**Part 2**


**Working With SoundEasy Tools**


Before progressing any further, please note, that your copy of CD-ROM contains driver files, project file and an FEM-type of data file. The files are fully edited and they offer you an excellent way of familiarizing yourself with all program's functions. For instance, when learning about drivers and enclosures, all you need to do, is to load a driver file and use screens and functions related to driver's editing, enclosure editing and modeling and optimization.

**Using SoundEasy**

Any computer modeling program requires you to provide it with some data to be processed by the program's functions and algorithms. SoundEasy is no exception. Ideally, you would provide the program with all necessary data – in this case, you would be able to utilize all built-in, powerful functionality. In many instances, you may be able to extrapolate some missing data, or use program's default settings.

**The design concept, that SoundEasy follows, could be broadly described as shown below:**

1. **Create library of drivers.** This should be really your starting point. For sealed/vented enclosure analysis, you can get going with only a minimum of several parameters entered. On the top of this, you will need SPL and impedance curves entered into the program to allow you for crossover analysis – see step 3. The EasyLab should be used extensively at this point to determine T/S parameters.
2. **Design enclosure for appropriate drivers**. At this point of the design process, you should be able to determine physical shape of your enclosure. This is typically accomplished by selecting enclosure internal volume, which corresponds to the SPL of your design goal. For a simple, rectangular enclosures, you can get very good design drawings from SoundEasy as well.
3. **Construct the enclosure and measure SPL/Impedance of the selected drivers**. The enclosure does not to be "commercially finished", but needs to have all sound affecting attributes in-place. At this point, you have all data needed for crossover design. You can use EasyLab at this point of the design process. The SPL and impedance curves need to be measured at this time.
4. **Design crossover**. Use provided CAD screen. You can start with a simple two-way built in crossover and learn from there.
5. **Perform listening tests using Digital Filter function of SoundEasy**. Here you have an opportunity to perform all tweaks and optimizations of the crossover in time and frequency domains.
6. **Built the crossover and perform final system assembly, measurements and optimizations**. Be prepared to spent significant amount of time in Steps 4,5 and 6.
7. **Analyze your listening room using FEM modeling system**. Predict the best placement for bass.
8. **Enjoy your new speaker system in action**.

It needs to be noted, that SoundEasy is capable of a lot more complex tasks than listed above. You will be able to master the program in time and learn quite a few "trick-of-trade" as you move forward.

**Create Library of Drivers**

You will need to edit all drivers you intend to use in your system. Here, we are talking about entering T/S parameters of the driver, entering the mechanical and non-linear parameters and entering or measuring it's SPL, impedance curves and non-linear parameters. One parameter, that is often considered "esoteric" and difficult to determine is the Acoustic Center Offset (AC-offset) of the driver. The EasyLab section of the Reference Manual shows you one possible method of determining the AC-offset. Having your drivers fully edited is very handy. You will be able to swap drivers in your projects at will, without worry about relative AC-offsets between the drivers. Editing of the driver is grouped into four tasks (four tabs) in "Driver Parameter Editor" control box.

**Entering SPL and Impedance Curves**

There are basically four ways of entering SPL/Zin curves into the program.

1. Using "Amplitude Model" tab
2. Importing data from measurement file
3. Hand-drawing the curves on the screen
4. Using EasyLab

At times, you will use combination of the methods.

