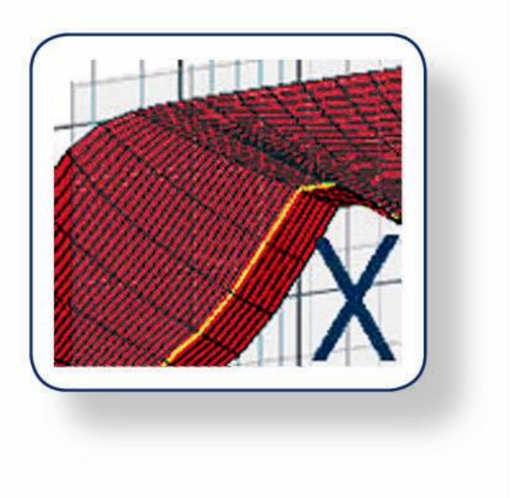
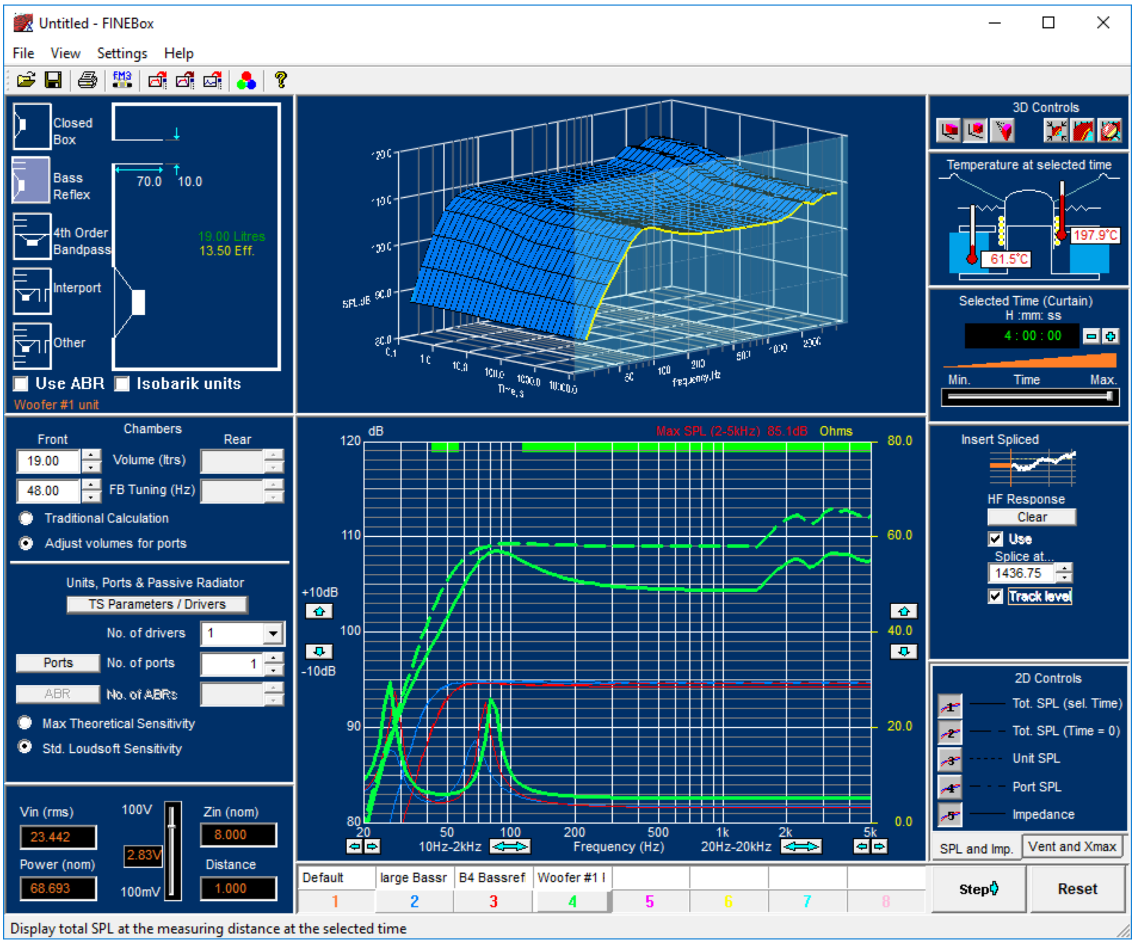
Manual



FINEBox™

Non-Linear High-Power Box Design Program
For Hi-Fi, PA and Micro loudspeakers

Contents



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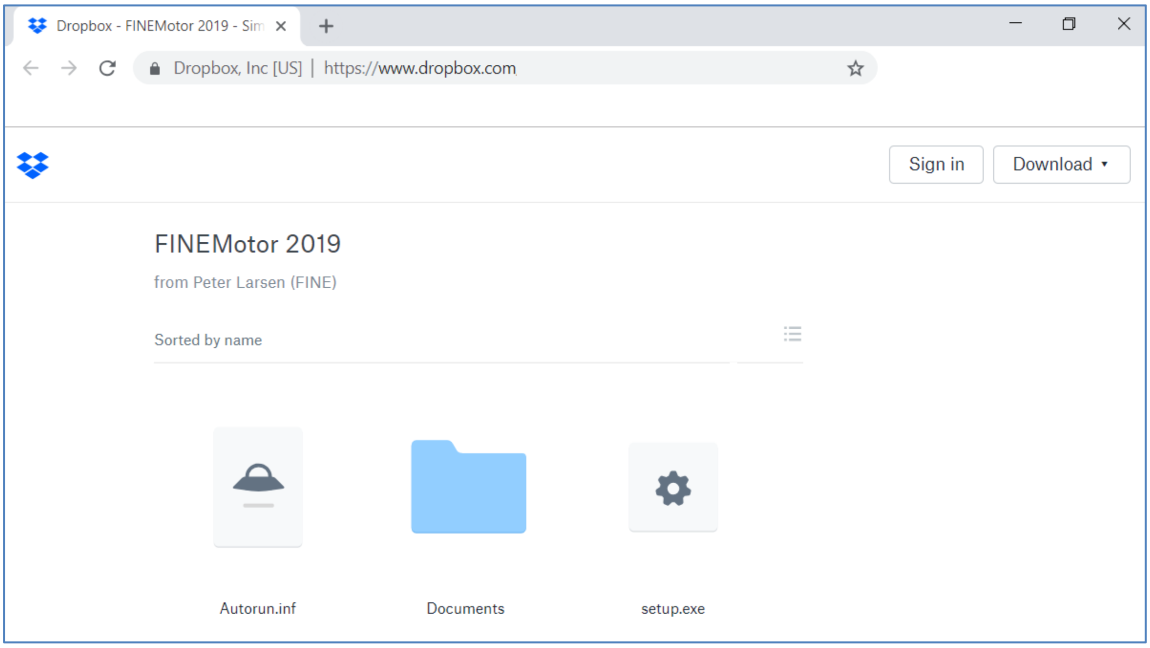
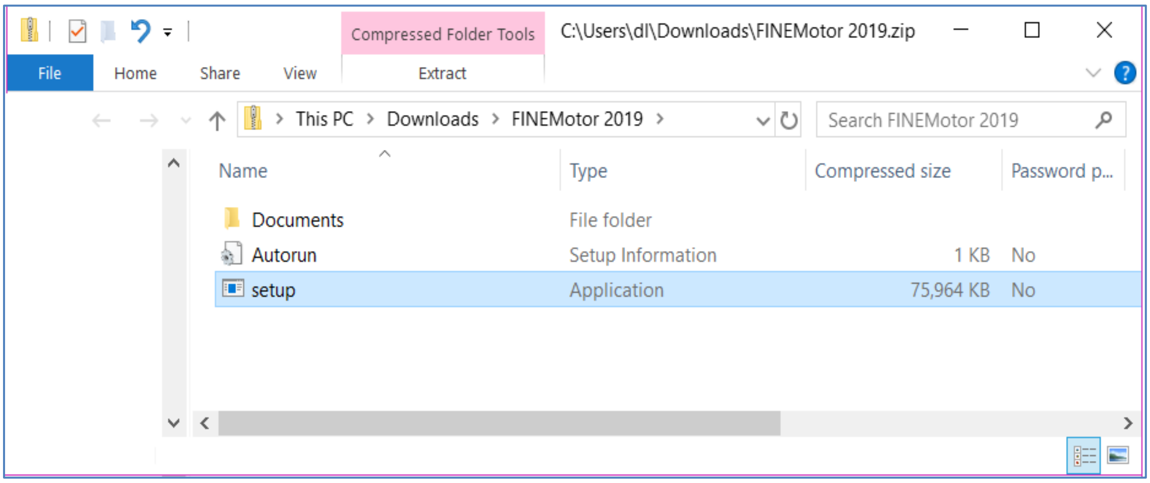
1. How to install the LOUDSOFT programs from a link

The computer must be connected to internet during installation.
You can´t move the program after installation, so make sure to install on the right computer.

- When you click on the license link, you must download the program. Click on "Download" at the top right corner of your screen. Make sure to save it, you might need it later. We change the links from time to time for security.

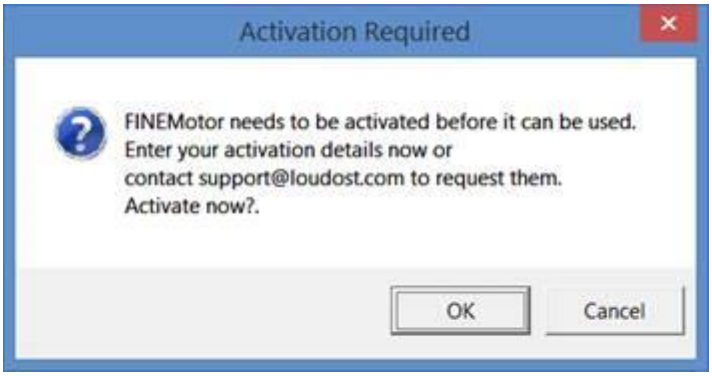


- Now find the downloaded file at the left bottom of your screen. Click on it and you will see the picture below. Click on "Setup" and follow the instructions to install the program.

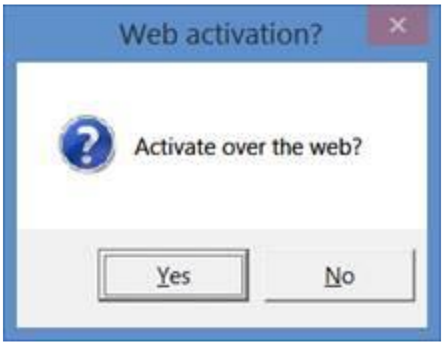


- Once the installation has finished you have to activate (and not later, because it will cause problems). The software will be usable once the activation has been completed.

