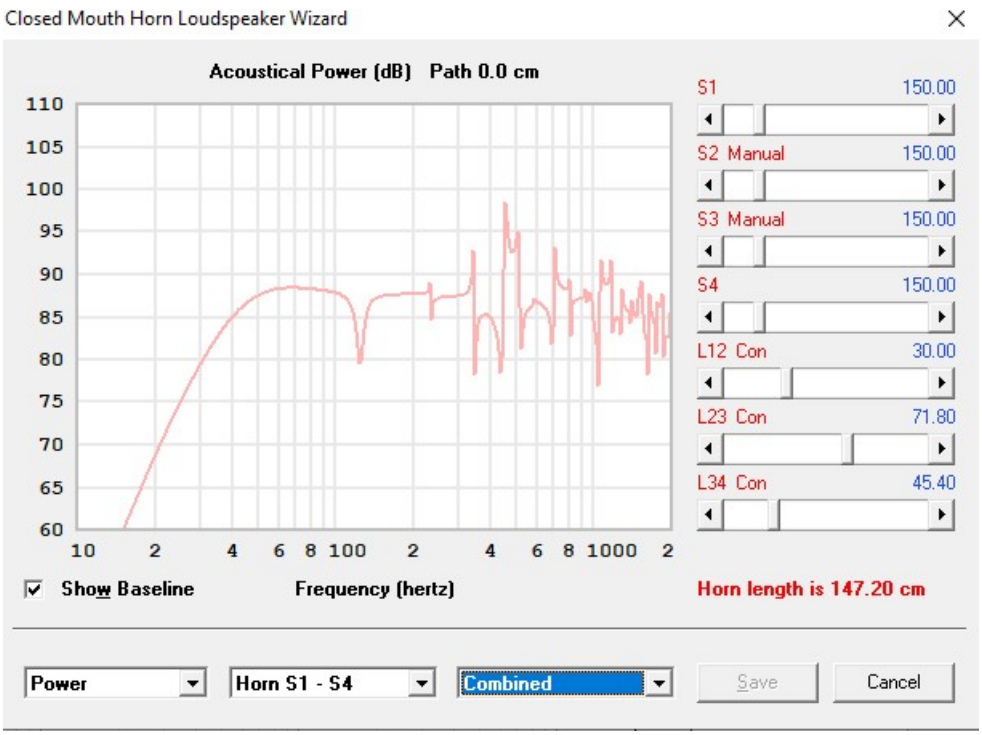
So now the line length is about right, but the volume is too big.
I think you are now seeing the iterative nature of TL designs in Hornresp



After playing with the CSA (Cross Section Area) and line lengths, we are now looking closer to the WinISD bass reflex model. FB about 35Hz.

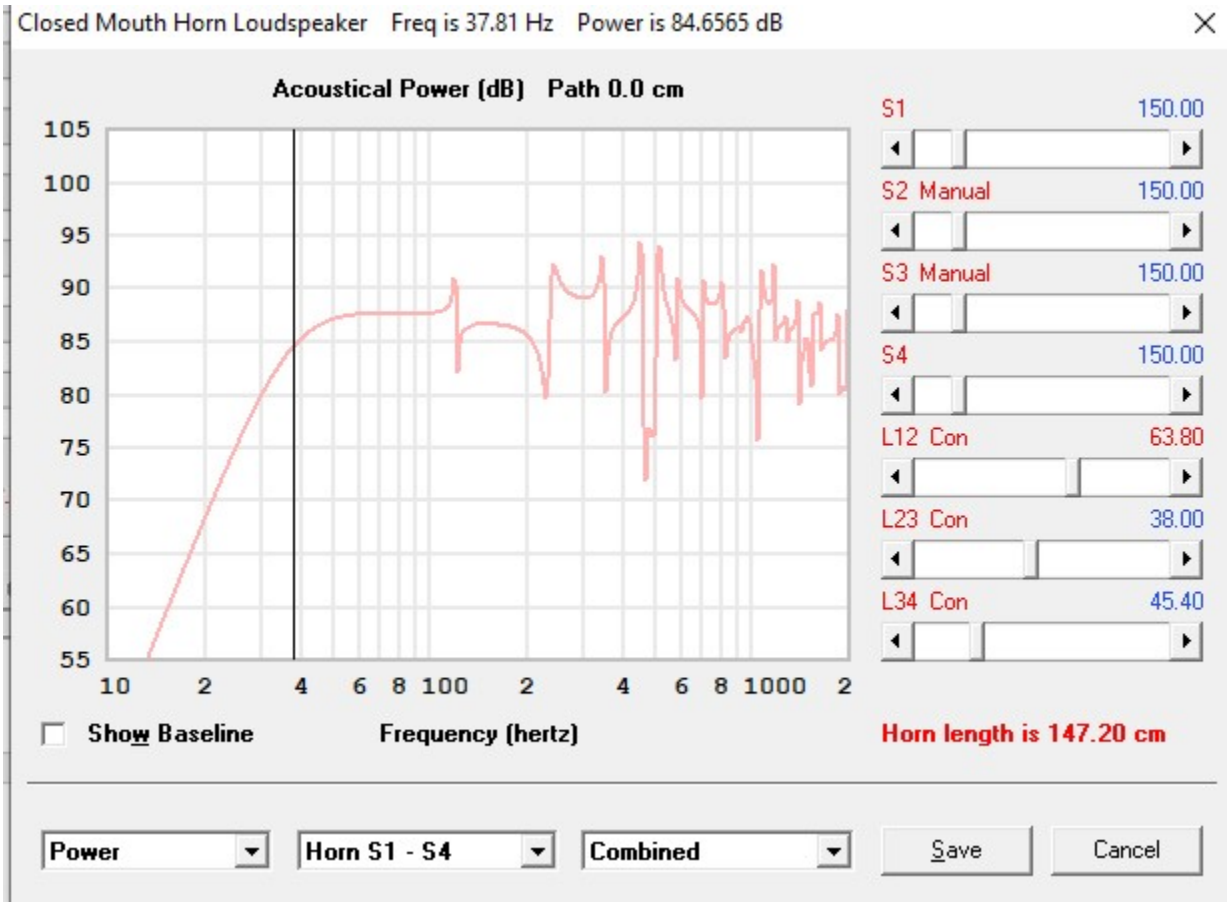


But what is that notch at 124 Hz?

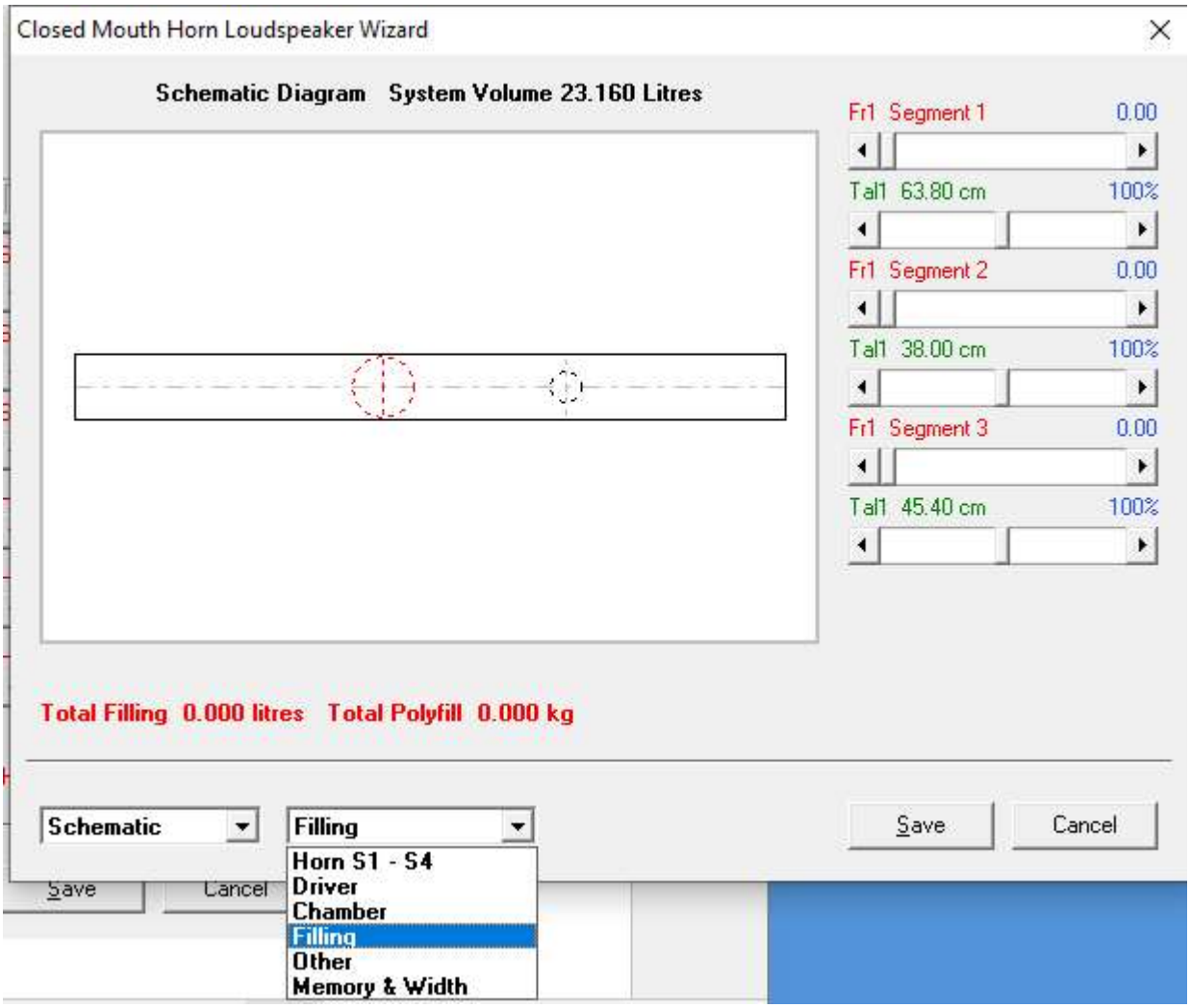


It’s undoubtedly a harmonic cancellation, but we can fix it by moving the driver a bit down or up in relation to the rest of the line. So, L12 Con was at 30cm (about 12 inches).