**Hand-drawing Data Point on the Screen**

Frequency response can also be accomplished with the help of the mouse and cursor keys. The initial frequency response curve is a flat line, that defaults to 90 dB efficiency. Position the pointer arrow at the point with the corresponding coordinates to those on the data sheet frequency response at the same frequency and then click the LEFT mouse button. Then a little gray rectangle will move from the flat '90 dB line to the newly created frequency response plot. The Frequency/Amplitude coordinates, just above of the graph area, indicate the exact coordinates. It is recommended to "fine tune" the position of each data point using cursor keys which move the frequency response current data points by smaller amounts and are very useful after the broad frequency response has been entered. A manual way to edit the frequency response is to position the mouse pointer on the plotting area and press LEFT mouse button. Keep the button depressed and simply trace (draw) the frequency response on the screen. The resulting frequency response will be coarse, but then you can fine tune it using the cursor keys. Use "**Edit Amplitude**" button frequently to clean-up the plotting area and confirm, that none of the data points were left out. This process may seem time consuming. It does, however, need to be performed accurately because errors acquired during this initial phase, must affect all data processing performed by the other tools. It is performed only once per driver, during the creation of the data library. Having edited SPL curve you need to convert it into the driver's amplitude and phase data. This is called creating a **Transfer Function** and is accomplished with the help of Hilbert-Bode Transform screen.
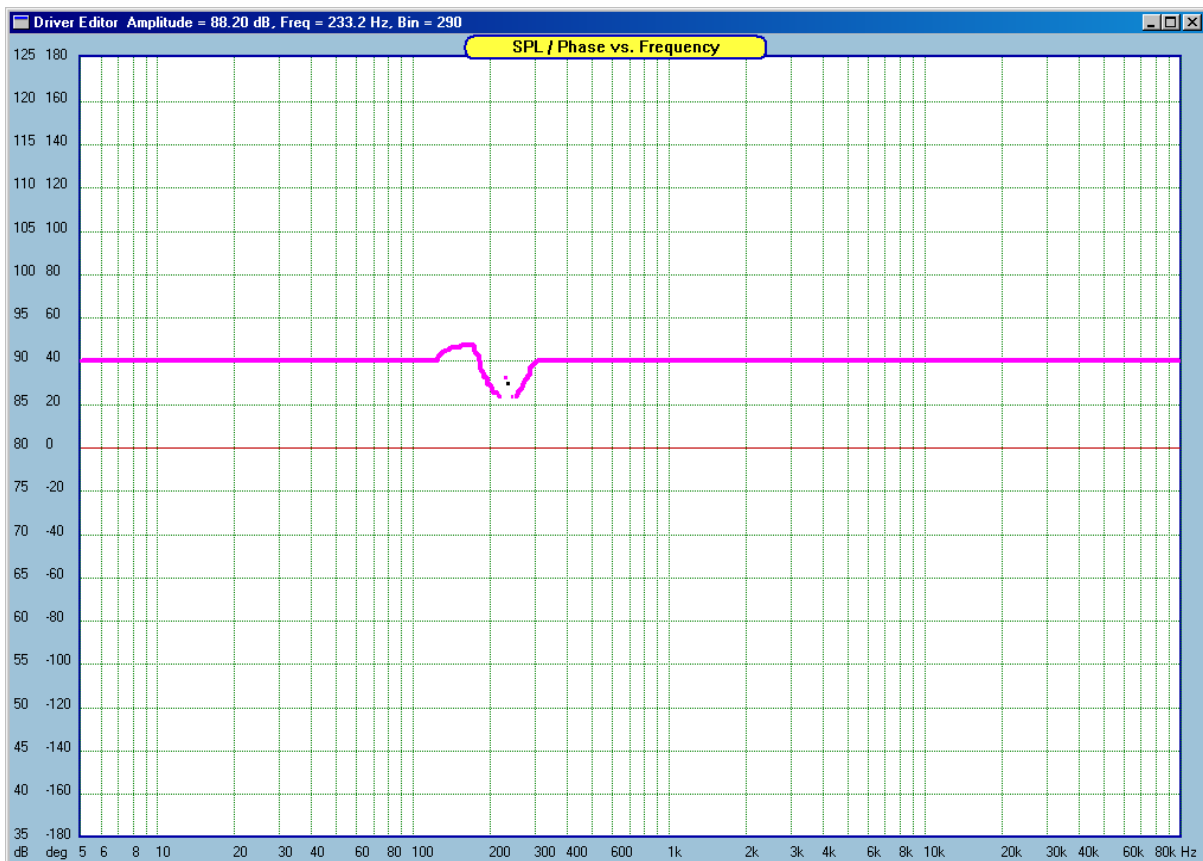


Fig 2.1. Hand-drawing SPL curve on the screen

**What to do if you only have SPL graph ?**

Driver frequency response plots, as obtained from the manufacturer, specify the test conditions under which the curve was obtained. In the majority of cases the frequency response is a graph representing the sound pressure as a function of frequency when the driver is fed a constant sine wave signal. That implies, the test amplifier was a voltage source, just like your Hi-Fi amplifier. Also, the test enclosure volume and type filling will be given. The test is usually conducted in an anechoic room with the pick-up microphone placed at 1 meter distance. It is almost certain, that the manufacturer's test enclosure type and volume will be different from the one you attempt to design. However, it is all that you have and it does contain valuable information for SoundEasy. It is then recommended, to follow the procedure outlined below. Remember, the goal here is to obtain driver's complex transfer function.

1.  Enter all electromechanical parameters of the driver using 'Editor' screen.

2.  Invoke 'Enclosure Design' screen and plot the frequency response of the driver selecting exact parameters of the manufacturer's test  enclosure.

3.  Design the enclosure for your application and plot the resulting frequency response on the same graph as the manufacturer's box frequency response. You now have two graphs on the same plotting area.

4.  Then compare the two plots. What is important is the difference between them. It is recommended to have a hard copy of the two plots (printout). You will notice, that for certain frequencies, your box frequency response was drawn above manufacturer's box frequency response ( the difference is positive ) and for other frequencies, it was drawn below ( the difference is negative ). Print this screen for reference.

For example:

| Frequency | Manufacturer's box response | Your box response | Difference |
|---|---|---|---|
| 30.0 Hz | 75.2 dB | 81.0 dB | +5.8 dB |
| 32.0 Hz | 77.0 dB | 84.0 dB | +7.0 dB |

and so on....

5.  Now you can go back to the 'Editor' screen and enter the frequency response required by this module. It is entered as the manufacturer's anechoic room test frequency response plus the difference between their test enclosure and your chosen enclosure ( values in column 4 above)  That is, for every frequency step offered by the 'Editor' module (occasionally, you may have to approximate your readout from the manufacturer's box frequency response, since SoundEasy offers discrete and fixed frequency steps ) you need to enter corresponding value of the manufacturer's anechoic room test frequency response plus the difference above.