- Click OK on the first dialog



- Click YES on the second dialog



- Fill in your license ID and password in next dialog. Your License ID is XXXXXXXX, and your password is PPPPPPPP

- Click OK. It is all done!

2. Direct TS parameter input

From this version you can directly input and save individual driver (TS) parameters (for example from Klippel). However, in that case the High-Power Thermal calculations are NOT applied, because the mechanical dimensions are only known from the FM3 files from FINEMotor.

Press the button: TS Parameters / Drivers

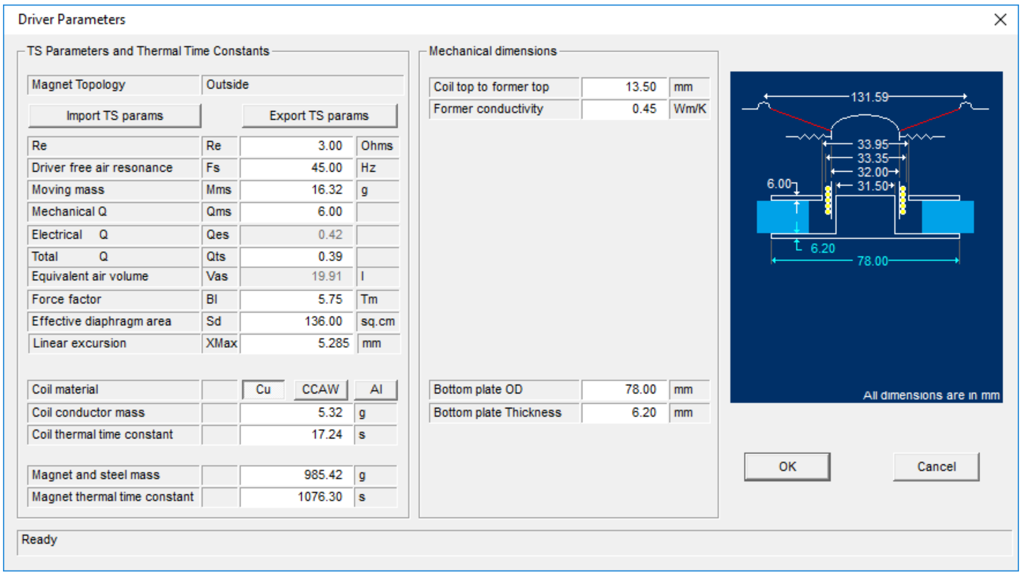


Figure 1 – Direct input of TS parameters (High-Power Thermal not available in this mode)

The TS parameters are shown in Figure 1. Here you can just change the TS parameters one by one and see the change in the box response as soon as you press OK.

For example, you can freely change Qts and view the change of the response in the box. Or if you want to see the effect of higher BL, you can watch Qts change and observe the response changes.

You can also save / export the TS parameters as a txt file for later use.

Figure 2 - Bass reflex box, adjusted for Port volume

The Bass reflex box volume may be adjusted for the port volume, see Figure 2. This is especially important for small boxes where the port can take up a considerable part of the available volume! The bass reflex tuning is using the adjusted volume (shown in yellow) in this mode, which saves time and is much more accurate. A message in red is shown if the volume is not big enough for the chosen port.

3. 8-inch Woofer in different Enclosures

We are going to build several enclosures using the same 8inch woofer to demonstrate the difference in performance. (Saved as example files). The driver is SEAS L22RN4X/P, which has the following data:

SEAS L22RN4X/P main data:

Nominal impedance	8	ohms
Long Term maximum Power	125	W
Linear voice coil Travel (p-p)	14	mm
Voice Coil Resistance (DCR)	6.1	ohms
Force Factor	10.7	Tm
Free air Resonance (Fs)	23	Hz
Moving Mass incl. air load	44.9	g
Effective Cone Area	220	sq. cm
Vas	72	
Qms	3.62	
Qes	0.35	
Qts	0.32	

4. Closed box

Let us start with a closed box. Select the Closed Box Alignment and press Reset to erase the other simulations. Since the Qts is quite low we can expect that a volume much smaller than Vas will work. Let us therefore try with a 25L closed box, which is also the default volume.

We have previously modeled the L22RN4X/P woofer in FINEMotor, which means that we can import the non-linear T/S parameters and thermal data directly into FINEBox by pressing the “Read Unit” button.

The distance from the voice coil winding to the top of the former is approximately 20mm, but we are setting this value to 0 in order to estimate the effect of the open voice coil and phase plug, which provides better cooling. Set the Former conductivity to 226 Wm/K for aluminum.

All Driver Parameters can then be viewed by pressing the TS Parameter/Driver button

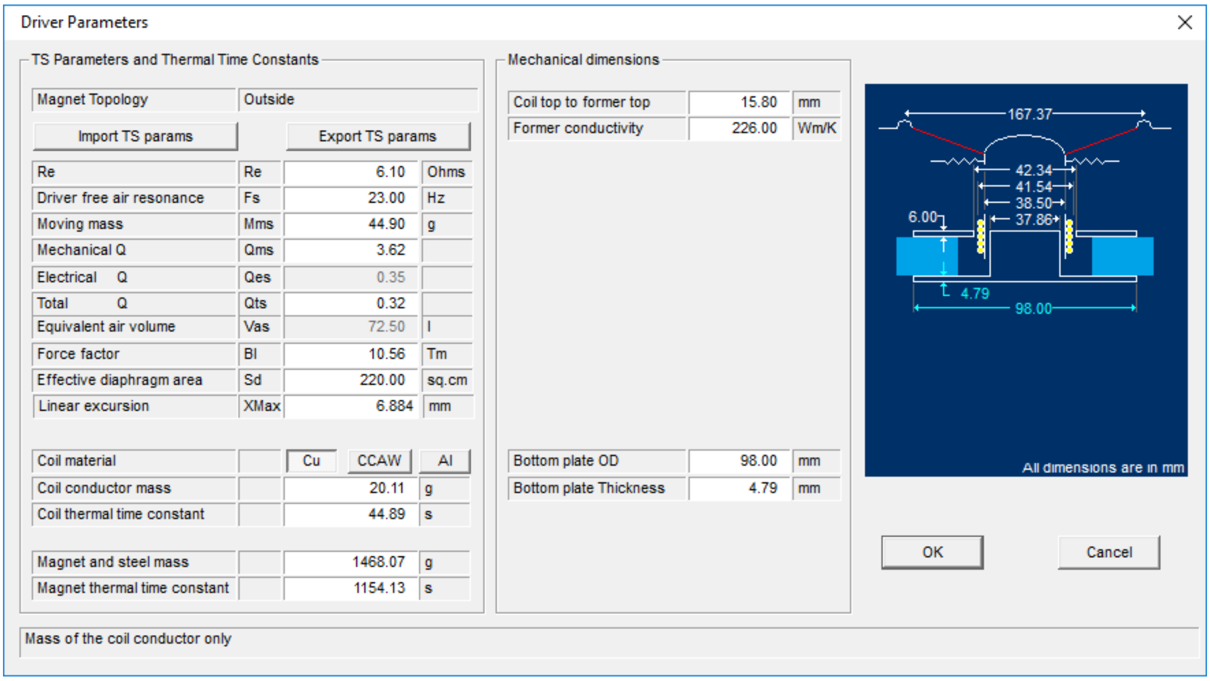


Figure 3 - Data imported from FINEMotor

All we have to do in FINEBox is now to set the input power. The L22RN4X/P woofer is rated at 125W (Long Term Max by IEC 268-5), which is simulated music signal with 1minute On and 2 min. Off. This is effectively a duty cycle of 33% and we may therefore set the input power to 1/3 of 125 W, which is 41.7W to see the long term effect.

The closed box response is well damped with a box resonance of approximately 45Hz, indicated by the peak on the shown impedance curve

.

Be sure to select max time by pulling the time slider to the right. Press Step and type 125W as power (nom). The dash-dot curve is the ideal response and the solid curve is with compression. #2 ideal response is ~5dB higher in SPL, but with the compression increased from 1.5 to 4dB at higher frequencies (until impedance rise), we actually only get 2.5dB more SPL. However the compression around resonance is much reduced, less than 1 dB.

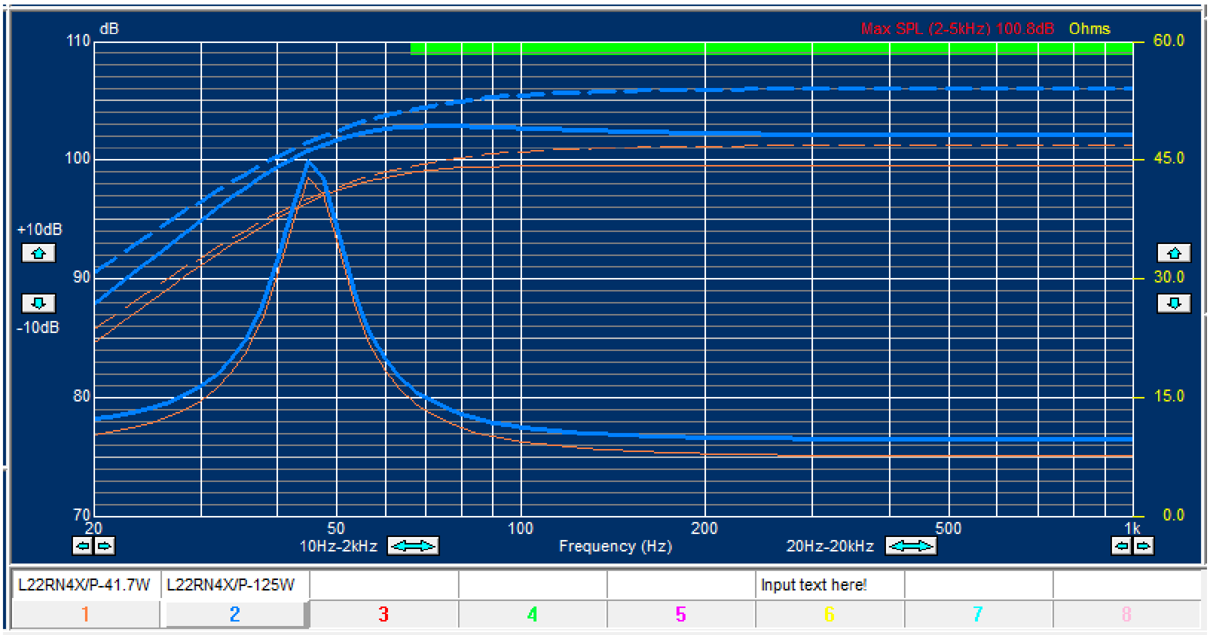


Figure 4 – 25L Closed box compression at 41.7 and 125W (Added label text)

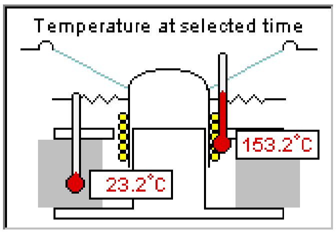


Figure 5 - VC and motor temperatures

Set the time Curtain to 2min25s (=145s), and Figure 5 shows the high temperature of the voice coil (153.2C) and magnet system (23.2C) with 125W input. At this time the magnet system has not yet heated up. Selecting max time = 4:00:00 shows the motor + voice coil fully heated which gives a magnet system temperature of 45.2C, while the voice coil is 167.7C.