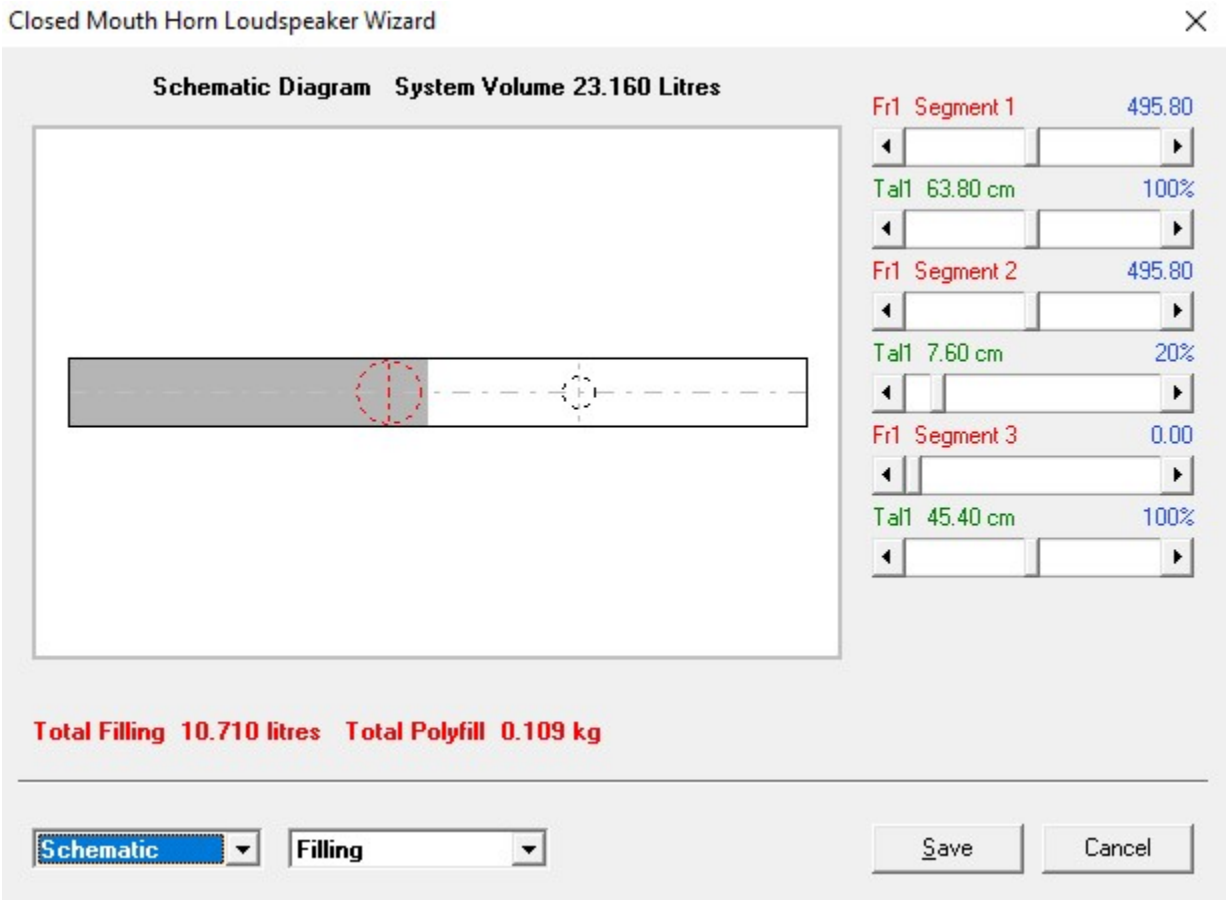
I was not able to eliminate that notch, but I minimized it by playing with L12 Con length ONLY. Note when you do this, the line length remains constant.



So now we can play with stuffing in the wizard

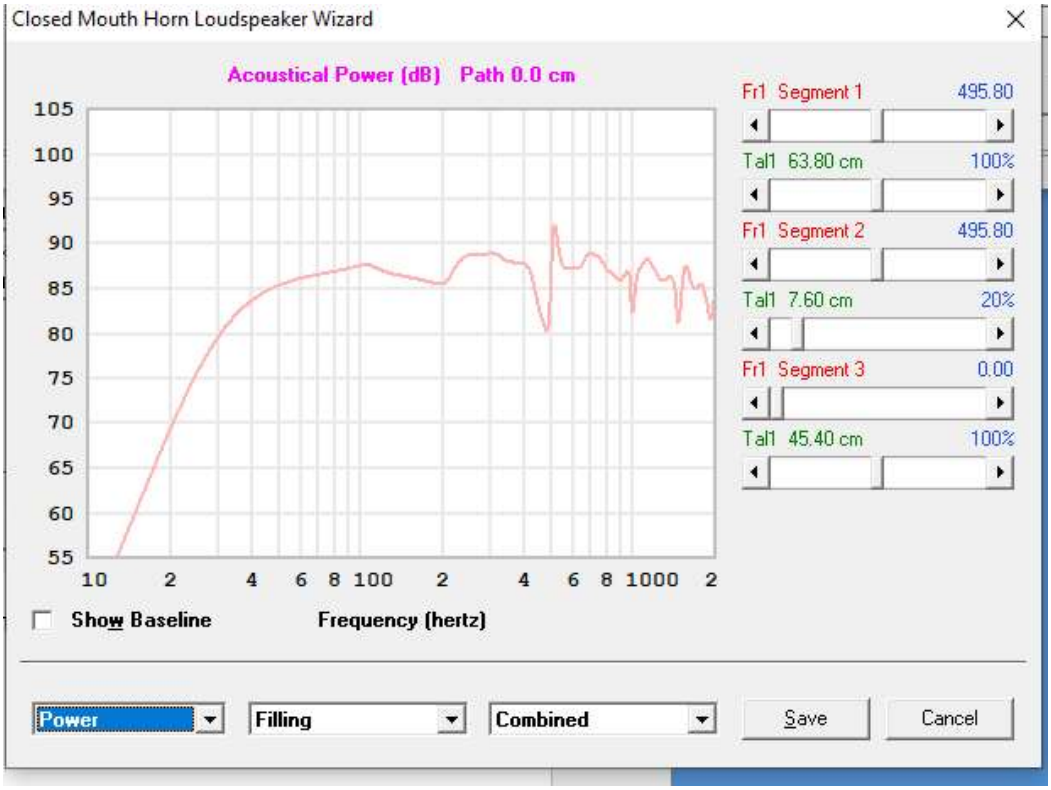


A good “Rule of Fum” is to use about “500” for stuffing and fill 100% of S1 and about 20% of S2. The Schematic view will show this to you:



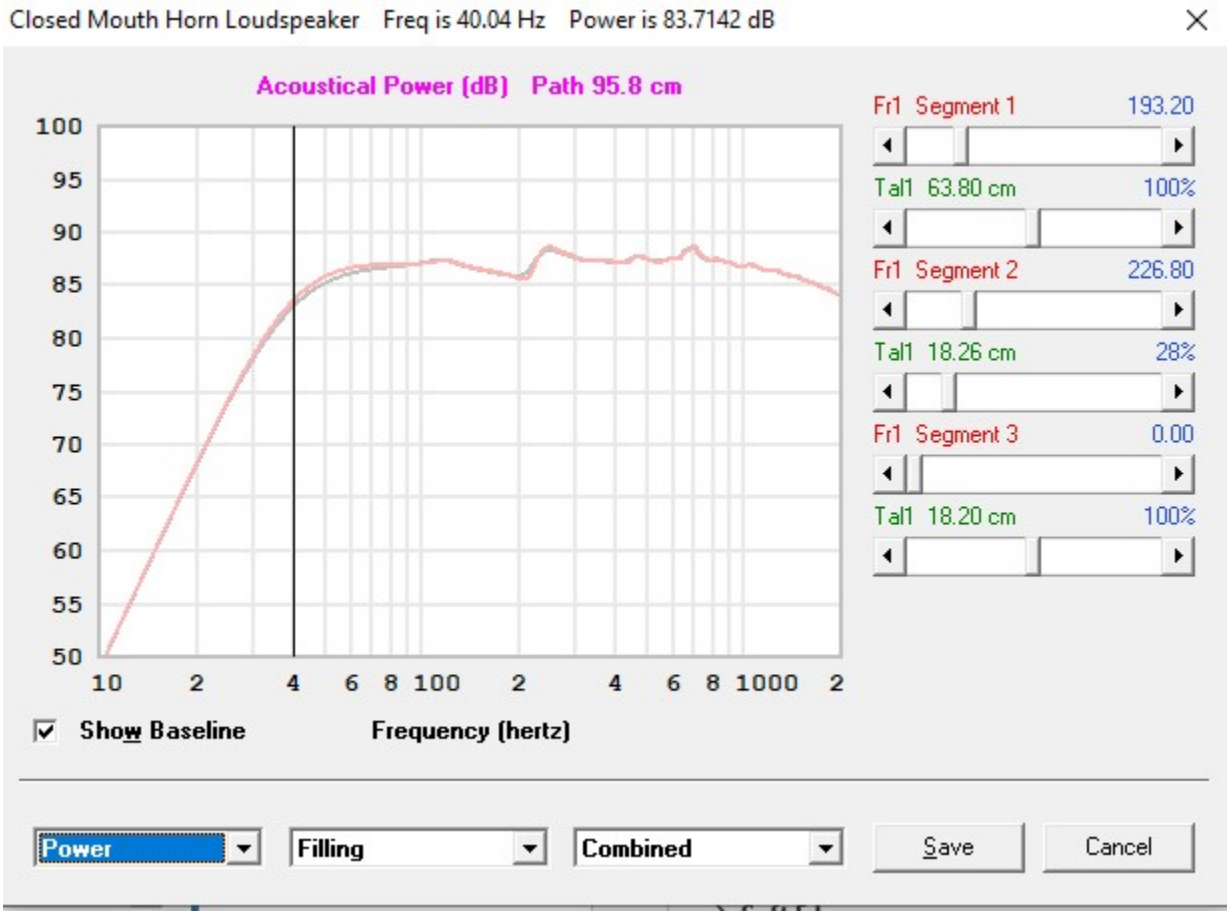
Note that the dialog shows how much fill volume, and how much fill weight.

And, of course, you can go back to “Power” to see the effect on Frequency Response. The notch is gone!