6.  While entering the final frequency response, you must preserve all the small ripples and irregularities that are evident in the manufacturer's anechoic room test frequency response. This method may require modification if the test microphone is placed at .5 meter instead of 1 meter, but the principle for obtaining the accurate frequency response remains the same. In order to correctly predict the summed magnitude response of the complete speaker system, the magnitude and phase responses of the individual drivers must be known. Using the 'Transfer Function' screen, it is feasible to develop accurate, minimum-phase complex transfer functions of the sound pressure and input impedance of the individual drivers. Previously entered frequency response becomes a reference data for Hilbert-Bode Transform. The transform calculates phase response from the given amplitude response. During this process, SoundEasy automatically develops the complex transfer function for the driver.

Fig 2.2 Woofer driver – SPL.



Fig 2.3 Woofer driver – Impedance.
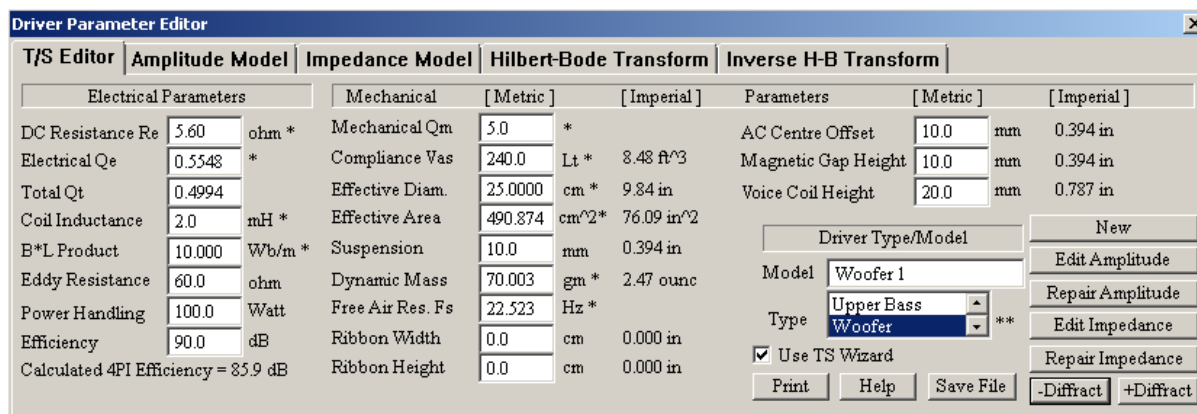
2.4
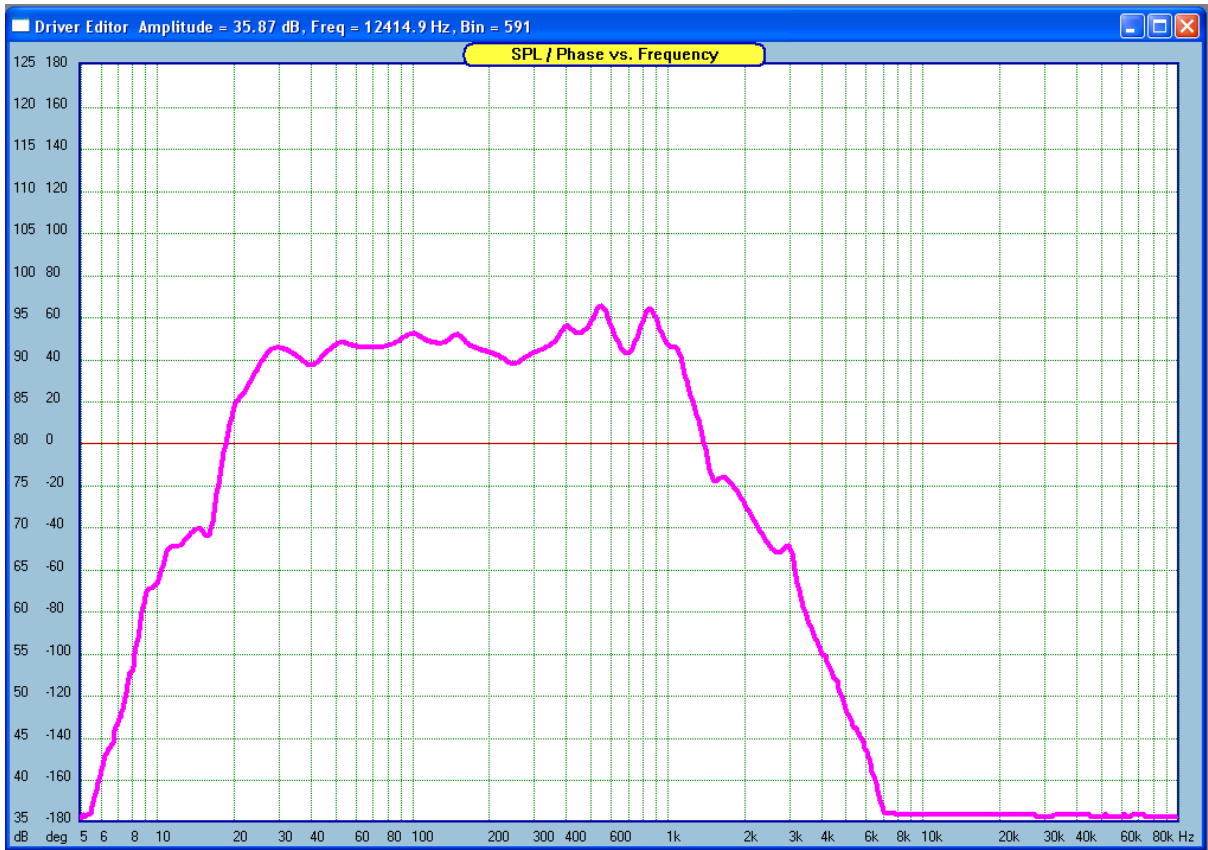
**Entering Driver's Data**



Fig 2.4. Driver Parameter Editor (T/S parameters) dialogue. Parameters with asterisk, " * " are essential.