By pressing the Vent & Xmax tab we get the actual unit displacement (excursion) in millimeters (mm). The max displacement is reaching 8mm below resonance, which is acceptable.

5. Bass Reflex Enclosure

Press Step and the Bass Reflex alignment button. The new simulation is red and shown by the active button #3 in Figure 6 (You may right-click the #1 button to turn if off for now). This response is unacceptable with the high peak at 60Hz. The solution is a lower tuning frequency Fb. #4 curve (green) is therefore tuned to 27Hz and gives a nice QB3 type response with a rounded corner. The dashed responses are the driver (unit) SPL alone. (The long time responses are not shown for clarity)

In order to make a B4 (maximally flat/ Butterworth) response we need a larger volume. The last curve #5 (violet) is a 36 L box and is tuned to 30Hz. Note the corner is now filled out.

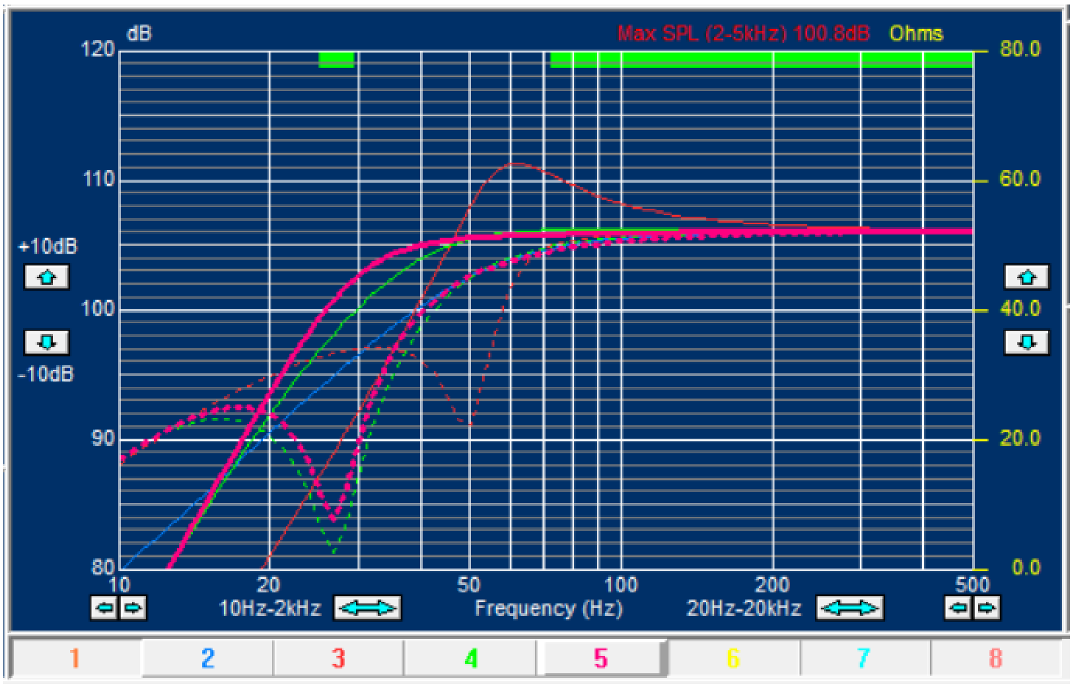


Figure 6 - Four different Bass Reflex Simulations

In comparison let us examine the high-power responses after 4 hours input, in detail. Set the "Digital Clock" (Time Curtain) to 4:00:00 and see the compressed responses (2D Controls [1] & [2] must be depressed). Since we want to compare the last #5 response (bass reflex) against the first (closed box #2) we can turn off buttons #3 and #4 by right-clicking them (right-click to turn on again). See Figure 7.

We now see two new curves below the previous. These are the system responses after 4 hours transferred from the 3D view and we see both responses are about 4dB lower above 200 Hz, but the reflex curve now has a large bump at 50Hz compared to the closed box, which has a more flat response. Unit and port responses are shown as dashed for the bass reflex simulation.
So both responses are compressed at higher frequencies but the reflex curve has changed to a non-flat response with a pronounced bumpy bass, which was not the intention.
At this point you can use FINEBox to experiment and test alternative tunings, alignments, boxes, drivers etc. Even changes to drivers can be suggested with FINEMotor and simulated in FINEBox.

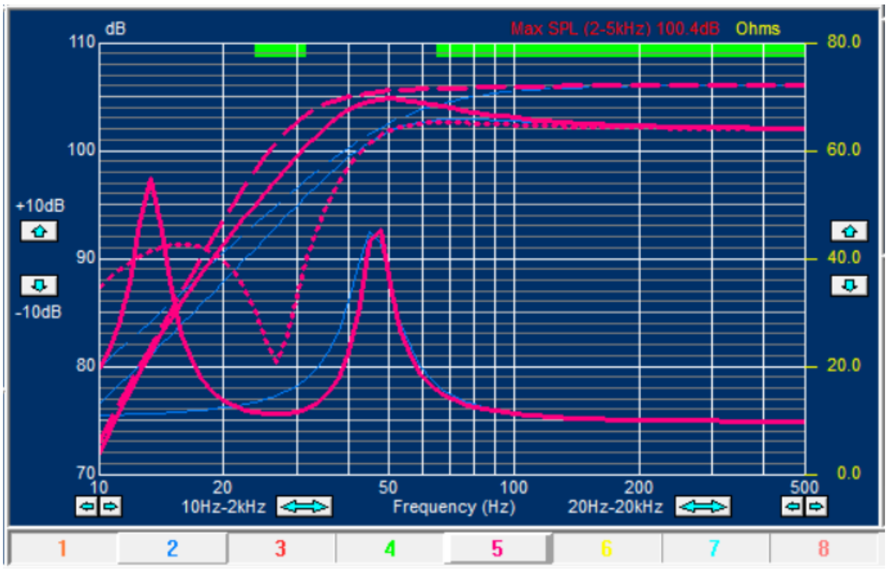


Figure 7 - High Power Bass Reflex versus Closed Box

Press the “Vent and Xmax” tab and we get curves over unit displacement, seen in Figure 8. (the previous high-power curves are also visible). The closed box has a max displacement of 13mm below 50Hz, which is a little more than allowed (10.5). The reflex in comparison shows reduced unit displacement around 27 Hz due to the reflex port “taking over”, but increased displacement below 20 Hz. However the energy content of normal music is much reduced below 20Hz. The bass reflex design may therefore be preferable.
Press the button: “Reflex port Velocity” in 2D controls (#8). This curve is the speed of the air in the port (vent) and is much too high at low frequencies. The rule is to keep the vent speed below 15m/s to avoid “whistling”. Press the “port” button to edit the port dimensions. Let us increase the port diameter to 10cm. Curve #6 shows the resulting vent speed, which is now acceptable. We may select the flanged option to further reduce noise.

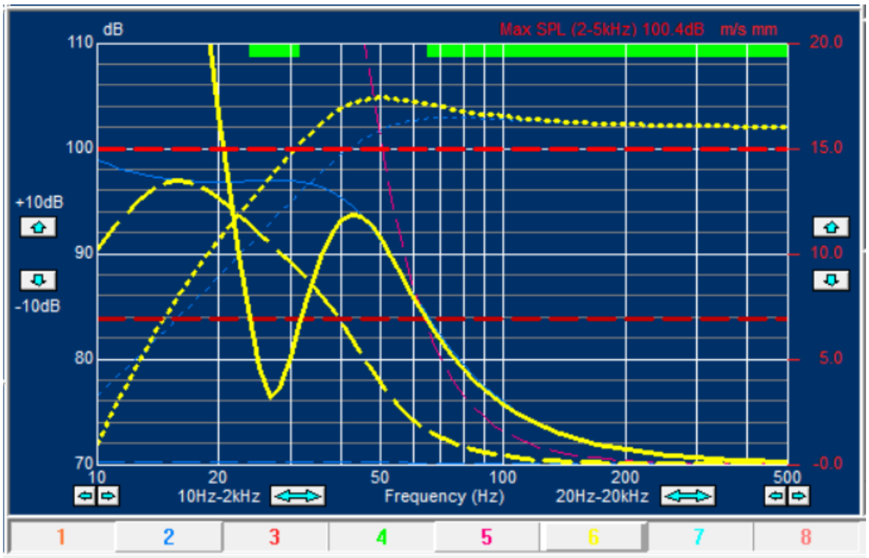


Figure 8 - Vent Speed and Xmax of closed and Reflex Box

The port length is 81.7cm, which may be too large. Choosing a smaller diameter will increase the vent speed at low frequencies and it may be possible to find a good compromise between port diameters and vent speed, because the energy content of normal music is reduced below 20-50Hz.

6. ABR – Passive Radiator Enclosure

An alternative to the bass reflex enclosure is the ABR or passive radiator enclosure. Instead of a tuned port tube a woofer without motor can be used as resonator. The advantage is absence of port noise and suppression of un-damped resonances from inside the cabinet. The ABR can be made using a shallow cone with surround + added mass for tuning. Figure 9 shows the 36Liter bass reflex box tuned to 27 Hz from the previous example, as the blue curve. The red curve is the comparable ABR having a moving mass of 70g to provide close to the same tuning and pass band response. The ABR data are shown in Figure 10. The Fs of the ABR is 15Hz, which causes a notch in the response at that frequency, therefore changing the slope of the low frequency response. The ABR Fs should therefore be placed well under the pass band.