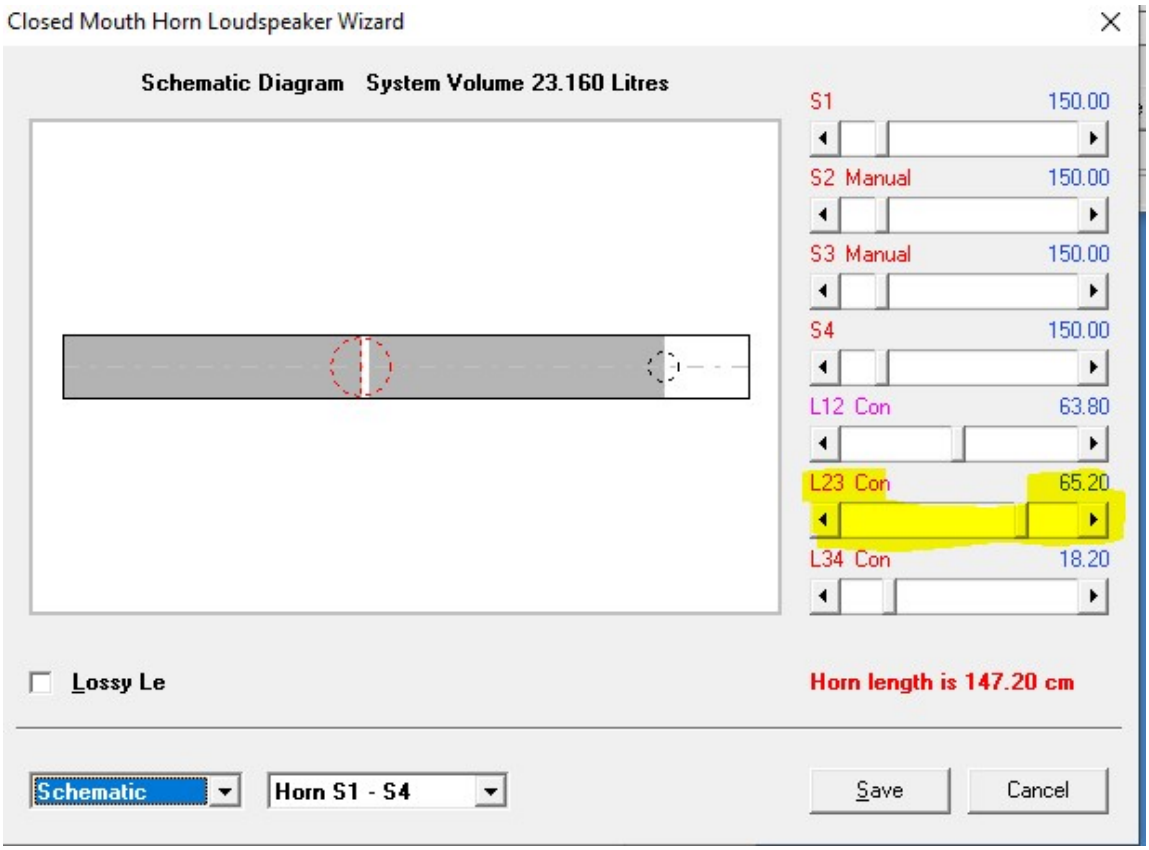


If you use too much stuffing, you will kill the bass response, adjust filling while showing the Power panel.

Remember grey is the baseline before we made changes, and the red line is with the new amount of stuffing. F3 used to be about 37Hz, now it's about 40Hz, (But the filling has smoothed out higher frequencies.)

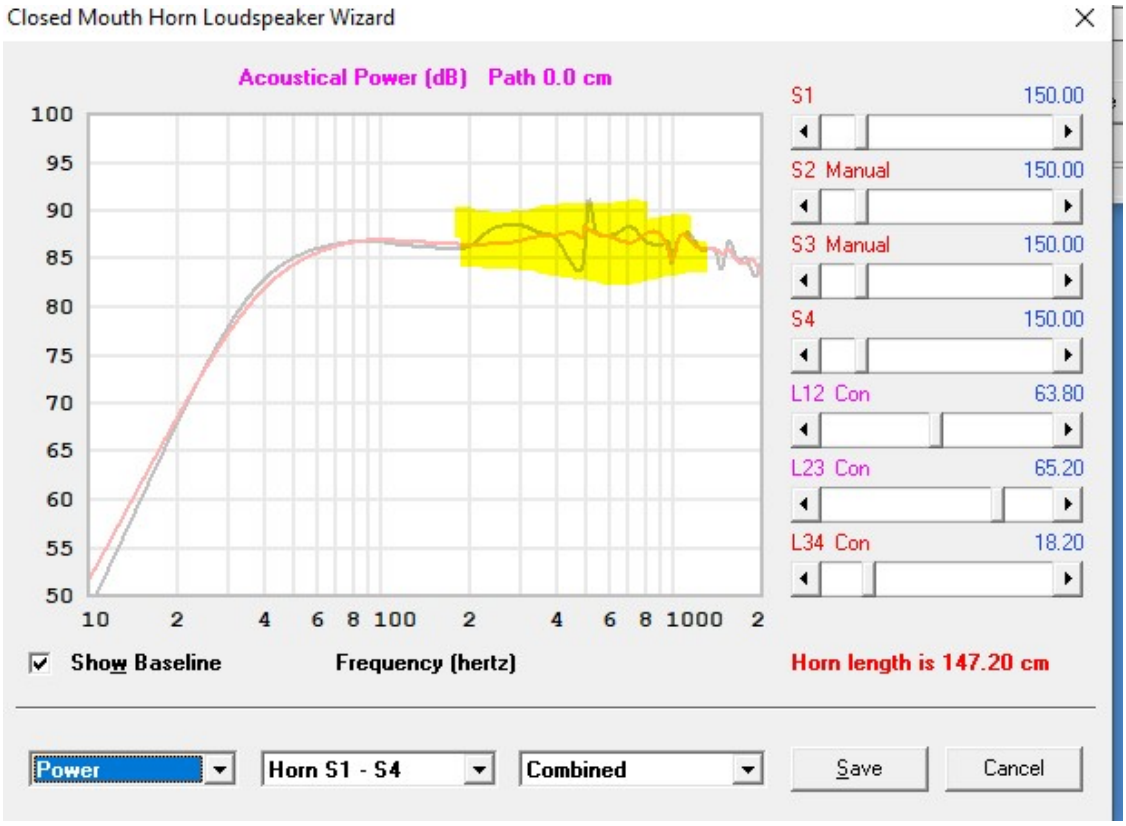


You can move the port, so I did. The distance between the center of the driver and the center of the port is L23 Con – I increased it a lot which moved the port down closer to the floor.



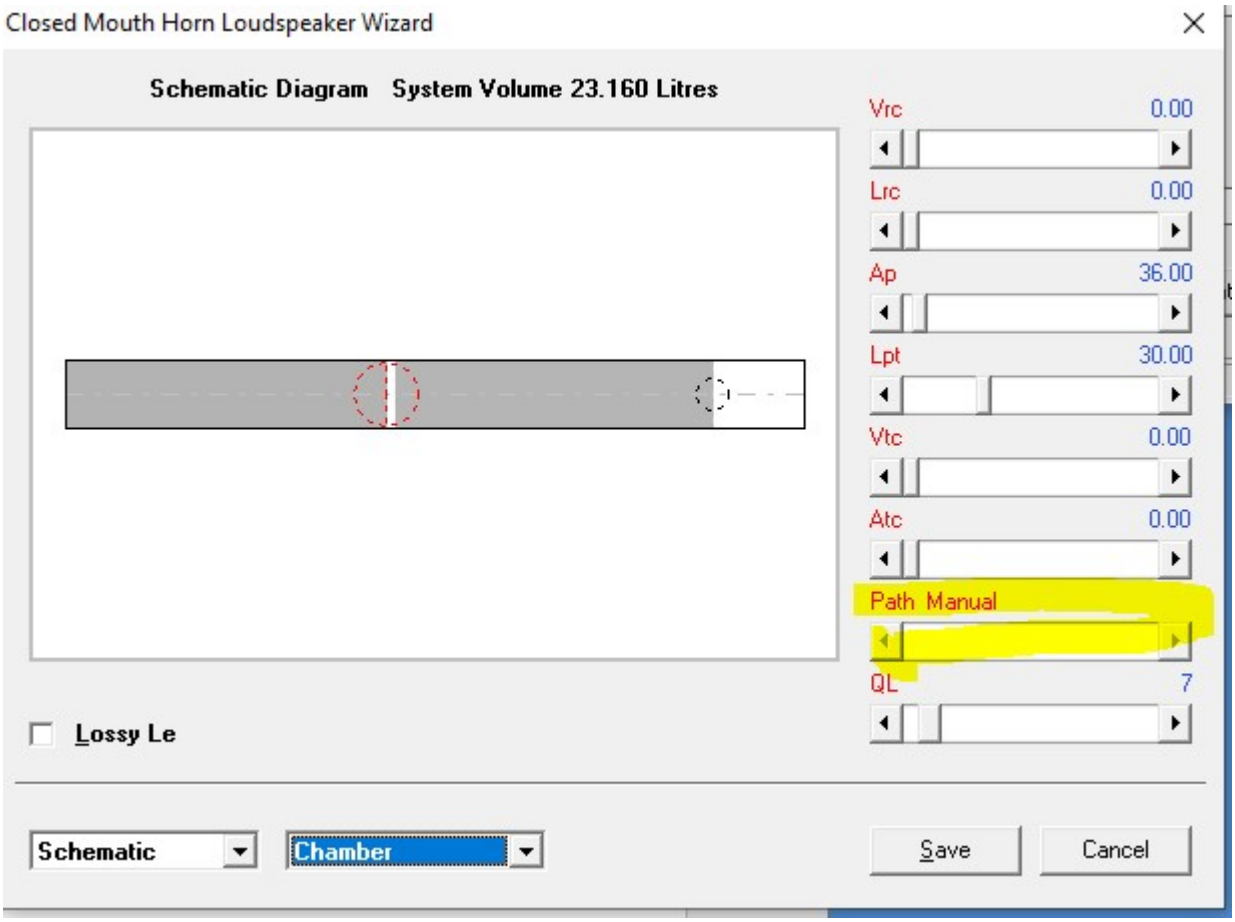
And this smoothed out a lot of the upper frequency bobbles!

Grey is before the change and red is after the change.



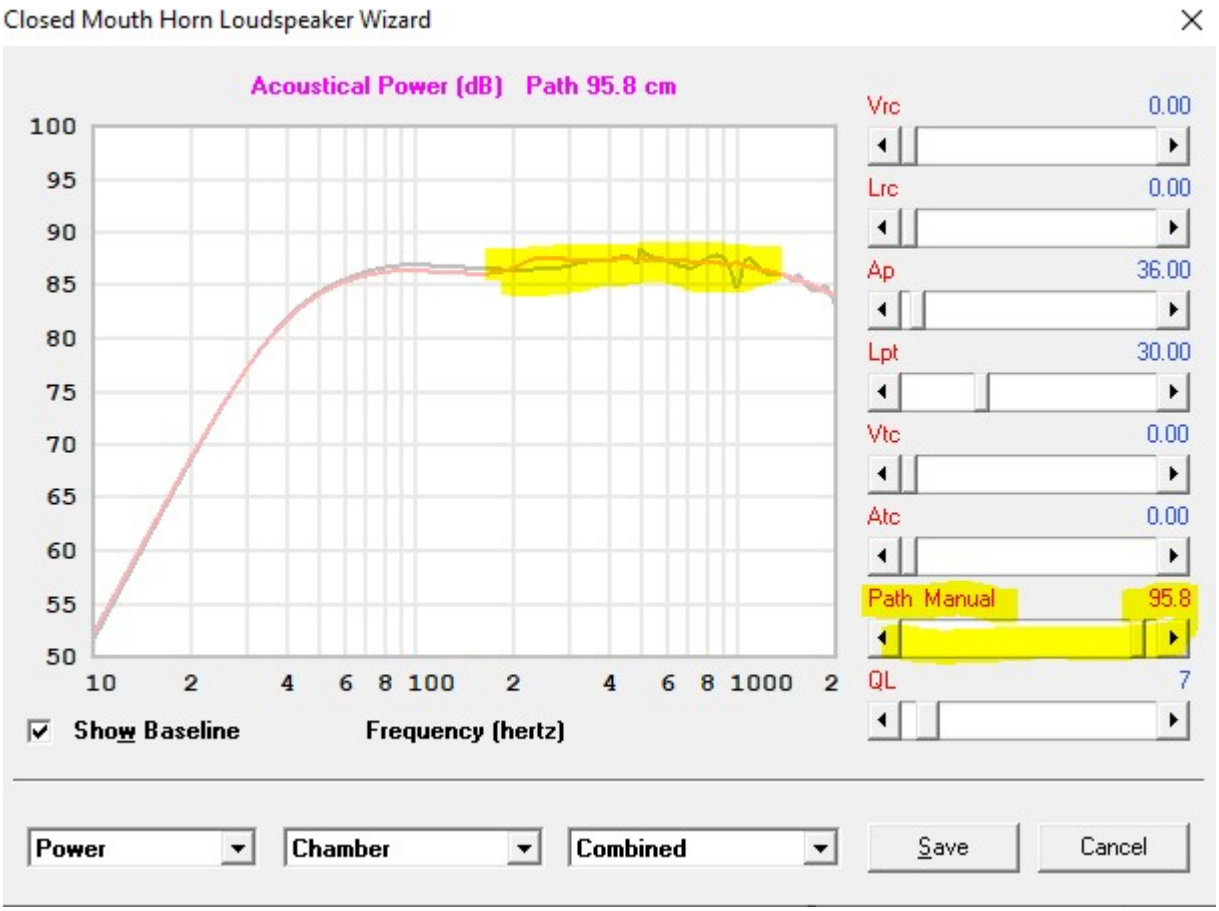
Last tip on this model, in Hornresp, “Path” is the length between the port and the driver.