      When the 'Driver Editor' menu option is opened, you will be presented with the window shown in Fig 2.4. The window contains 30 editable data entry fields and a plotting area to enter the frequency response. To activate a data entry field, move the pointer arrow above the field of interest and click LEFT mouse button. A blinking cursor will appear within the data field and you can enter the required parameter. All data entered must be in positive, real numbers. Alphanumeric characters are not allowed. All data must be entered in the units of measure indicated on the right of the data fields.

      The dialogue box above shows essential parameters you will need to key-in, in order to plot basic responses of sealed and vented enclosures. Full linear and non-linear analysis of a driver in an enclosure requires you to enter all relevant parameters of the driver and the enclosure(s). Another (recommended) way of acquiring the T/S parameters is to use EasyLab and simply measure them. The T/S parameters are only needed if you intend to perform enclosure design or THD analysis.


**Electrical Parameters**

**1. DC Resistance Re**......DC resistance of the voice coil. Can be  measured using an ohmmeter.
**2. Electrical Qe**.............…Electrical Q-factor of the driver. Should be listed in the driver's data chart or can
                be measured. **NOTE: Qe=2\*PI\*Fs\*Md\*Re/(BL\*BL)**
**3. Total Q**.....................…Total Q-factor being a combination of Qe and Qm.
**4. Coil inductance**...........Inductance of the voice coil. Should be listed in the driver's data chart or  can be
                measured.
**5. B\*L Product**.............…(BL) Also known as a "force factor" of the driver's motor system. Should be listed  in
                the driver's data chart or can be  measured. **NOTE: BL=sqrt(2\*PI\*Fs\*Md\*Re/Qe)**
**6. Eddy resistance**..........This parameter may not be listed in the data charts. Eddy resistance represents
                loss in the pole piece and front plate. User should be able to measure eddy
                resistance at 20-100kHz by measuring impedance magnitude at 20kHz and
                subtracting voice coil DC resistance from it.. If in doubt, consult [26].
**7. Power handling**..........Should be listed in the driver's data  chart or can be measured.
**8. Efficiency**...………….Should be listed in the driver's data chart or can be measured. Enter in dB's.
**Calculated 4PI Efficiency** ….This parameter is calculated automatically, based on entered velues.