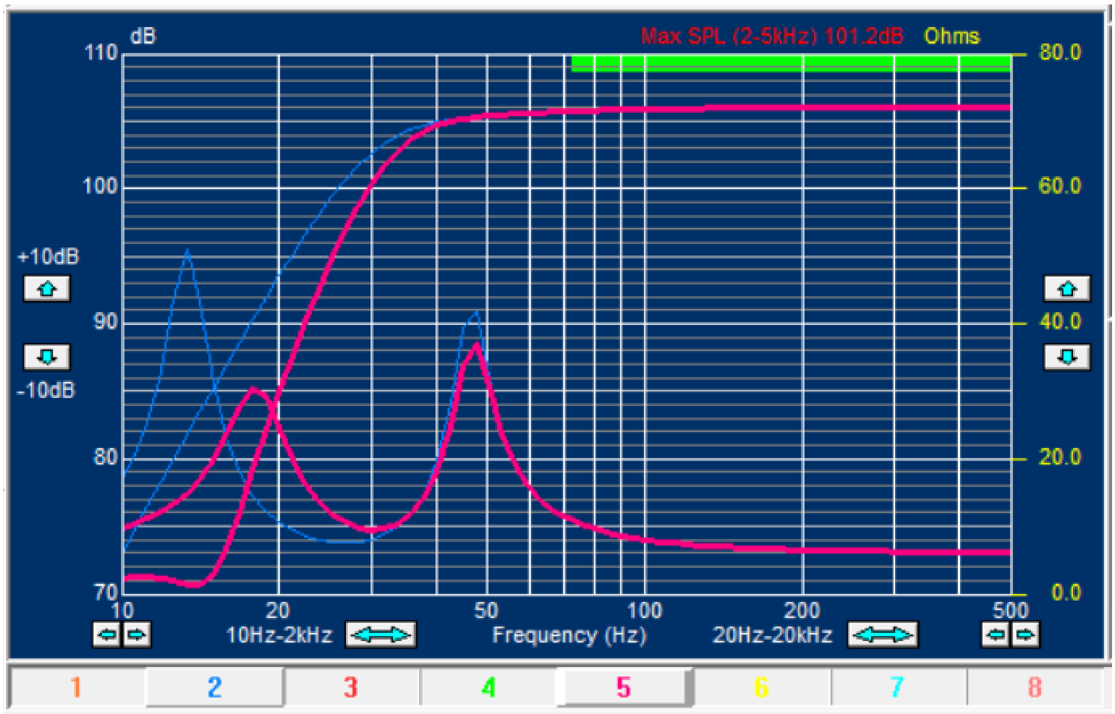


Figure 9 - ABR response___ compared to bass reflex___

The passive ABR unit can be designed by pressing the [ABR] button to get the dialogue shown in Figure 10.

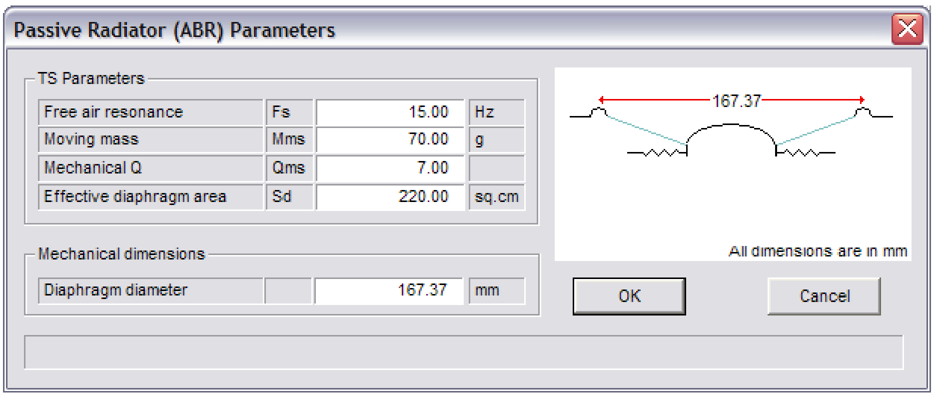


Figure 10 - Passive ABR unit designer

The ABR unit will have its own resonance Fs just like the cone Fo (Use FINEMotor to calculate the compliance and Fs of the ABR). Figure 10 shows the dialogue which is used to specify the ABR. The moving mass is the combination of the passive cone +½ surround, plus an added mass. Increasing the added mass will work like a lower tuning frequency in the box.

Choosing an ABR with the same area as the woofer cone area Sd, puts high demands on the excursion capability of the ABR. This is calculated in FINEBox under the [Vent and Xmax] tab. The excursion can be reduced by choosing a larger ABR diaphragm area, but the added mass must be increased (by the power of 2). All this is calculated automatically and the user can just experiment with different inputs.

7. Band Pass Enclosure

First we will press Reset and OK to keep only the last bass reflex simulation on the screen for comparison. Then press the Band Pass alignment button. The new simulation is blue and shown by the active button #2 in Figure 12. However this response is tilted and not good due to mistuning. Chance the tuning to 45Hz (press the step button each time to keep the old responses) and see a nice symmetrical response but with limited bandwidth. In addition, the box is quite large, 36+25 = 61L.

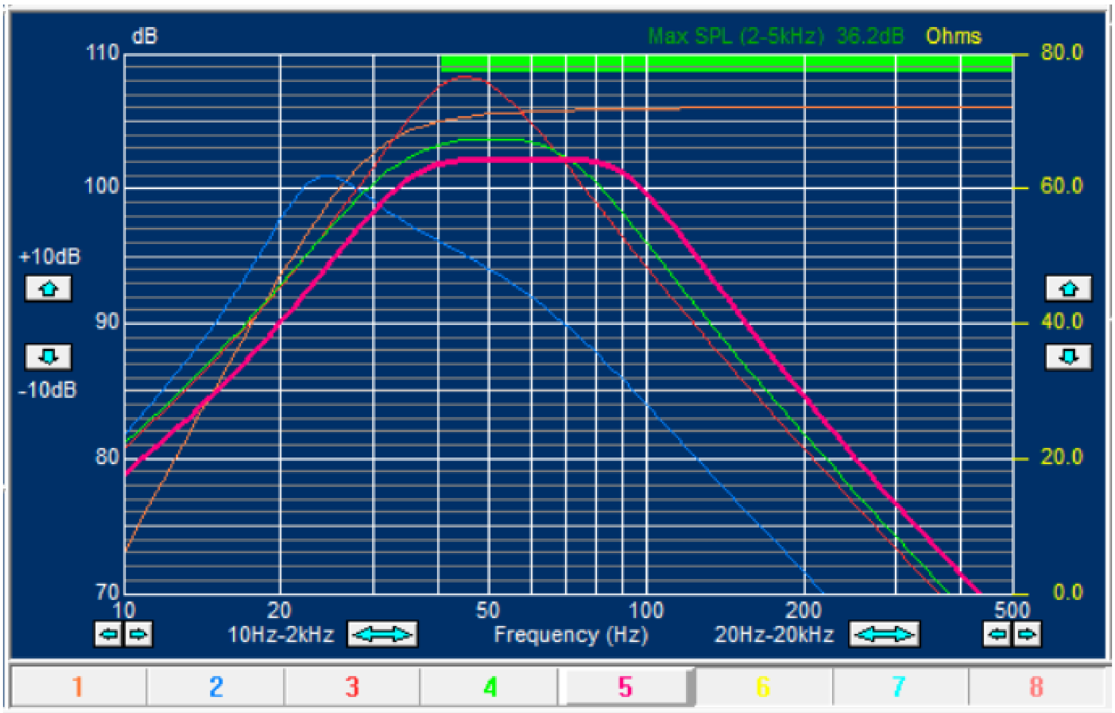


Figure 11 - Band Pass simulations

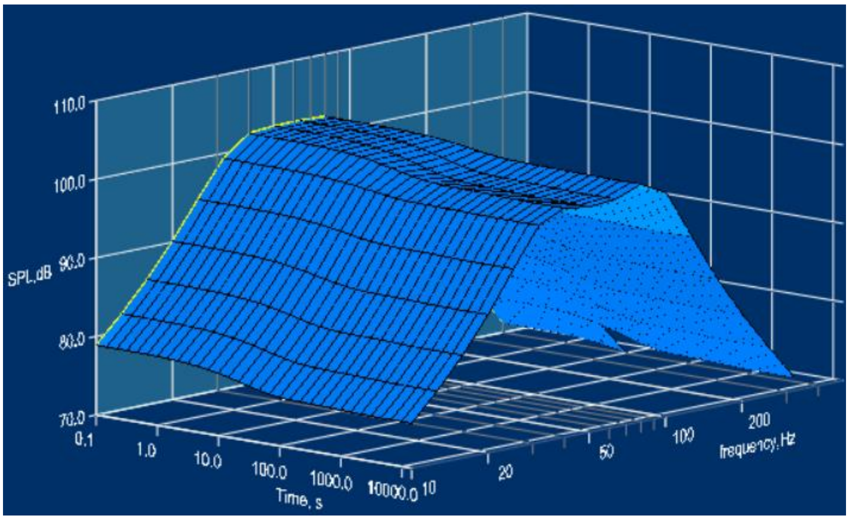


Figure 12 - Band Pass Response has less compression

The front volume can safely be made smaller, let us try 16 l and 47Hz tuning, which becomes simulation #4. Interestingly the low end is unchanged and the top is much reduced in level making the response more band pass. There are several ways to design Band Pass systems and we will only show another here. Changing the front volume to 10 l and the rear volume to 15 l plus 53Hz tuning we get a new more flat Band Pass response (#5) slightly lower in level and with more high frequency extension.
Figure 12 shows the #5 response maintains the Band Pass shape with high input power and has less compression.

8. 15-inch PRO-Sound Woofer

We will show how a typical 15inch PA woofer and Bass Reflex enclosure was simulated in FINEBox with regards to driver non-linearities and compression at various power levels.

The driver is Celestion Frontline 15, which has a die-cast aluminum frame, 4in/100mm voice coil and a large ferrite motor.

Frontline 15 main data:

Nominal impedance	8	ohms
Rated Power (Pink Noise)	600	W (rms)
Voice coil Travel Xmax (+/-)	3.7	mm
Voice Coil Resistance (DCR)	6.0	ohms
Force Factor	25.6	Tm
Free air Resonance (Fs)	37	Hz
Moving Mass incl. air load	109.5	g
Effective Cone Area	855.3	sq. cm
Vas	173.6	liters
Qms	5.6	
Qts	0.22	

Since we have previously modelled the Frontline 15 woofer in FINEMotor, we can import the non-linear T/S parameters and thermal data directly into FINEBox by pressing the "Read Unit" button.