It is found in this dialog in the wizard:



So for this design of a slim tower, with a woofer about 100 cm from the floor, and a port on the back about 18 cm from the floor and a cab that is about 38 cm front to back, the “Path” will be about 120 cm.

And setting this once again helps smooth out the frequency response.

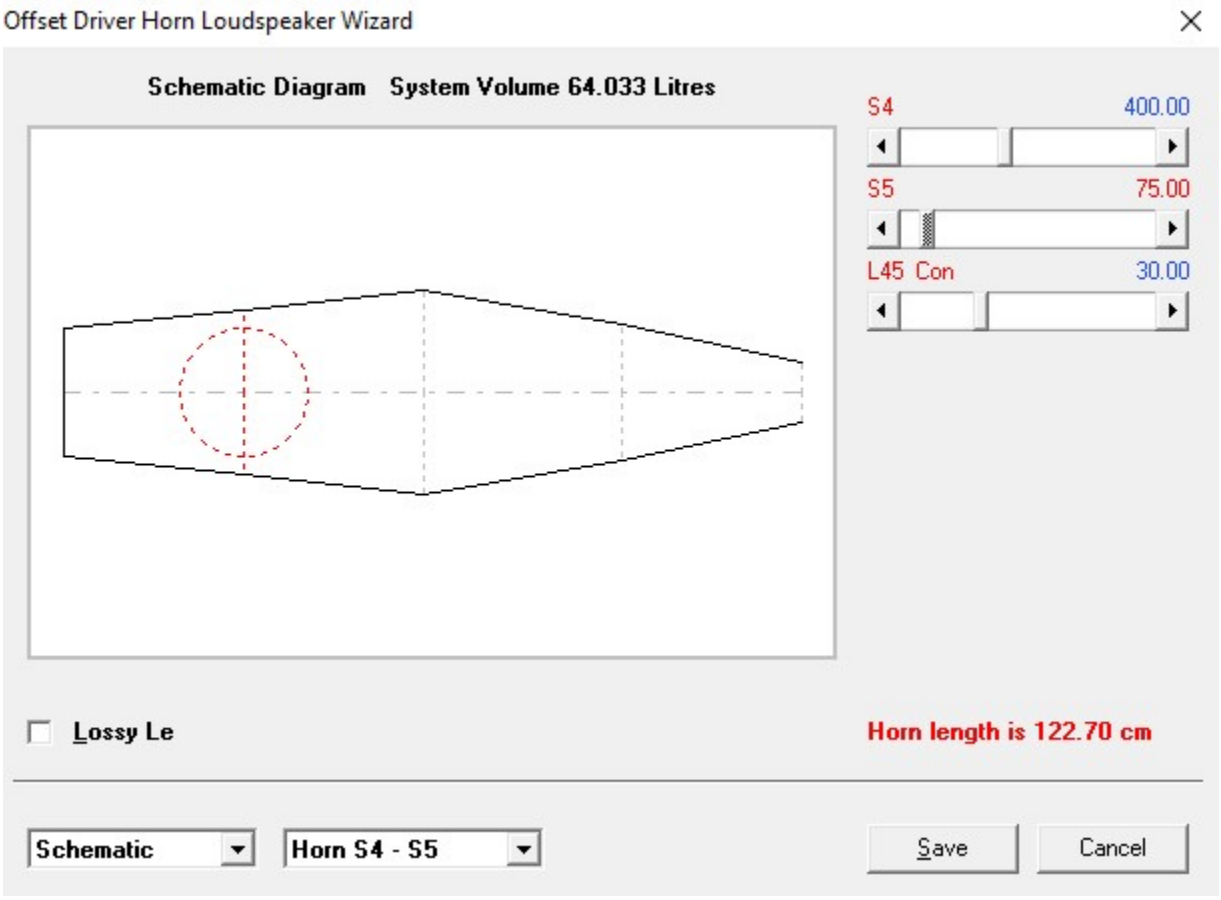


Tapered Transmission Line Simulation

So now we will walk through Hornresp modeling of a tapered transmission line.
Martin J King (guru of “modern” transmission line design often states that tapered TLs can be smaller and have less frequency response wiggles than straight chambers.

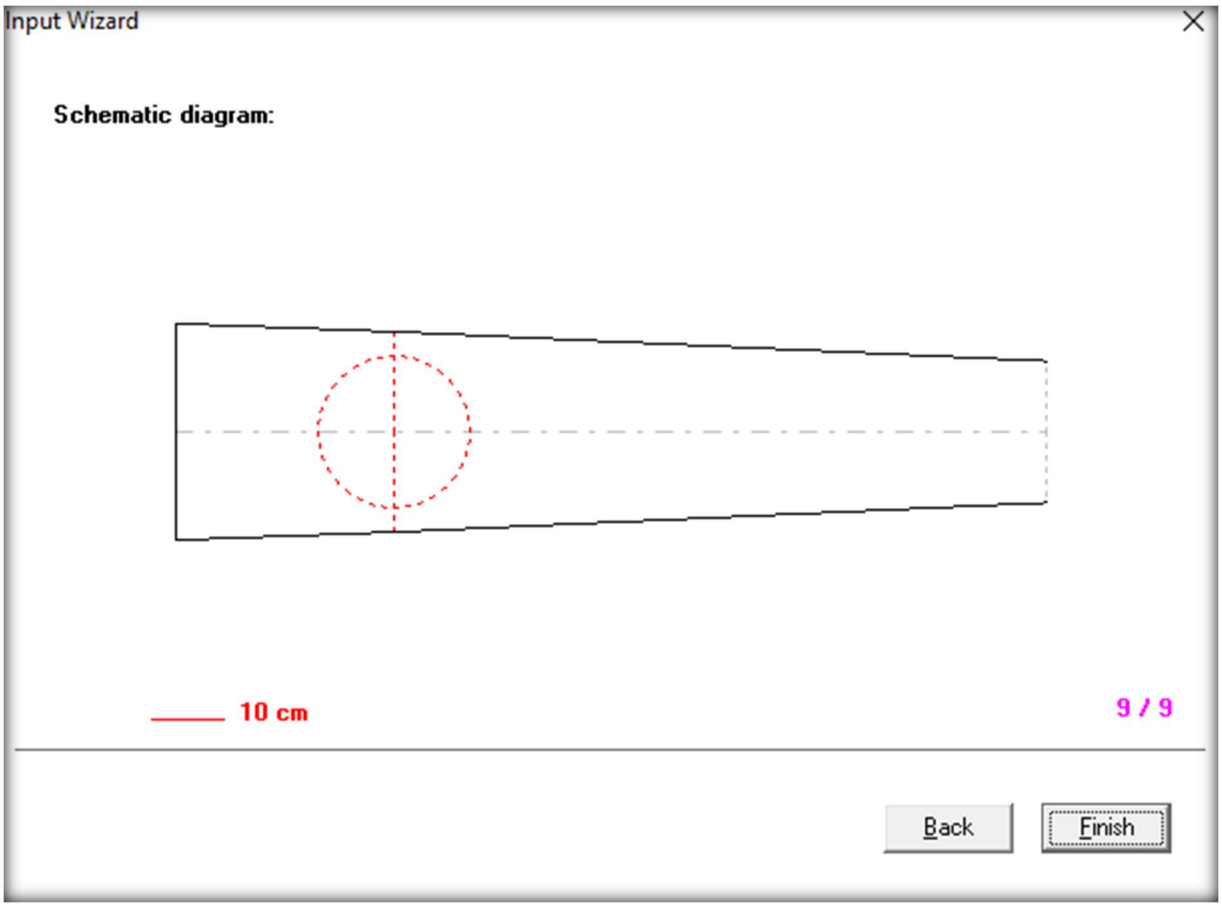
“Negative Taper” Offset Driver Quarter Wave Transmission Line
Exit dimensions are smaller than the “origin” of the line. Often a 10:1 ratio is recommended.