**Mechanical Parameters**

**9. Mechanical Qm**..........Mechanical Q-factor of the driver. Should be listed in the driver's data chart or
                can be measured.
**10. Compliance Vas**.......Equivalent compliance volume of the river. This is the volume of air that has the
                same compliance as the driver's suspension system. Should be listed in the driver's
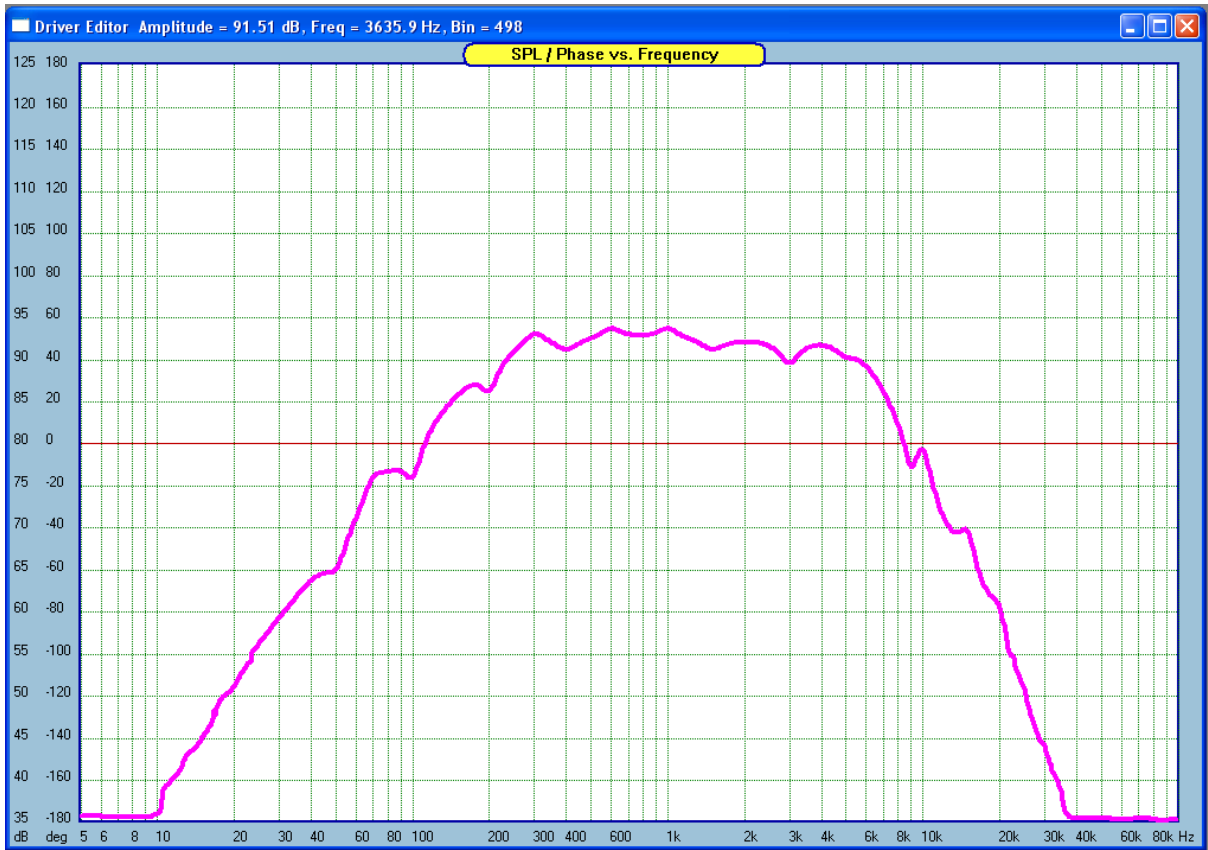                data chart or can be  measured.
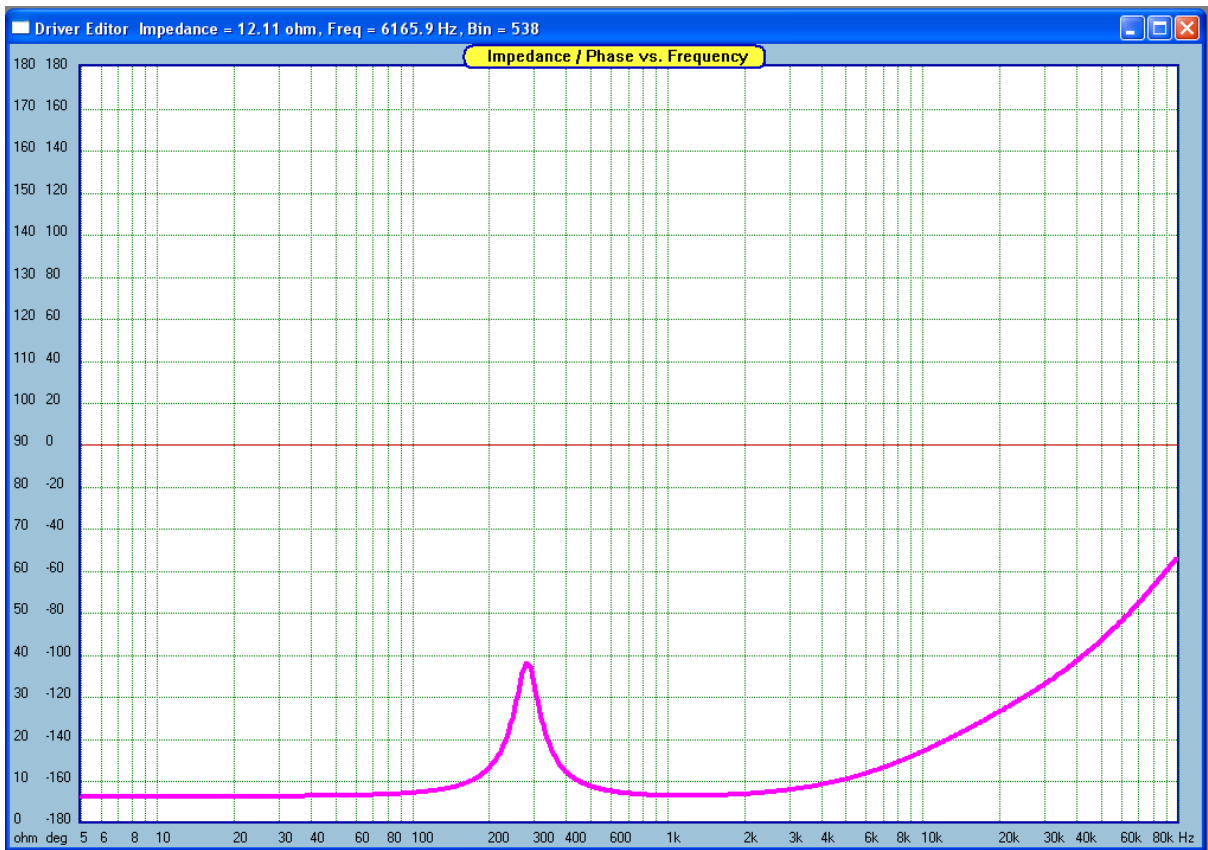
2.5

Fig 2.5 Midrange driver – SPL.


Fig 2.6 Midrange driver – Impedance.