Use 40mm and 700 Wm/K for initial input. (This is the 15inch Reflex Box.fb1 example file).

Press the driver button to view these data, see Figure 13, which include mechanical dimensions plus voice coil and magnet system masses besides the thermal Time Constants. (For example, the voice coil Time Constant indicates the linear start of the exponential voice coil heating, i.e. similar to the charging of a capacitor).

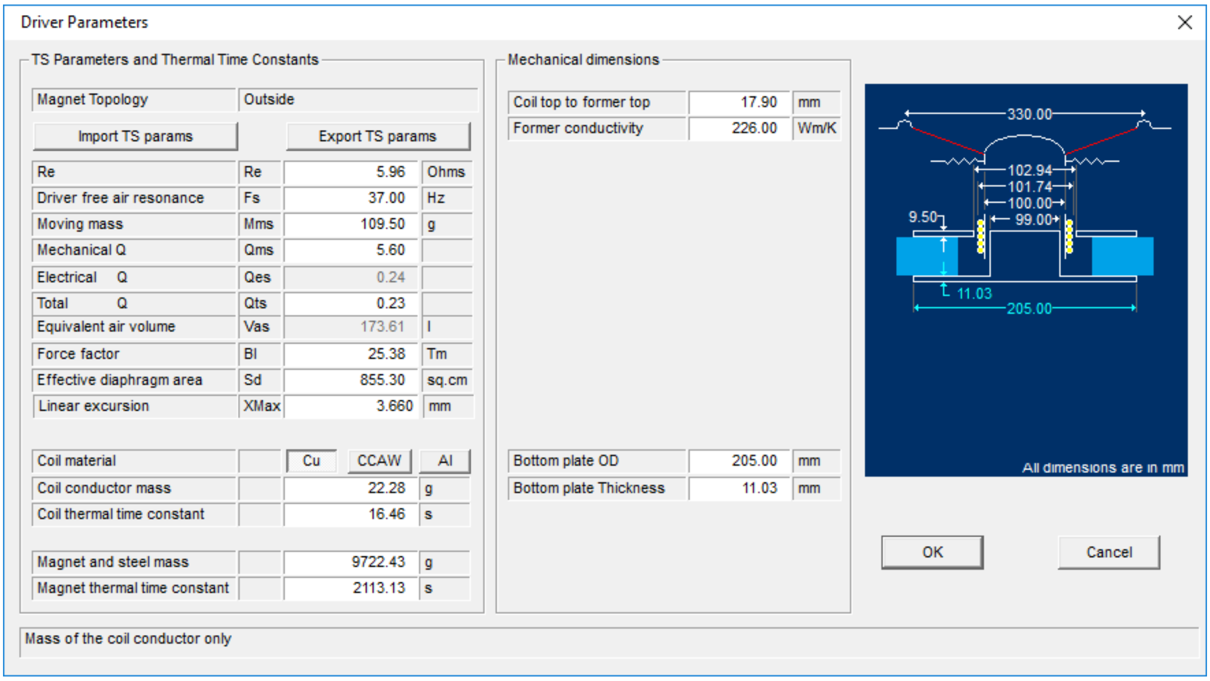
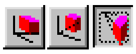


Figure 13 - 15-inch woofer data imported from FINEMotor

Note the (VC-) former conductivity is increased from 0.45 for Kapton to 700 Wm/K in order to estimate the cooling of the ø60mm pole vent. Distance from coil to former top is 40mm, and the bottom plate is tapering to 7mm, so the thickness is set to 7mm. Set power to 600W.
The voice coil thermal Time Constant is 15.45 seconds compared to 1926.63 s for the Magnet (system) as shown in Figure 13. So, the voice coil will heat up much faster than the motor, also because the magnet and steel mass is much higher than the voice coil mass.

Open the 15inch Reflex Box.fb1 example and select one of the 3D view buttons  and view the high-power response using the non-linear T/S parameters (Bring the response in view using the –10dB arrow). Figure 1 shows the perspective 3D view. Note the 3rd axis, which is Time. The response on the "left rear wall" is the initial low frequency system response, which can also be viewed below on the 2D normal frequency response curve.

The blue "carpet" shows what happens with the response when the 600W high input power is applied for a long time.

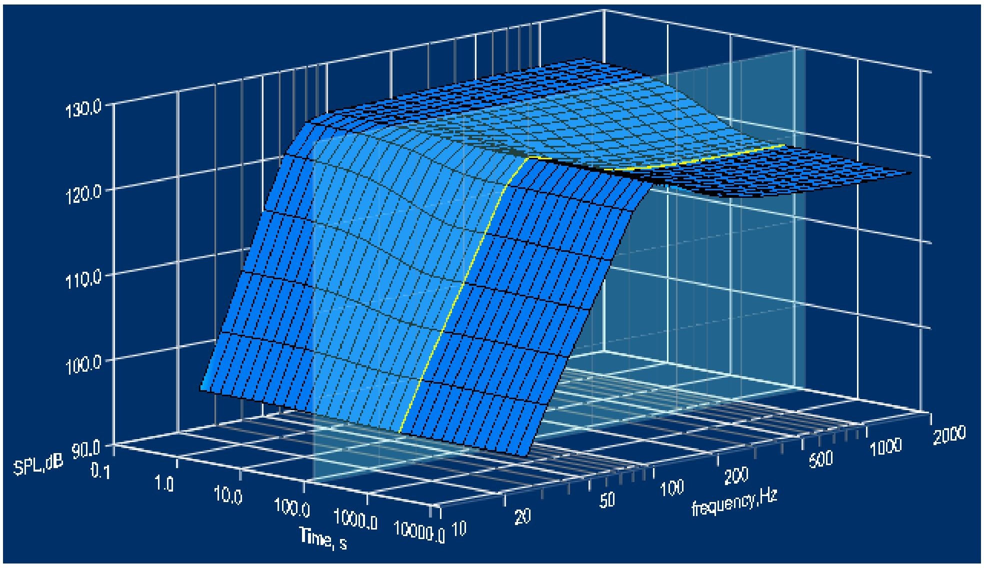


Figure 1- 3D Frequency / Time response with "Curtain"

Note: You can rotate the 3D curve left/right and up/down by dragging! And the divider between 2D and 3D windows can move up/down.

Between 10-100 seconds the curve is changing in SPL level and response shape first due to heating of the voice coil, which is increasing the DCR value, and later heating of the magnet system.

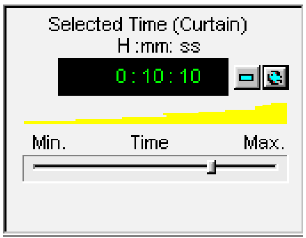


Figure 2 - Time Curtain setting

Figure 2 shows the "Digital Clock" used to set the time of the "Glass Layer" Curtain, to select a detailed response. Use the slider to adjust.

Note: The time axis is logarithmic enabling the user to see both the short voice coil time constant and the much longer magnet system time constant.

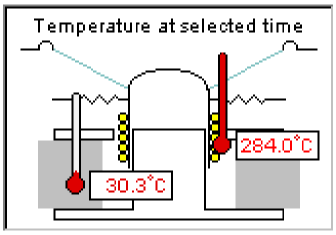
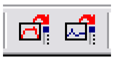


Figure 16 - VC and motor temperatures

Set the time Curtain at 10min10s (=610s) and the Temperature view in Figure 16 shows the high temperature of the voice coil (284.0C) and magnet system (30.3C). At this time the magnet system has not yet heated up. Selecting max time = 4:00:00 shows the motor + voice coil fully heated which gives a magnet system temperature of 57.2C, while the voice coil is 305.5C (from 15inch Reflex Box.fb1 example)

9. 15-inch Bass reflex Enclosure

Due to the very low Qts we can expect to use this woofer with a bass reflex enclosure having a volume much lower than Vas. Accepting the default volume of 25L and selecting a tuning frequency Fb of 63Hz (use the mouse wheel for easy tuning) gives a rounded QB3 type response with –3dB at 90Hz. View these details on the lower 2D frequency response, shown in Figure 17. However, we would like some more bass extension. Press Step and change the volume to 44L and the new curve #2 (blue) shows a –3dB point of 65Hz and this response is quite close to a B4 (4'th order Butterworth/maximally flat).

Note: Use  to export the response + impedance to FINE X-over and here calculate the actual power with crossover. For example, the real power in this woofer would go down from 600W to 209W with one series 2.2mH inductor

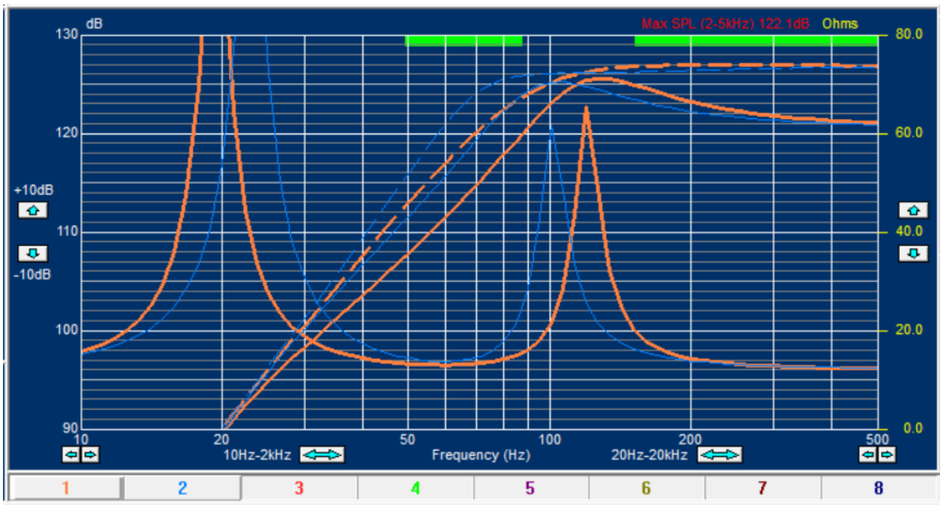


Figure 17 - 15-inch Bass Reflex Box at 600W, 25L___/44L___

When the [1] [2] buttons next to the 2D frequency response are selected, we also see a copy of the "curtain" frequency response i.e. the response WITH compression (solid line). At the max time (4 hrs.) and 600W power, the response is no longer flat, but has a peak at 100Hz.