When I first started to design tapered TLs, I used 4 or 5 segments, and that is pretty cool because you can design speakers that look like this:

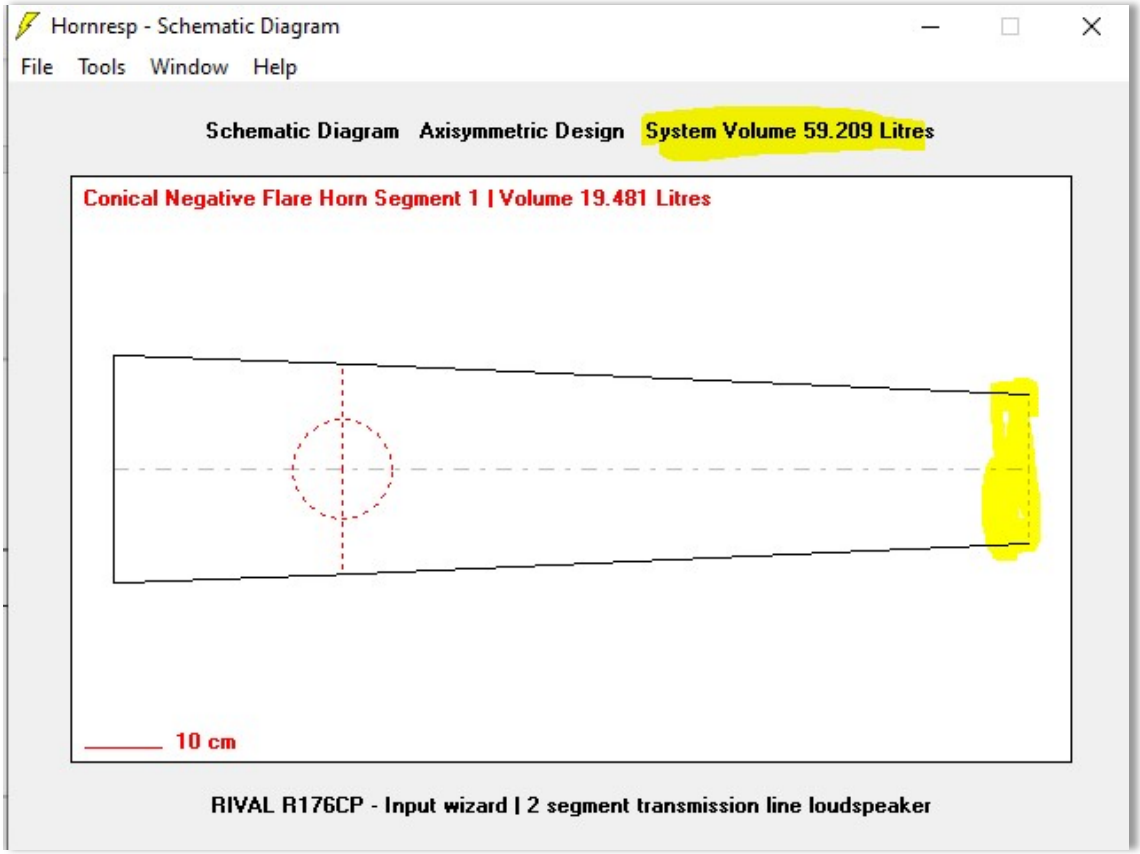


But that is not useful for me.
Remember when I said that the woofer is ALWAYS at the line between Segment 1 (S1) and Segment 2 (S2)? For the basic tapered TL, we only need 2 segments (KISS principle).

The Input Wizard with 2 segments will produce something like this, which is close to what we want:

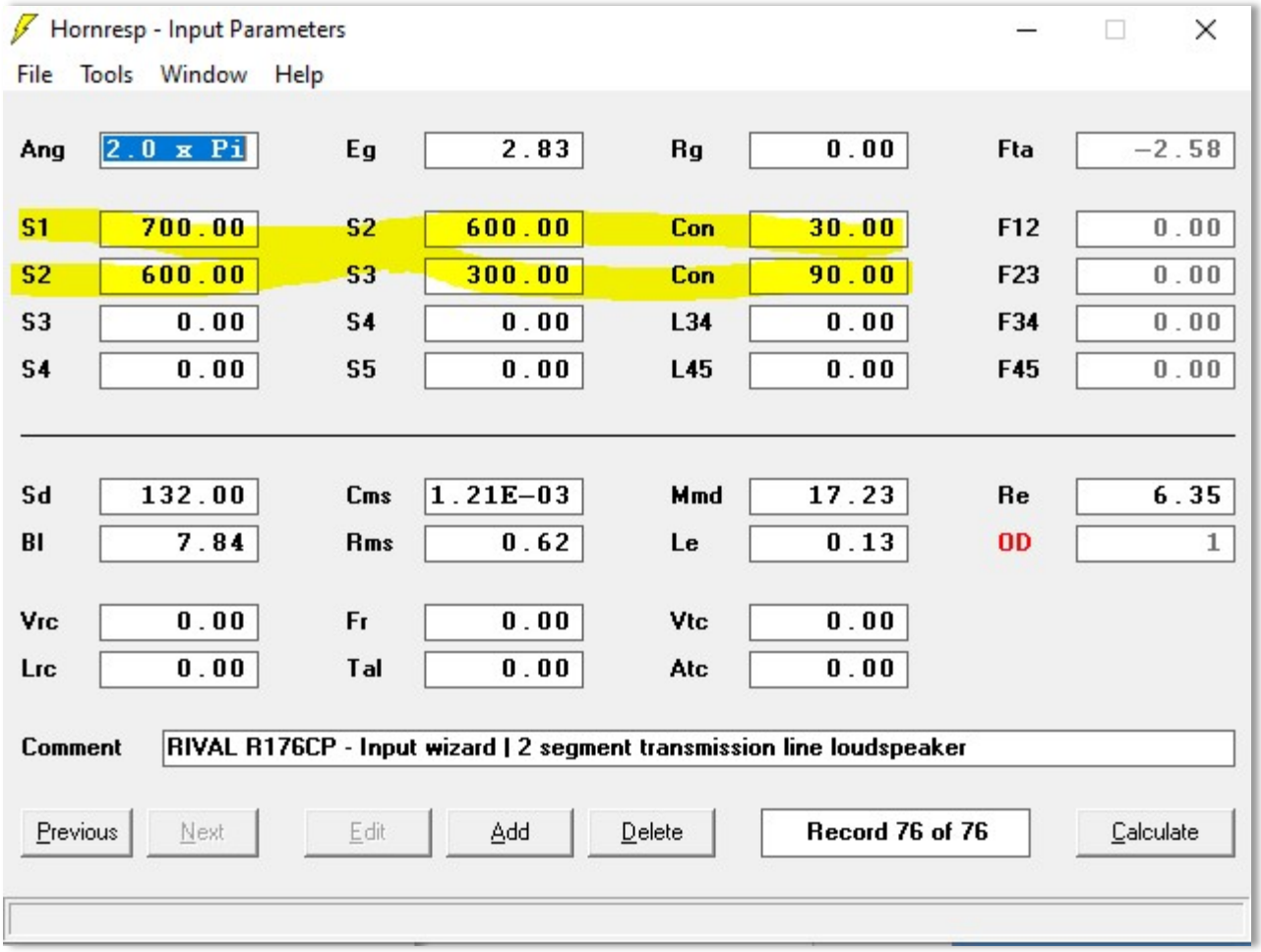


I pasted the example woofer Rival 176CP into the model, and Hornresp produced this:



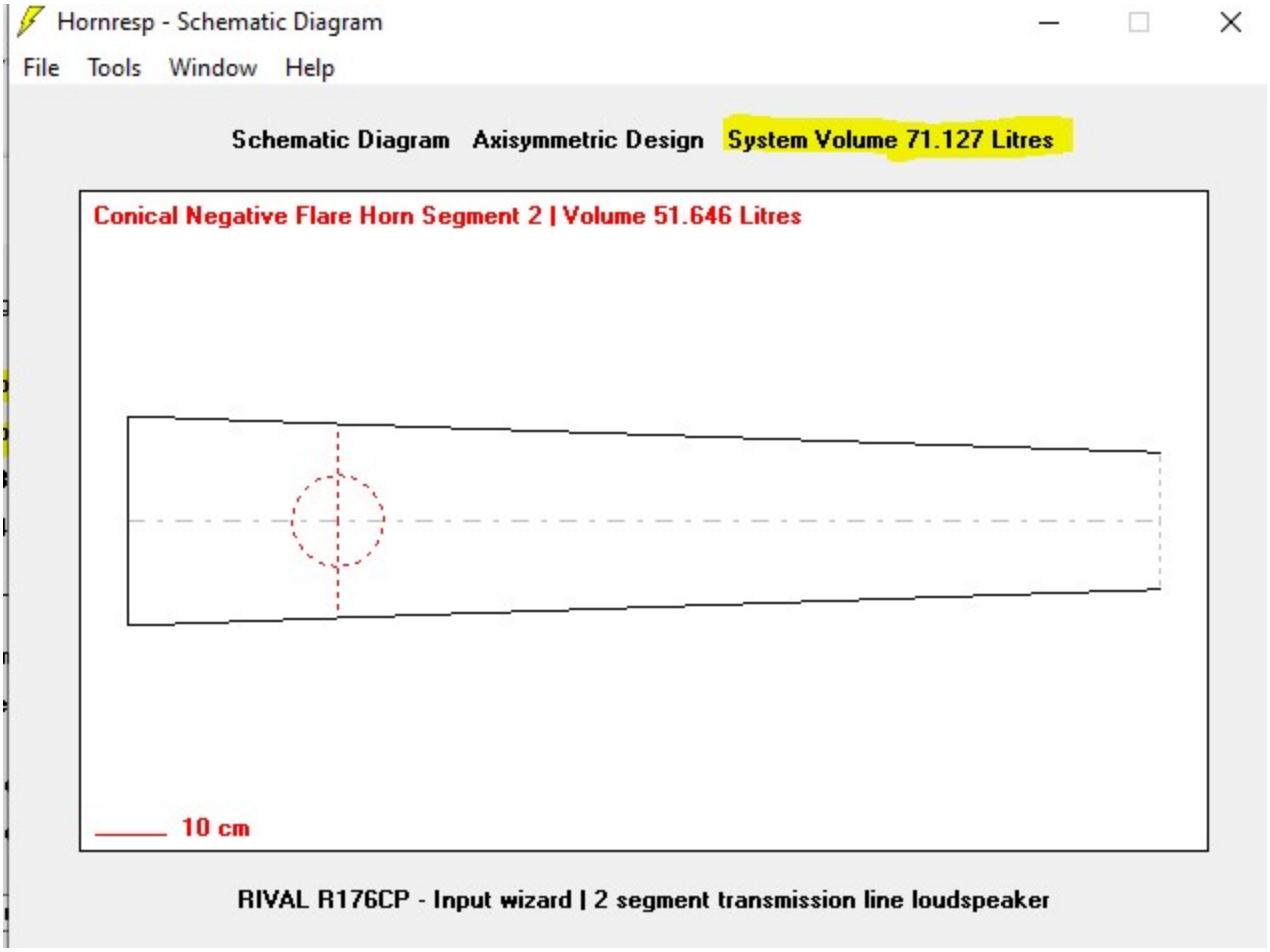
Couple of problems with this. Volume is too big, the exit is too big, and I'm not sure what the line length is. All easily fixed!

So in the Input Parameters panel, we see the 2 segments, which are specified as S1, S2, and S3. So the 2 segments are: closed end to the center of the woofer, and the center of the woofer to the exit. So we have a bit of cognitive dissonance. Why do we have 3 S numbers when we only have 2 segments? Well, you can also look at an S number as the Cross Section Area (CSA) for a segment.



First lets change the line length to match the previous example (147cm)
"Con" is the length of the segment. Right now it's at 120cm, but we'll just increase Con 2, because we can always move the woofer later to smooth out response.