2.6

**11. Effective Diameter.**..Usually, the effective diameter is 75-85% of the basket diameter. If you don't know what the effective diameter is, enter this parameter as 80% of the basket diameter. You may notice, that SoundEasy attempts to check the entered data and it will modify other fields is sufficient data has been entered. Later on, when all other parameters are entered, you may need to change this data such a way that Qe and Fs, recalculated by the software, are exactly as listed in the data sheets of the driver.

**12. Suspension Xmax**.....Maximum linear cone displacement due to spider. See page 2.17 for details.

**13. Suspension Type**.....Select from the list box. See page 2.17 for details.

**14. Dynamic mass Md**...(Md) Mass of the whole moving assembly of the driver + "air loading" of the driver.

**15. Free air resonance**...(Fs) Should be listed in the driver's data chart or can be measured.

<p align="center">**NOTE: Fs=Qe*BL*BL/(Re*Md*2*PI)**</p>

**16. Center offset**............Acoustic center offset, measured from the baffle ( mounting ) plane of all drivers. An approximation would be the distance from the mounting flange to the voice coil.

**17. Gap Height**..........Magnetic gap height. Should be listed in the driver's data chart.

**18. Coil Height**..………Height of the voice coil winding. Should be listed in the driver's data chart.

**19. Ribbon Width**

**20. Ribbon Height**

## Thermal Resistance Data

**21. Coil to Magnet Rvc**..Thermal resistance between coil and magnet structure.

**22. Magnet to air Rmt**....Thermal resistance between magnet and air.

**23. Total Rtot**.............…Calculated by SoundEasy. Rtot=Rvc+Rmt.

**24. Coil Temp Coeff**.......Resistance increase per deg C.

**25. Magnet type**..........…Select from "Magnet Type" list box. Determines loss of magnetic flux as follows:

(1) Alnico 5......................loss=2.3% per 100 deg C, (2) Crumax 355.....loss=11.5% per 100 deg C and

(3) Ceramic 5...................loss=17.4% per 100 deg C.

**26 Minimum Z**............…Enter "8.0" for eight ohm driver, "4.0" for four ohm driver and so on...

## Model/Make

**27 Driver Type**..........…Select from "Driver Type" list box.

**28 Driver Model**.....…...Enter model name.

## Other Data Required

**29 Input Power**……….Entered from "Power Compression Analyser"

**30 Impedance model**….**It is essential to select and fully edit impedance model that you wish to use**. Data entered from "Impedance Models" dialogue box.

**NOTE 1: Entering the Driver Type (Woofer, Upper Bass, Midrange, Tweeter and Super Tweeter) is particularly important. All other SoundEasy modules will check this field and default according to this simple piece of data.**