The difference between the dashed and solid curves is the compression. The compression of the blue curve (#2) is only 1dB at 100Hz, increasing to around 6dB below and over this frequency (less due to VC inductance).

Figure 3 shows the port for the 63Hz tuning: The flange reduces port noise.

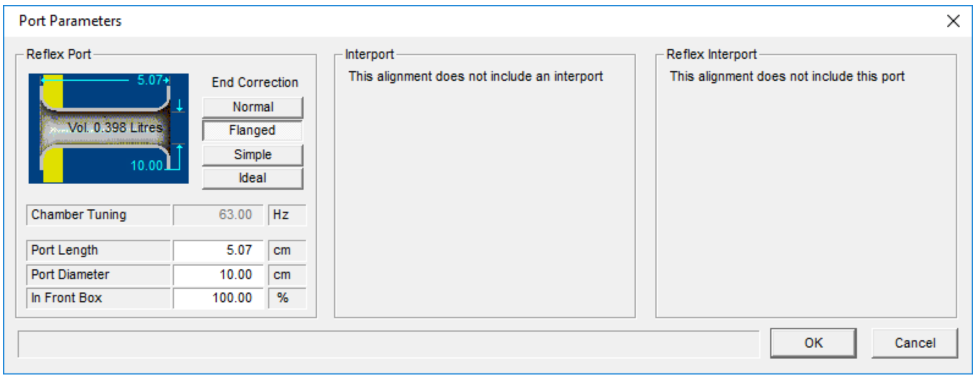


Figure 3 - Flanged Bass Reflex Port

10. 15-inch Bass reflex using Isobaric (dual) Woofers

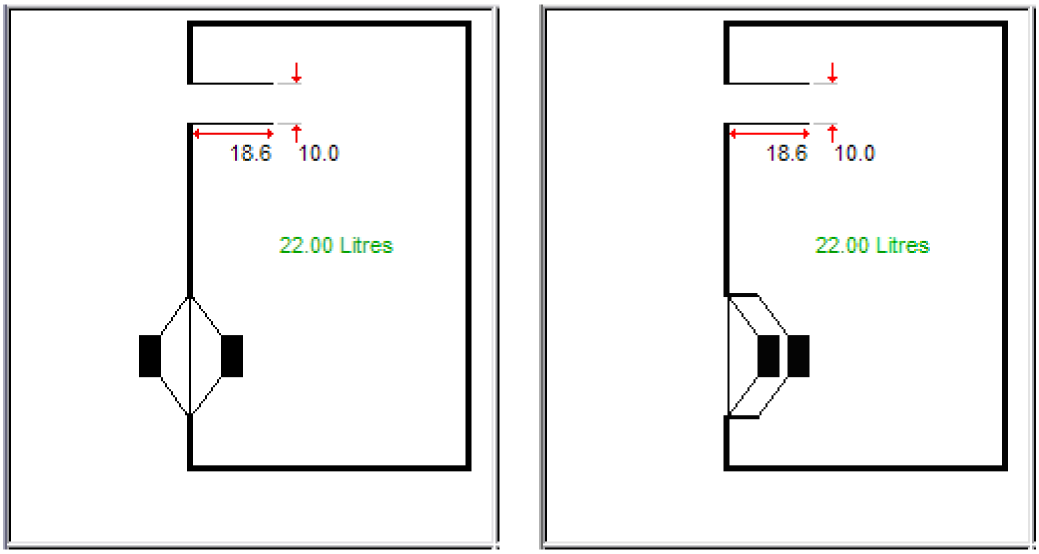


Figure 4 - Alternative Isobaric (dual) woofers

The isobaric concept is simply two woofers put together face to face. Two examples are shown above, and effectively the two woofers will perform as one “super-” woofer with double mass and half Vas and impedance when the two Voice Coils are connected in parallel.

The previous bass reflex box of 44 litres is shown in Figure 20 as the orange response and the red response is an isobaric consisting of two of the same 15” woofers. Note the box size is now only 22 litres due to the isobaric principle. (The red curve was moved 1 dB up for clarity).

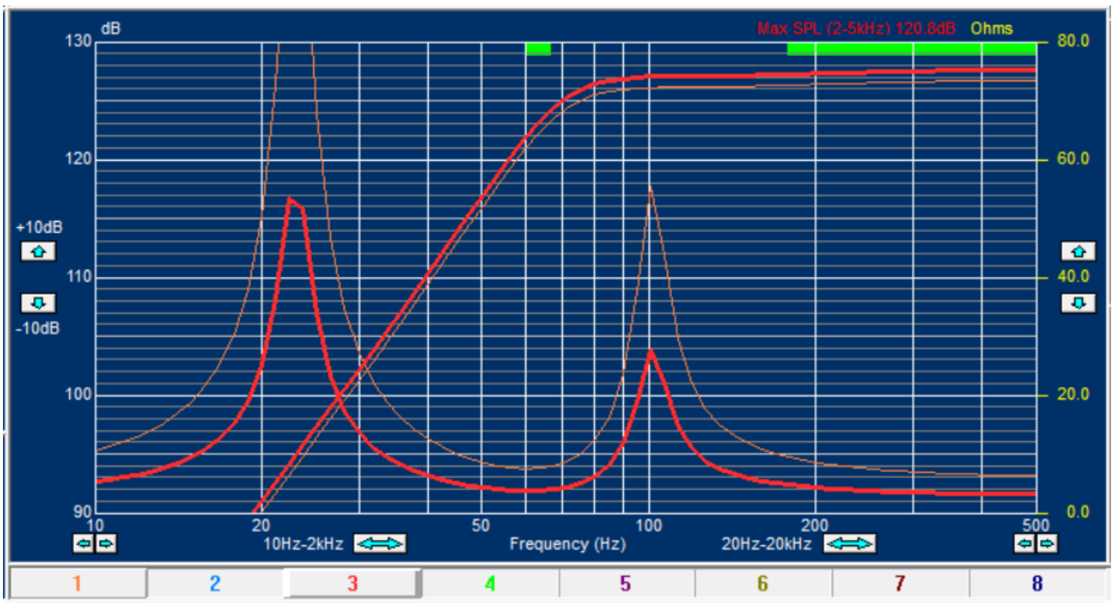


Figure 20 - 15-inch isobaric woofer in 22L Bass Reflex Box__ (+1 dB up for clarity) / Single woofer in 44L Bass reflex Box___

11. Micro Loudspeaker / Receiver Box Design

Micro loudspeakers and receivers can be designed in FINEMotor and imported into FINEBox, where the acoustic loading / box volume and tuning can be simulated. (See the Appendix for special micro settings)

(You may go to Settings and select: Display values with extra precision xx.xxx)

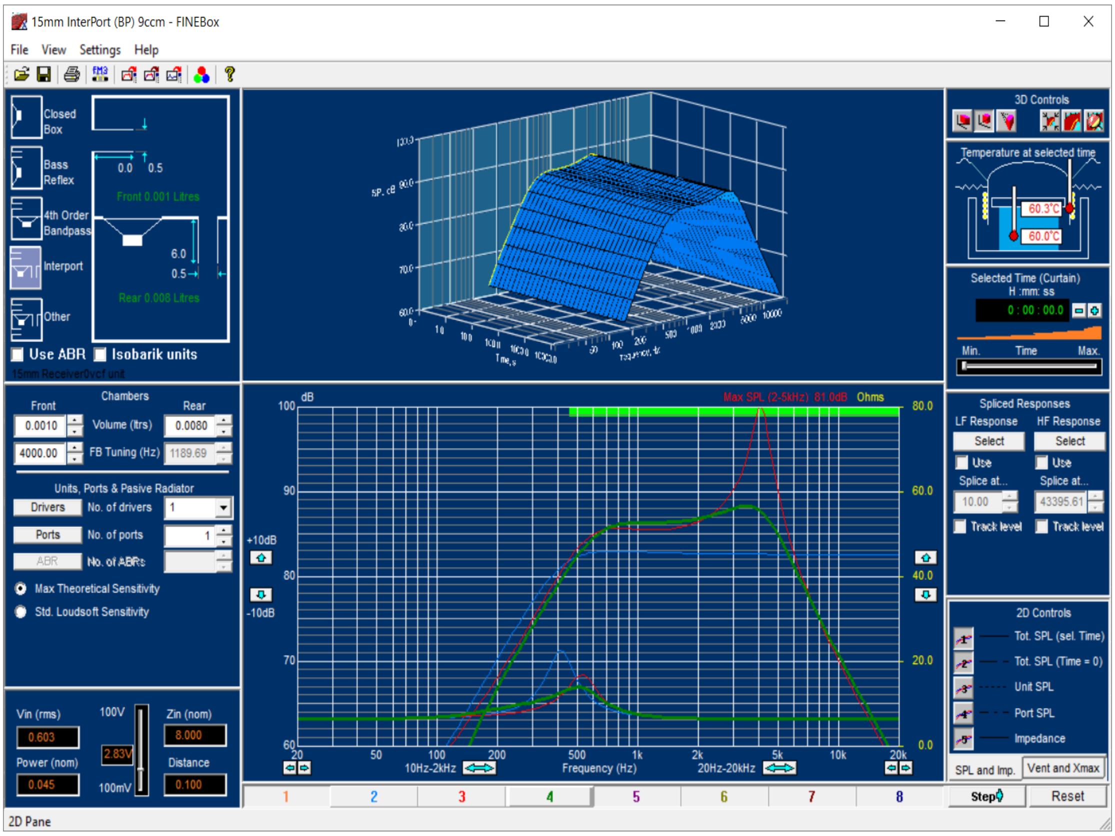


Figure 5- 15mm micro speaker in closed___/Band pass___/ damped InterPort___

Sensitivity

Note that you can display the sensitivity in two different modes:

- Max. Theoretical Sensitivity (This is very useful for micro speakers)
- Std. Loudsoft Sensitivity (This is the lower conservative Loudsoft SPL)

Note: The Max. Theoretical Sensitivity is using the original formula based on Re
The Std. Loudsoft Sensitivity is most valid for normal / Hi-Fi drivers

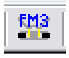
We will start a 15mm box design by importing a FINEMotor file (with T/S parameters and thermal data) directly into FINEBox by pressing the FM3 button. 

Figure 22 defines the additional information. The first is the distance from winding to diaphragm, which here is 0, since the VC is glued directly to the diaphragm. The second number is the thermal conductivity, which here is the lower number 0.45 Wm/K for isolating materials. The linear excursion Xmax=0.276mm is also imported.