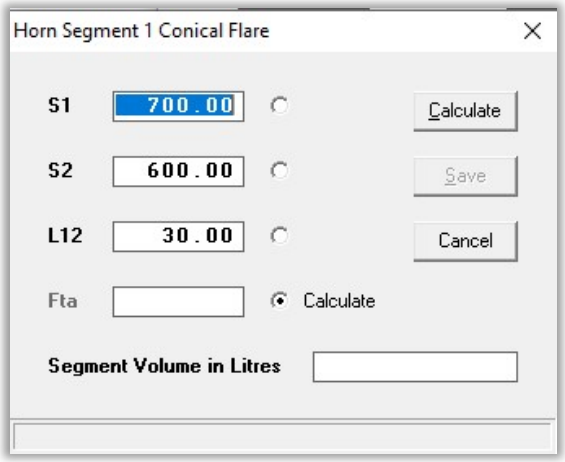
Yikes, the system volume is now WAY too big.
Relax, easily fixed.



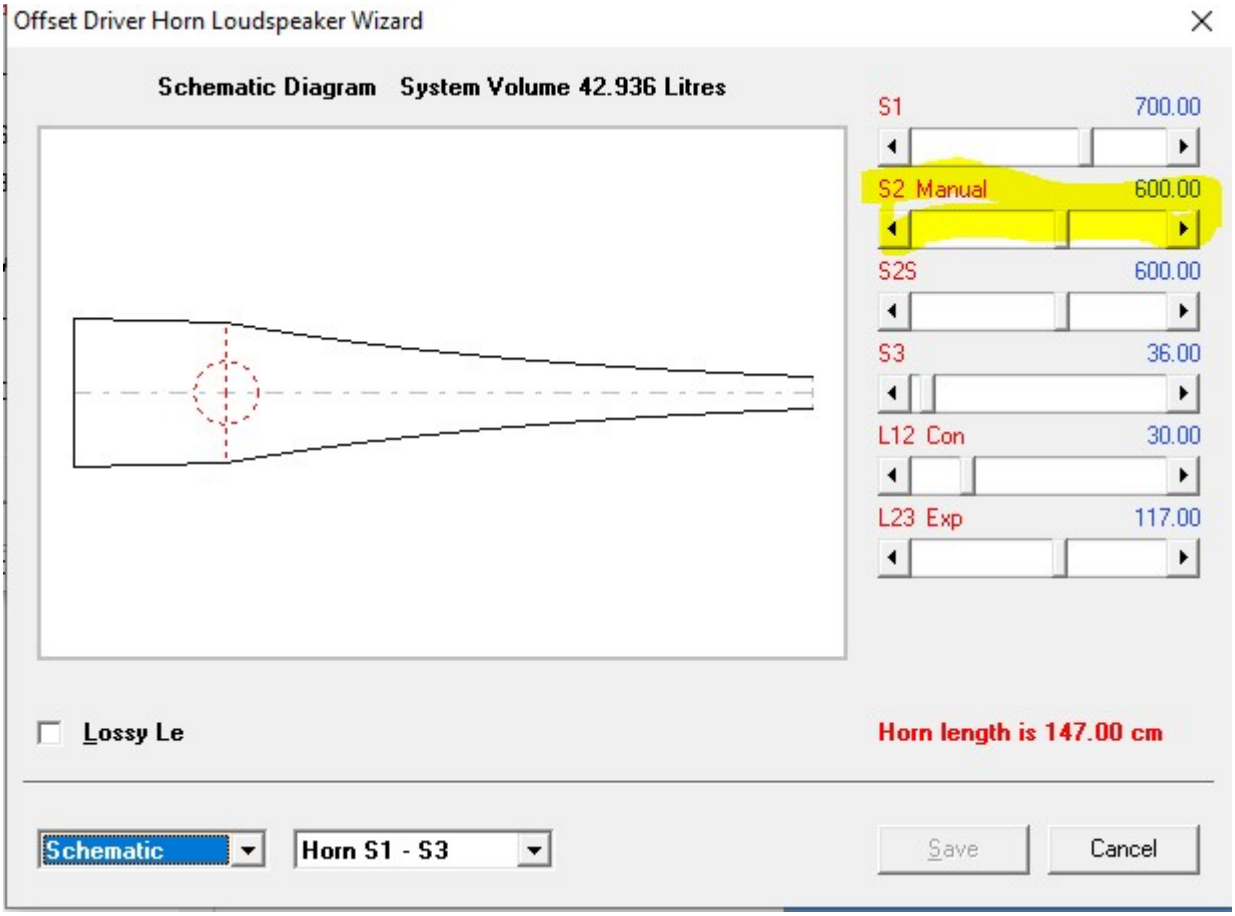
First of all let's set the exit "port" size. Since we used 36cm in WinISD and the Hornresp BR and MLTL, lets set this the same (for now).
The exit CSA is in S3.

Now we can set the system volume via S1. You can iteratively lower S1, hit calc, and check the schematic for the resultant volume, but there are 2 ways that are easier.
In the Input Parameter panel you can double click S1 and it will also show you S2 and volume.
Why would it do that, you might ask. Think it through – the segment is defined by the starting CSA and the end CSA (so 2 numbers).

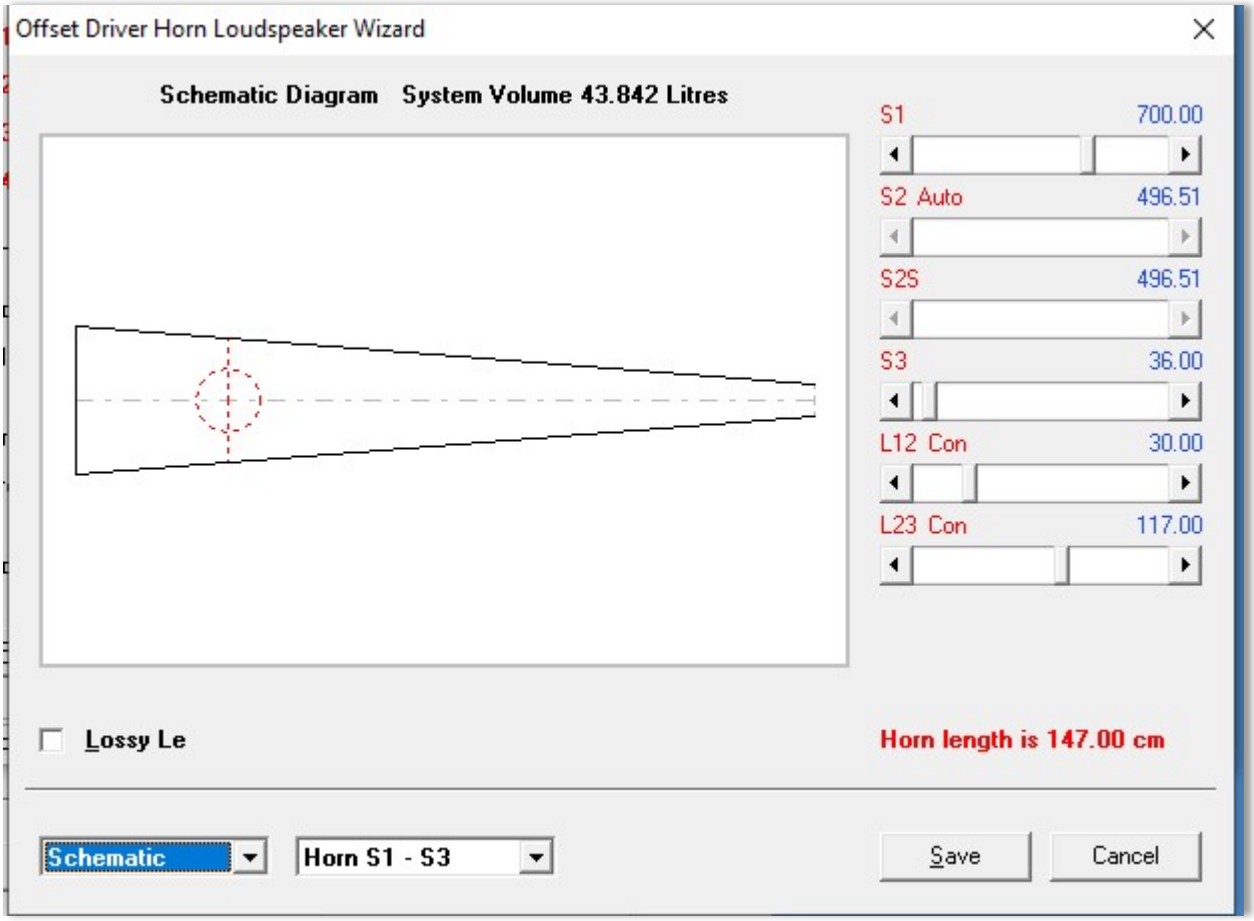
Double clicking in the Input field for S1 (not the label S1) gives us this:

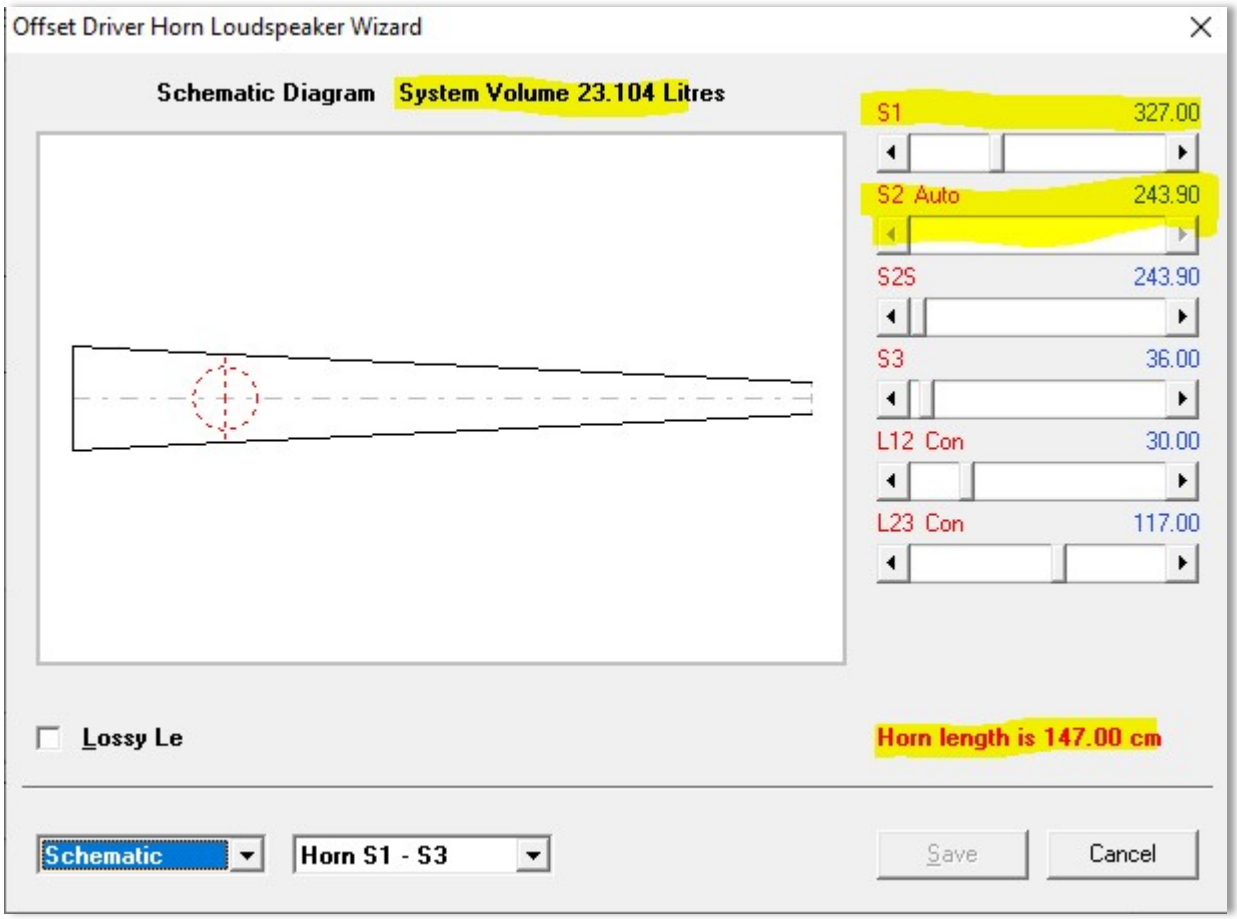


So nice that it also can calculate the segment volume, but there is a better way. Yep, back to the “good old” Loudspeaker Wizard.
So we see that the volume is too big, but we also can see that we don’t have a straight line for the taper.