**NOTE 2: If you enter Suspension Xmax = 0.0, the program assumes you do not wish to perform large-signal analysis due to suspension nonlinearities. If you enter Gap/Coil Height = 0.0, the program assumes you do not wish to perform large-signal analysis due to motor system nonlinearities.**
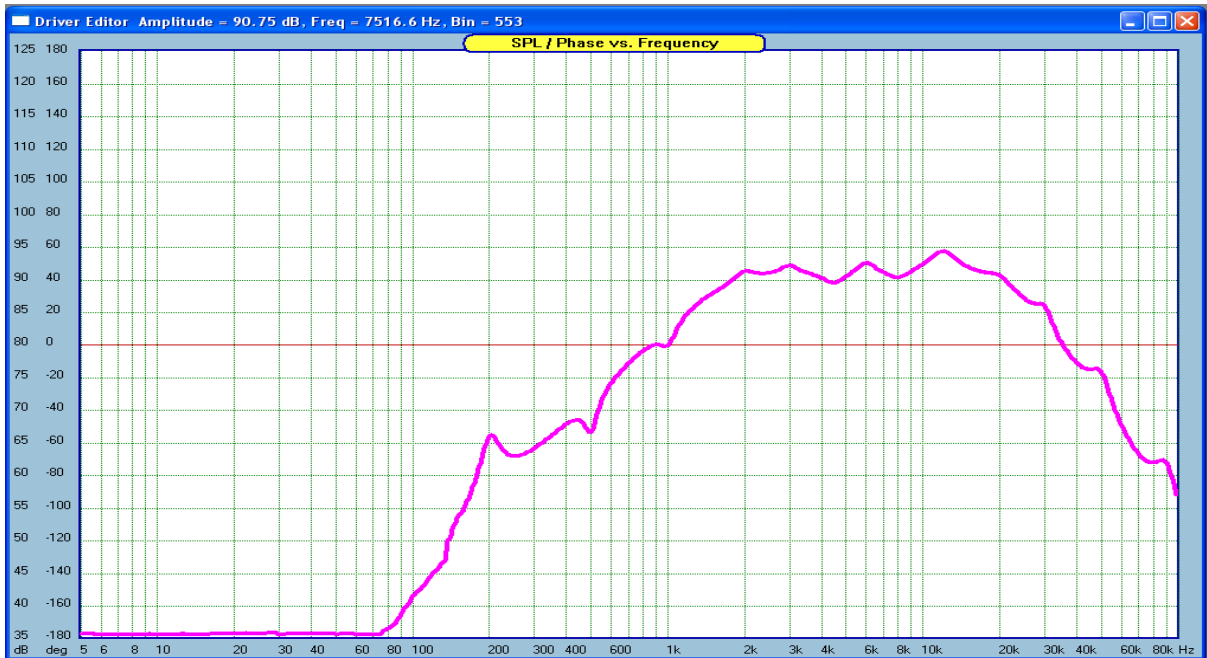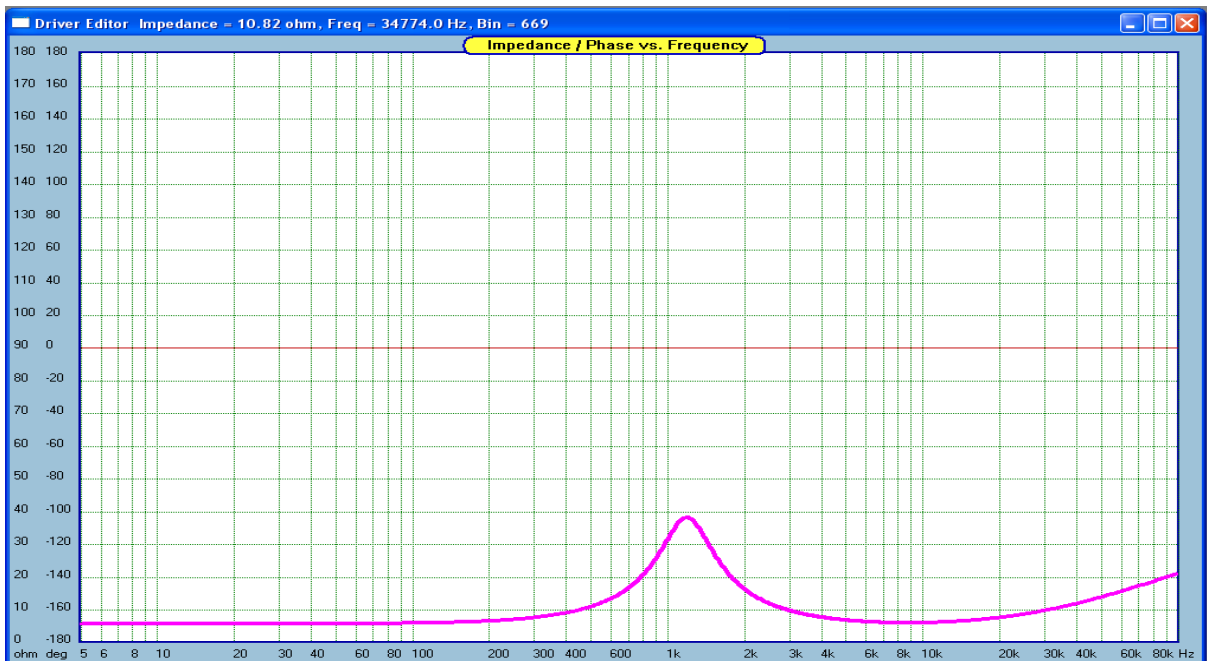
Fig 2.7 Tweeter driver – SPL.



Fig 2.8 Tweeter driver – Impedance.

**Entering Frequency Response**

In general, frequency response of all electro-dynamic loudspeakers can be compared to a band-pass filter. If all small ripples on the frequency response are disregarded, it is easy to observe the three main regions of the curve: (1) rising slope below the free-air resonant frequency followed by (2) reasonably flat section which is most useful to the designer and finally (3) roll-off section, where the driver loses its ability to maintain cone excursion. With the above in mind, there is a good argument in commencing the modeling of the frequency response as a band-pass filter and then adding all small individual ripples. This method can be very accurate if enough ripples are added. However, for many applications, a good approximation can be accomplished with as little as 10-15 ripples added to a band-pass filter frequency response. The only additional information necessary for the user to supply is the SPL efficiency parameter entered from the main screen.