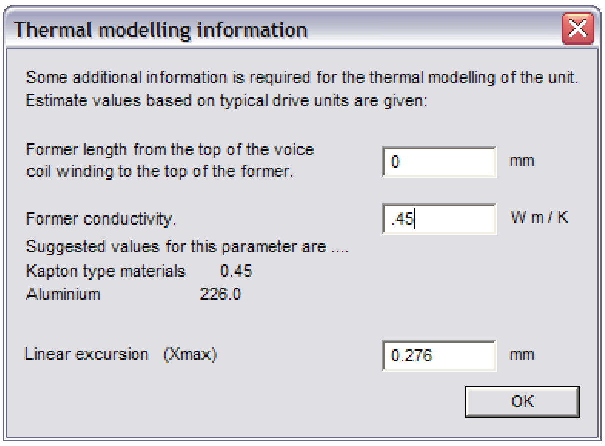


Figure 22 - Thermal Info Input

Figure 6 shows the complete driver data, imported from FINEMotor. The thermal time constants of the VC and motor are automatically calculated.

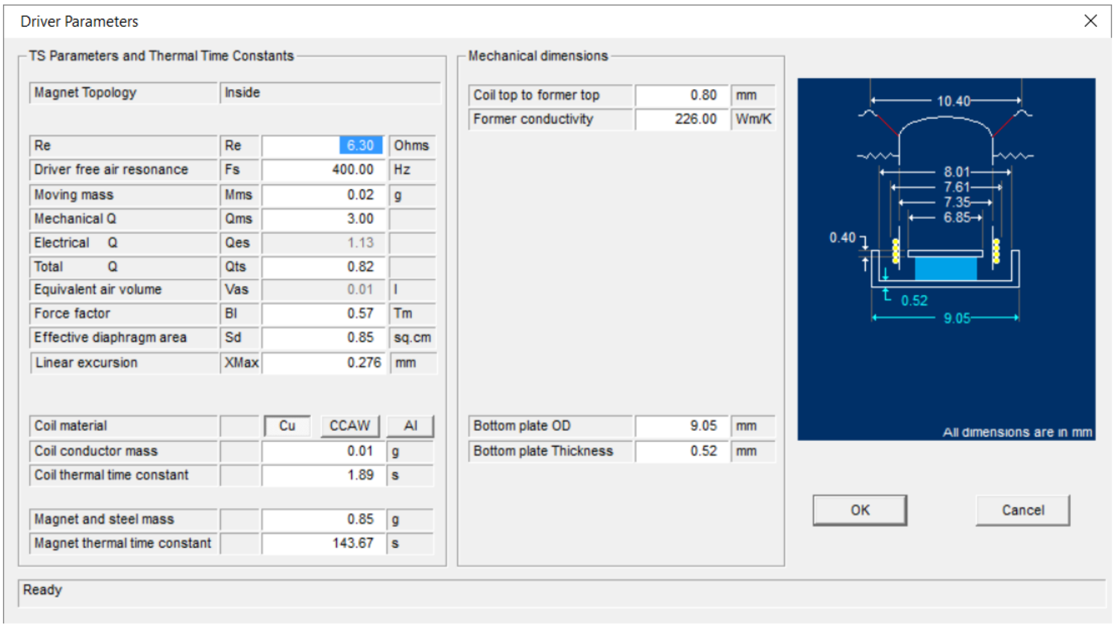


Figure 6 - Complete 15mm micro speaker data imported from FINEMotor

The FINEMotor FM3 import is necessary to take advantage of the high-power thermal calculations of VC temperature, motor temperature, power compression etc.

Now the 15mm micro speaker/receiver unit is placed in a closed box volume of 0.1 L (100ccm) by selecting the upper left button “Closed Box” and adjusting the (Front-) volume to 0.100 L by rolling the mouse wheel. This is shown as the blue curve in Figure 5 (Button #2).

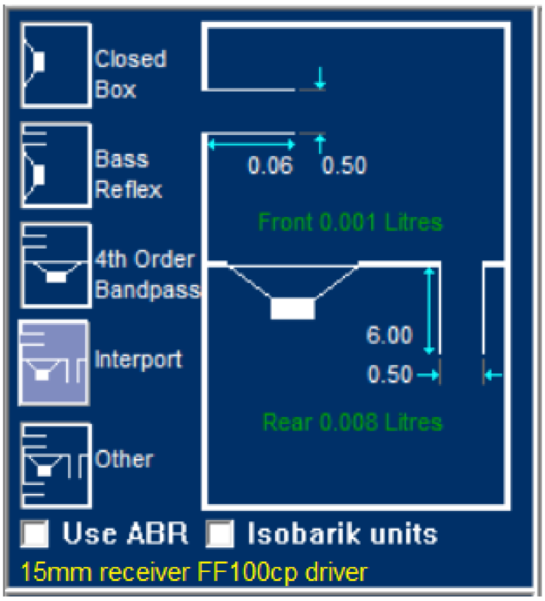


Figure 7 - FINEBox Acoustic Loadings

The blue curve (#2) has an impedance peak close to 400 Hz, which is the resonance Fs. The input voltage was adjusted to give an Xmax excursion of 0.28mm, (= Xmlin: max excursion with VC still in the gap). This gives a max SPL of 81dB at 0.1m defined by the frequency range indicated by the green line.

In contrast the red curve #3 is a bandpass design with a small hole (port) in front of the speaker. This port is tuned to 5000 Hz after which the response drops at higher frequencies. Again, the input voltage was adjusted to give a max excursion of 0.28mm, giving a max SPL of ~83.7 dB at 0.1m. However, there is a very large peak at 5000 Hz.

Choosing the InterPort option in Figure 7 and adjusting the interport Q to 0.9 as shown in Figure 8 brings down the peak and gives a quite flat bandpass response. The high damping (lower Q) is made by covering the (inter-) port with a cloth or felt, which will pass air but add damping. Actually, the front port can be damped in the same way. Max SPL (2-5 kHz) is dB.

The VC and magnet temperature are in the upper right picture. The VC is at 28.9C which is no problem. See the next two sections regarding high power simulations.

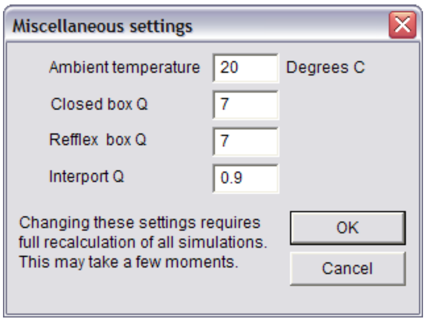


Figure 8 - Setting of Port Q and damping

The ports can be changed by modifying the port diameters as done in Figure 9 and the length will automatically be calculated according to the chosen tuning frequency. A flange (trumpet-like design) can reduce port noise/whistling.

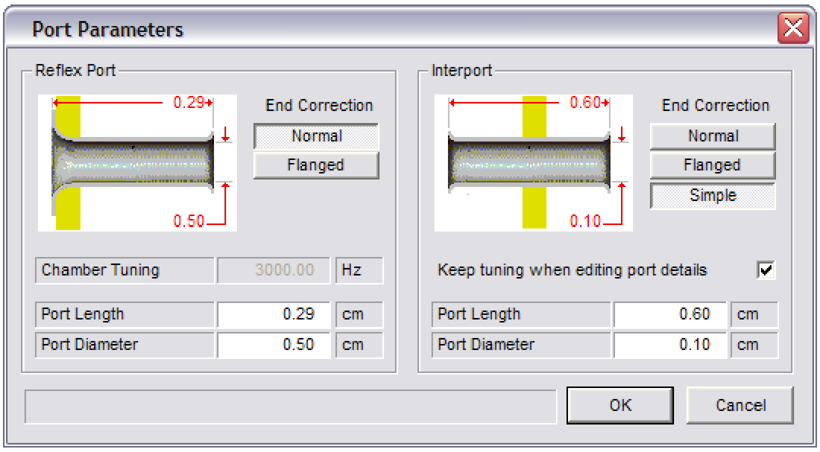


Figure 9 - Change of Port diameters and calculated lengths

Figure 10 - Excursion of 15mm closed/Band pass/InterPort

Figure 10 shows the VC excursion of the 3 designs, where the input was set to produce 0.28mm (Xmlin) at the resonance frequency (Fs) in the box. Because the excursion is increased at low frequencies, the design with the higher box resonance (green #4) can produce a higher SPL in the pass band. In order to prevent problems, it is advisable to insert a high pass filter to limit the low frequencies below Fs.

12. InterPort Enclosure

In comparison let us test an InterPort design. A front volume of 20 l and 15l rear tuned to 65Hz works fine (#6). The sensitivity is high but with less low frequency extension.

Note the displacement of the band pass design #6 in Figure 11, which exceeds Xmax (dashed horizontal line close to 7mm) below 53 Hz indicated by the upper green wide line. #5 is below Xmax down to 40 Hz, which is clearly better.

The InterPort displacements are high at low frequencies, like the previous bass reflex. However the energy content of normal music is reduced below 20-50Hz, which will limit the displacement.

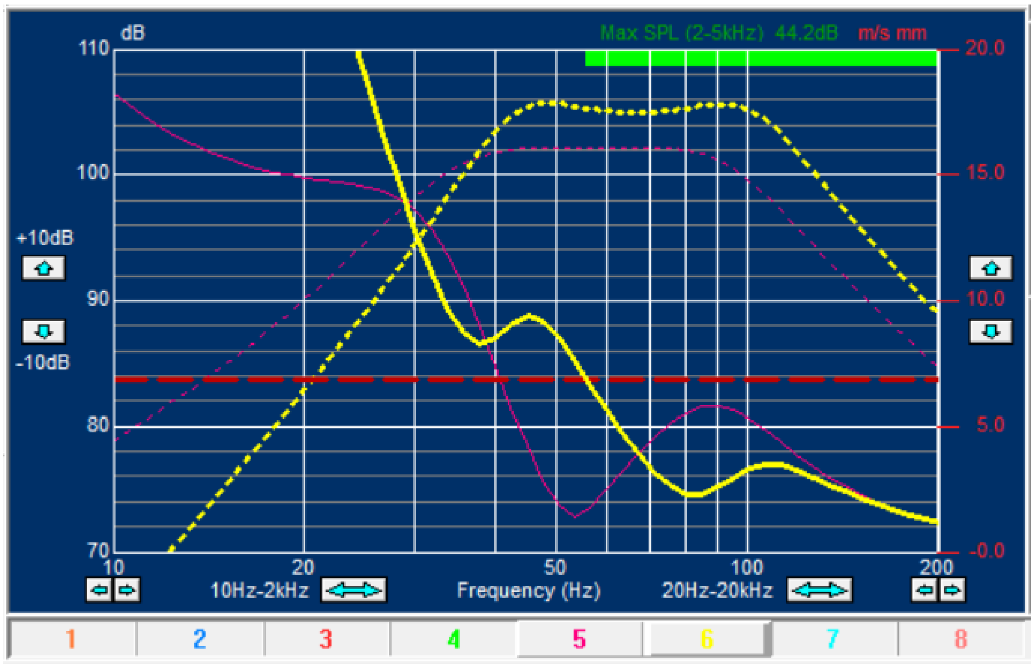


Figure 11 - Band Pass and InterPort unit displacements

Press the Ports button to design the InterPort. Choose between normal and flanged port like the bass reflex, but in addition a simple port may be selected. Note the option to keep tuning when editing port details.