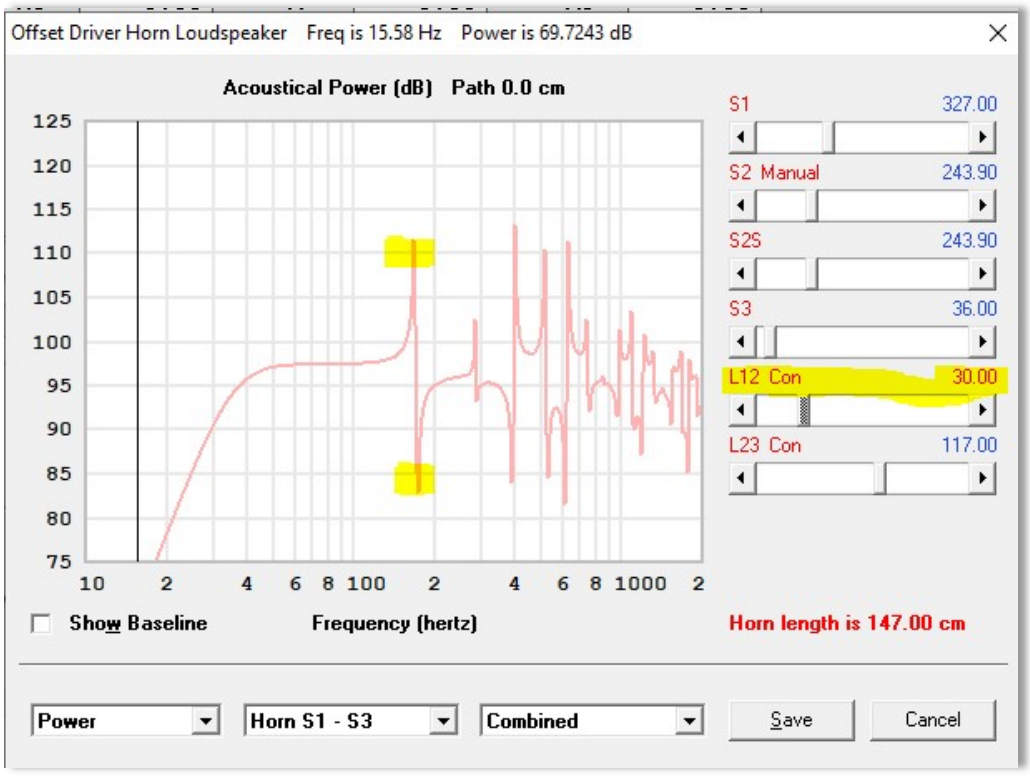
See the S2 Manual label? Sometimes you need that, but we can make it automatic and save a lot of iterative effort. Double click on the label “S2 Manual” and it changes to “S2 Auto” and fixes the straight line problem.


Offset Driver Horn Loudspeaker Wizard
Schematic Diagram System Volume 43.842 Litres
S1 700.00
S2 Auto 496.51
S2S 496.51
S3 36.00
L12 Con 30.00
L23 Con 117.00
Lossy Le
Horn length is 147.00 cm
Schematic
Horn S1 - S3
Save
Cancel



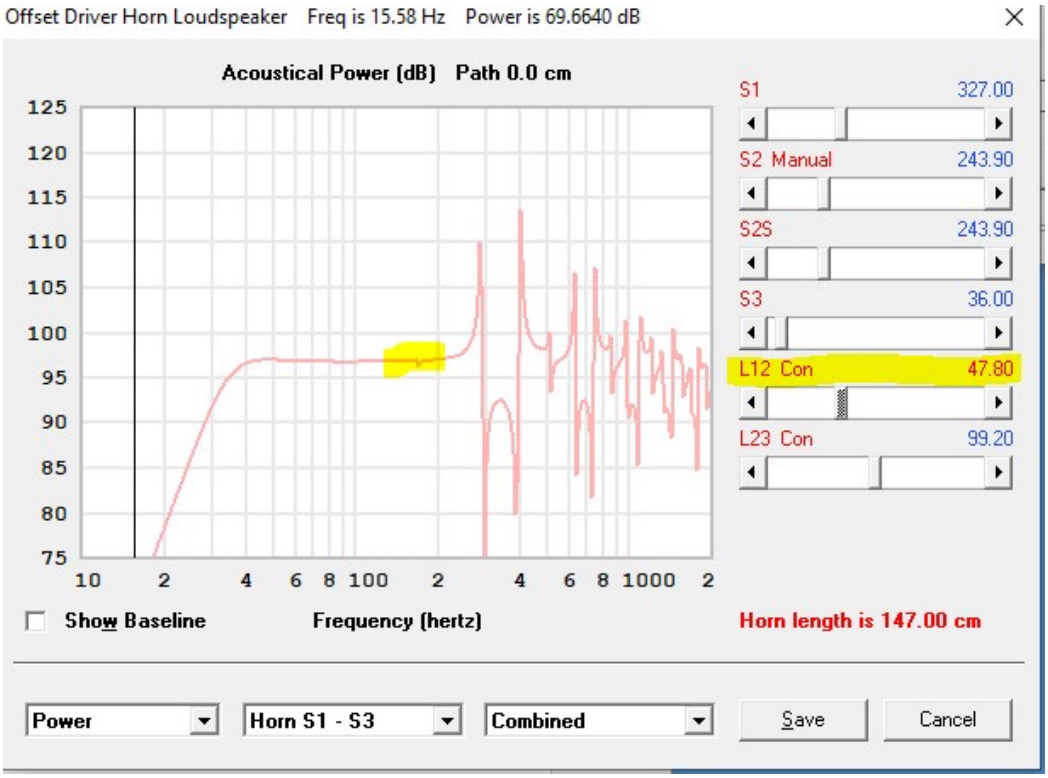
By turning S2 into Auto mode, we can easily adjust S1 until we have the desired System Volume.

But Frequency response is pretty ragged!

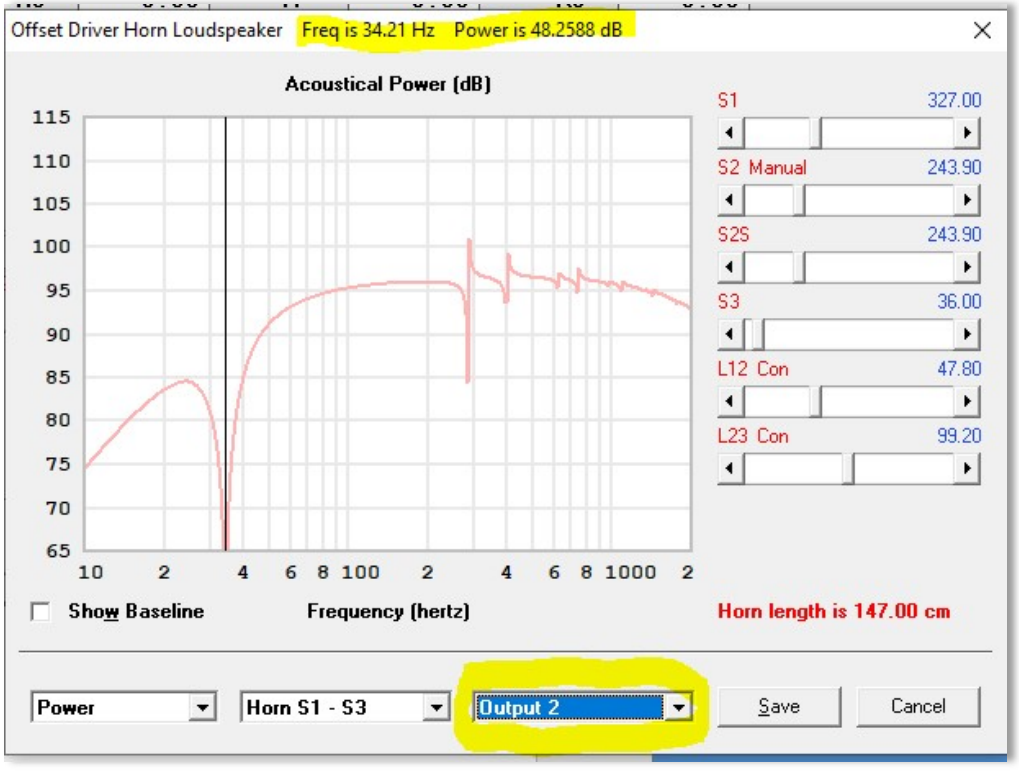


As before, play with L12 Con (the center of the woofer) – lets see:
You will often hear “Just set to 1/3 of the line length”, but it’s really sensitive and you must simulate.
At present, the first spike is from about 83dB – 111dB – a 28dB spike in total.