13. Multiple Drivers and Ports or ABR's

Sometimes it is an advantage to use more than one driver in a box. From 2017 you can select up to 4 drivers connected in different ways, see Figure 12.

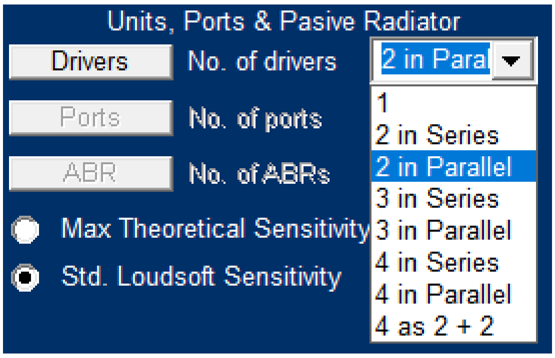
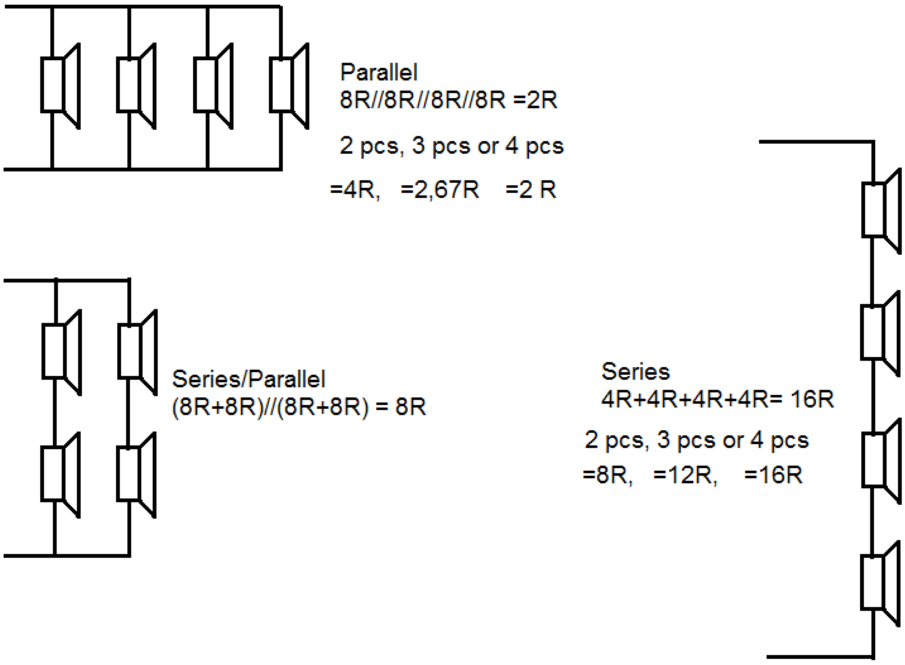


Figure 12 - Driver (Unit) combinations

Below are shown examples of 4 drivers in Parallel, Series and Series/Parallel (2 +2)



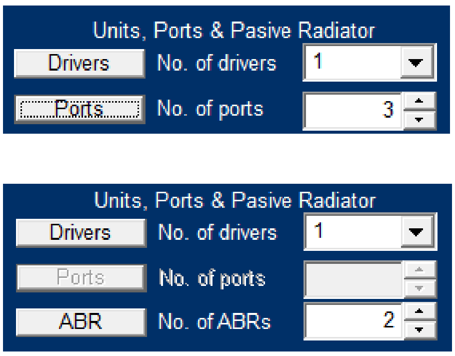


Figure 30 - Set number of Bass Reflex Ports or ABRs

14. Spliced Simulated + Measured Responses

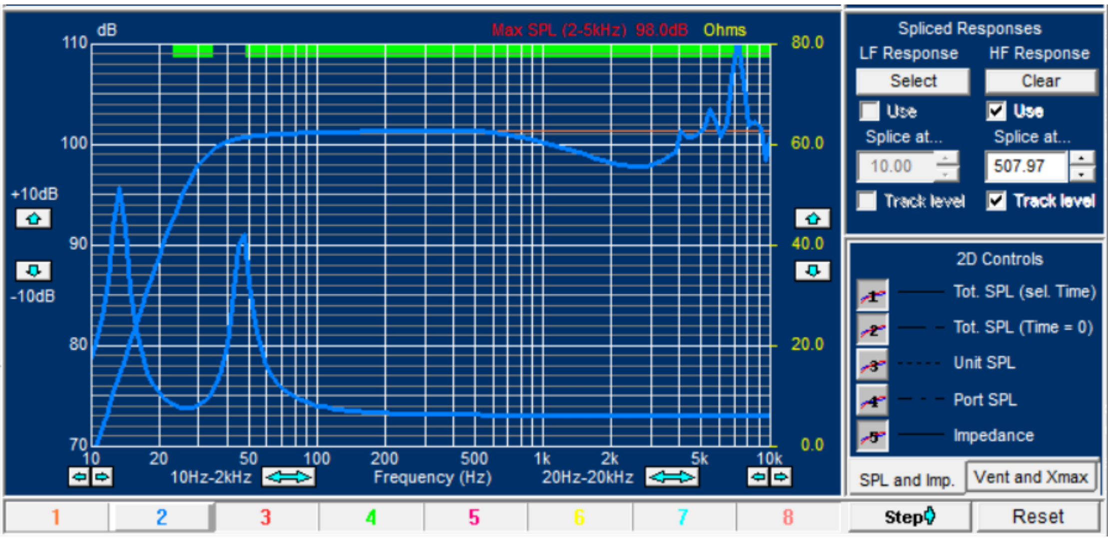


Figure 31 - Simulation with spliced response from 500 Hz

Further it is possible to mix a simulated response with a measured one from for example FINE QC, or a simulated response from other software simulations, see Figure 31. Here the simulated response 6_5 Woofer Large Dust Cap. FSIM was spliced to the FINEBox 8inch bass reflex simulation at 500 Hz. In addition the level was matched (at 500 Hz) by checking the Track level box [x].

The magnitude of the combined response may even be exported, for example to FINE X-over. Export the combined response in the FSIM format, which can be read by other FINE programs, by pressing the button. 

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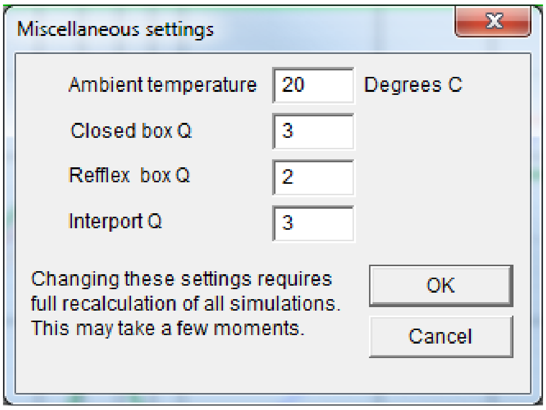
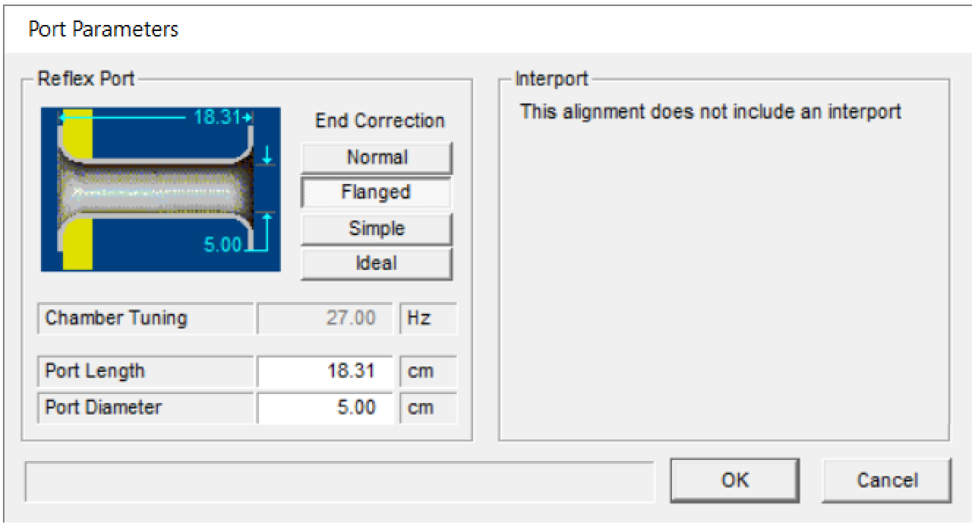
A. Appendix: Special settings for Micro Speakers

This version will import fm3 files from FINEMotor 2012 and up.

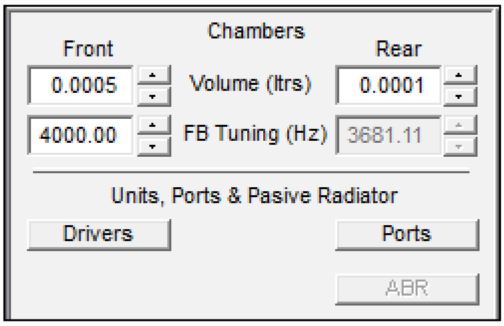


Q values can now be lower than 3, to simulate ports with cloth etc.



Ports:

Normal	One flange with correction
Flanged	Two flanges with correction
Simple	No flanges with correction
Ideal	No flanges without correction (use for small channels)



Volumes down to 0.0001L (=0.1ccm) – Use mouse wheel to step through range.