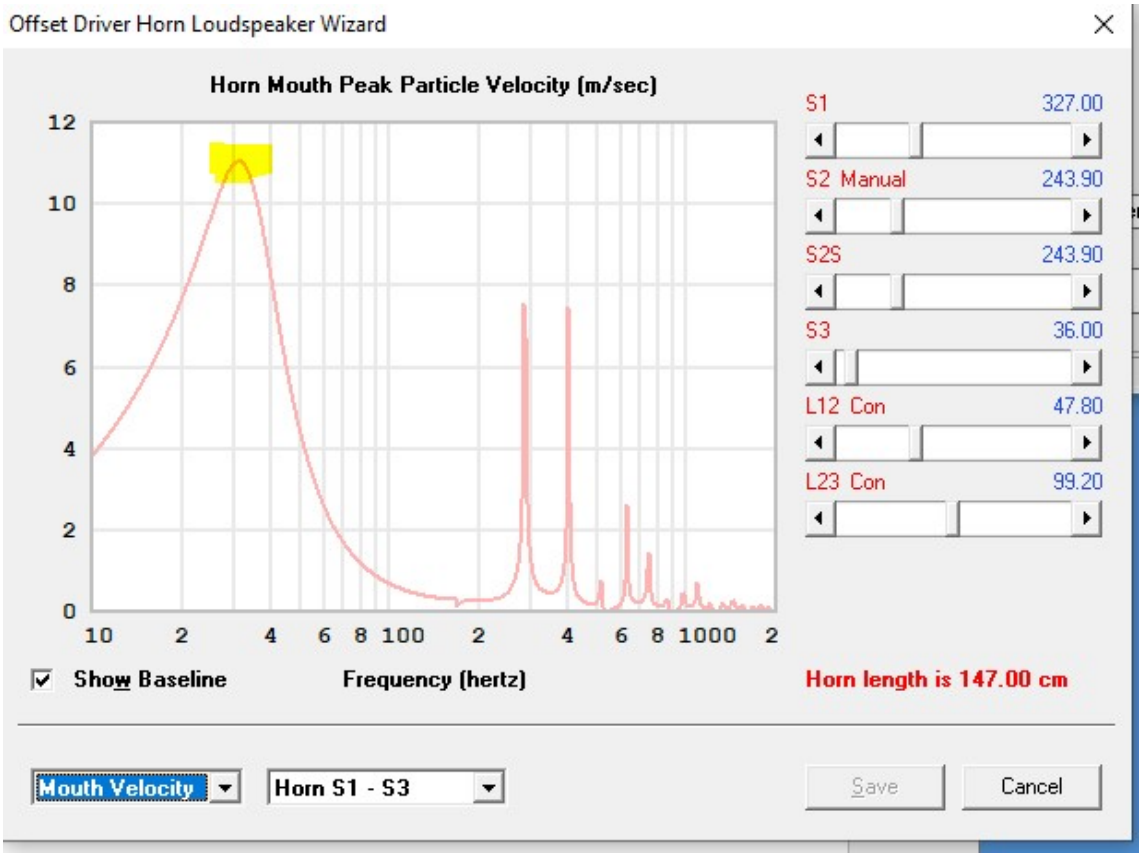
So now, that spike has disappeared!



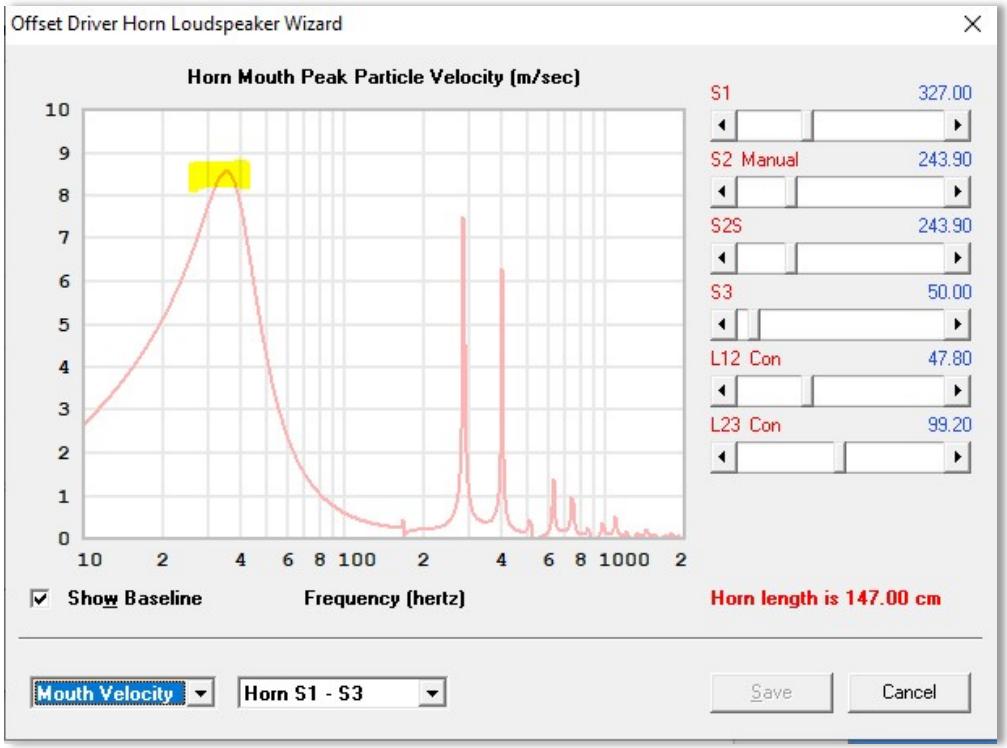
Driver minimum (Fb) is bit lower than the MLTL straight version.



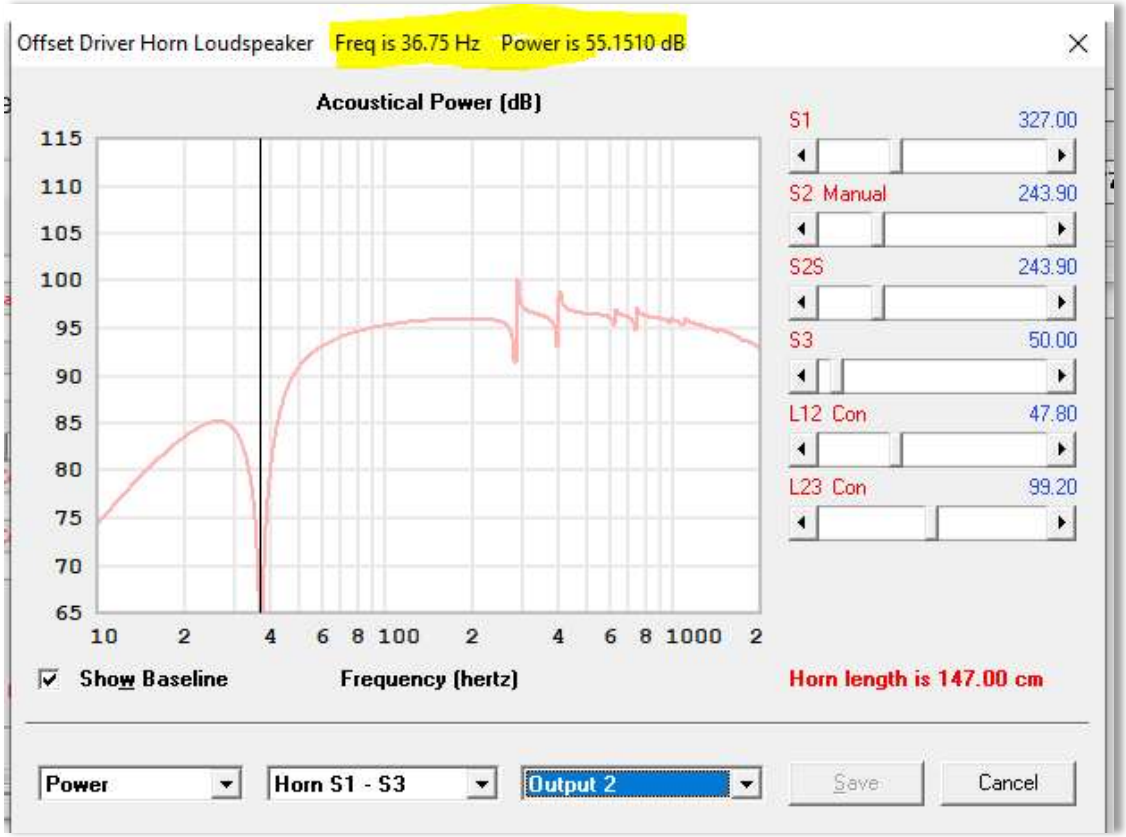
Remember, we set the area of the exit (S3) at 36cm, the same as the WinISD model.
So with 10W input, we have this exit velocity: (remember, 34Hz Fb)



But we can every easily make the exit larger. Lets change it from 36cm^2 to 50cm^2
Exit velocity lowers to 8.5, from the former 11 (23% better)

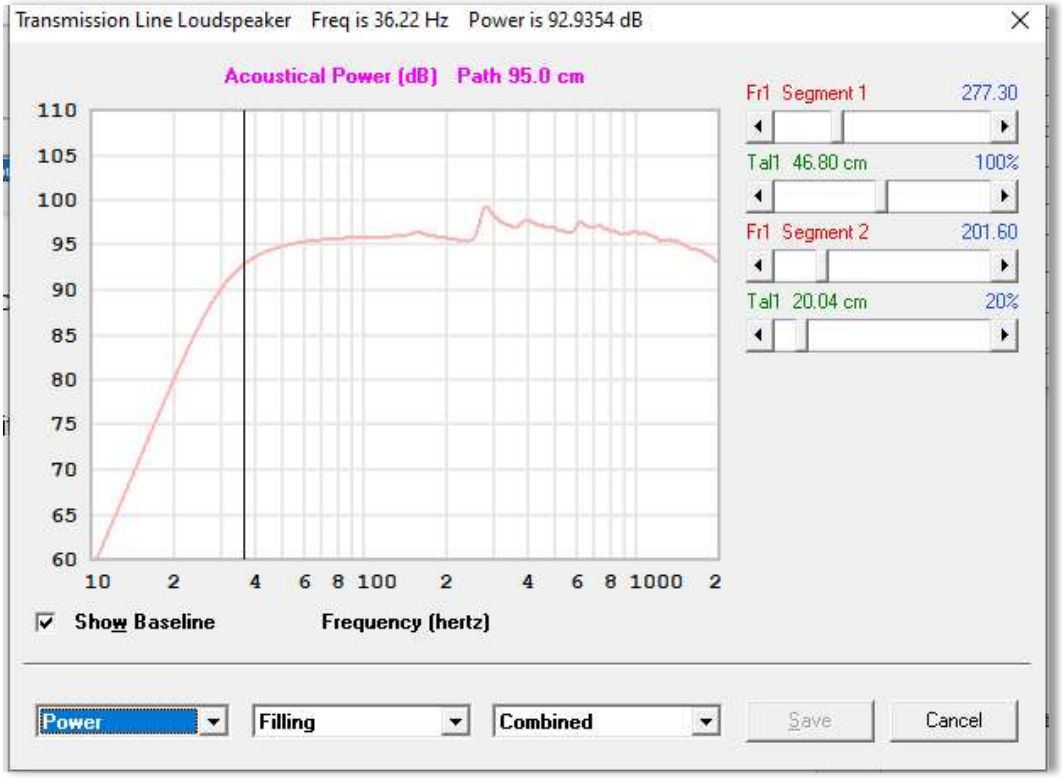


While Fb has only increased just a little – from 34Hz to 37Hz



My (opinion) statement is that exit area and Fb are closely related in a bass reflex,
but exit area in a tapered TL is more loosely related to Fb

After a bit more exploration of the tapered TL, I came up with this:



How to Fold a Transmission Line

Future version.