This will determine the overall SPL level of the whole curve. Please enter 90.0 in the "Efficiency" data field now. Entering frequency response is accomplished with the help of "Amplitude Model" tab box. The box is shown on Figure 2.9.
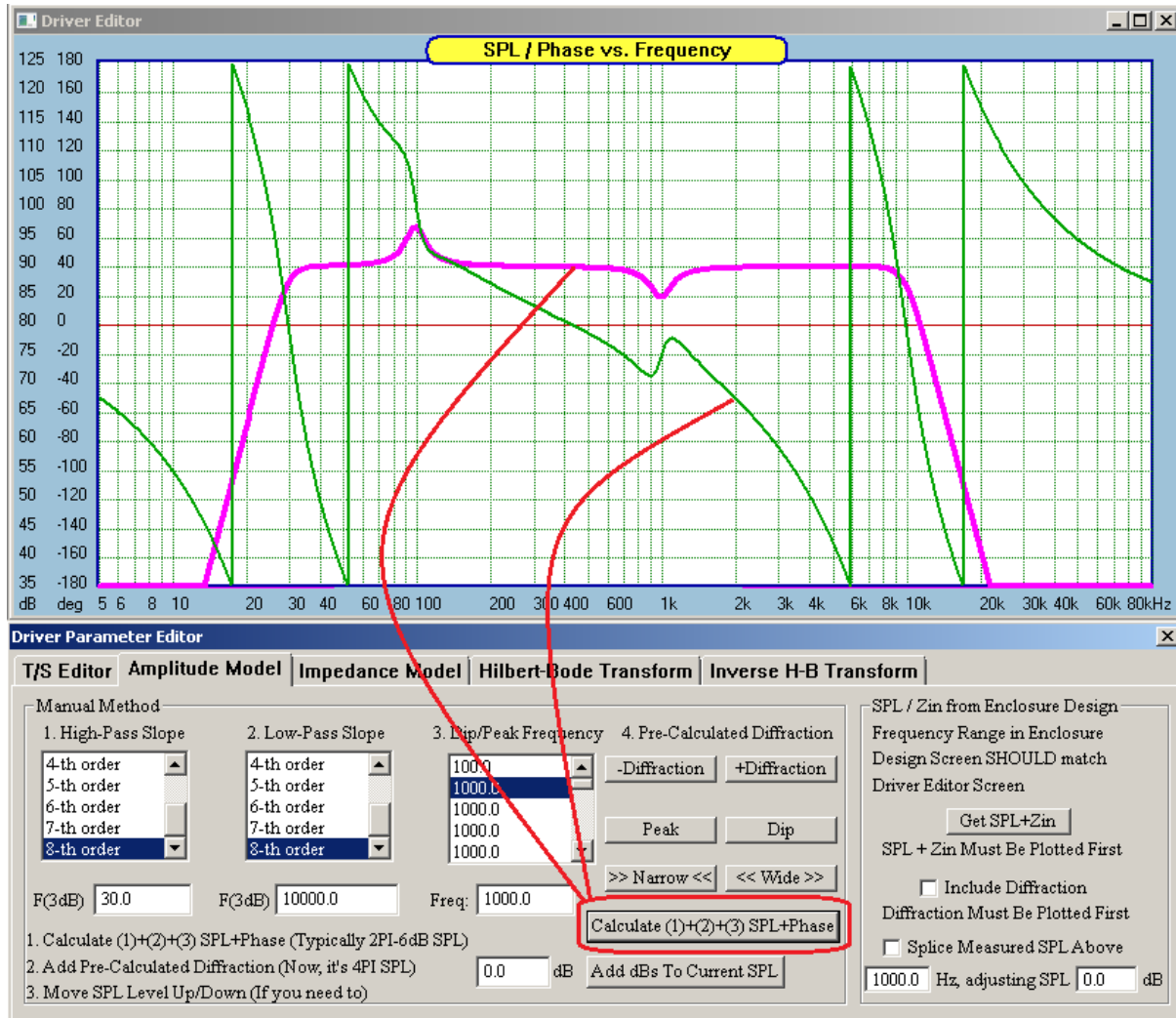


Fig 2.9 Edited SPL with a Dip and a Peak.

After examining the frequency response of the driver, it should be possible to approximately determine the three regions and order of the rising (high-pass) and falling (low-pass) slopes. Having done this, you need to select those orders by clicking left mouse button above the appropriate list box titled "1. High-Pass Slope" and "2. Low-Pass Slope". The associated cut-off frequencies of the filter approximations need to be entered in the associated data fields below the list boxes. Figure 2.9 shows 2-th and 3-rd orders respectively. The frequency response of our band-pass approximating filter can now be displayed by pressing on "→ ←" (means narrower) or "← →" (means wider) buttons. Next step is to add all small ripples onto the band-pass filter curve. The default values for all **50 available** ripples is 1000.0 and are displayed in the "3. Dip/Peak Frequency" list box. Please click on the first list box item – 1000.0 Hz. This will select the frequency to be edited in the data field available below the list box. Now, edit the frequency by entering the right value, say for the most-left ripple – you will see the value in the list box also changes. Now, you have four buttons available to determine the shape of the ripple: (1) "Peak", (2) "Dip", "→ ←" and "← →". Pressing repeatedly on all four buttons will shape the ripple and automatically re-plot the frequency response. Once the shape of the ripple has been finalized, please click on the second item in the list box and edit the second ripple frequency and determine it's shape. Please continue till you are satisfied with the total frequency response.

Additional information related to the usage of the Amplitude Modeller can be found in two papers available from **bodziosoftware.com.au** website: (1) **Diffraction Model in SoundEasy V26** and (2) **Diffraction Model in SoundEasy V26 Part II**.

2.9

When using the above method, SoundEasy will automatically generate **driver's transfer function** with NO ACOUSTIC DELAY – that is driver-microphone distance equal to 0.0[m]. Should you require the standard 1W/m SPL result, please use "Transfer Function" screen and set the microphone distance accordingly. Entering frequency response can also be accomplished with the help of the mouse and cursor keys. The initial frequency response curve is a flat line, that defaults to 90 dB efficiency. The user positions the pointer arrow at the point with the corresponding coordinates to those on the data sheet frequency response at the same frequency and then clicks the LEFT mouse button. Then a little gray rectangle will move from the flat '90 dB line to the newly created frequency response plot. The Frequency/Amplitude coordinates, just to the right of the graph area, indicate the exact coordinates. It is recommended to "fine tune" the position of each data point using cursor keys which move the frequency response current data points by smaller amounts and are very useful after the broad frequency response has been entered. A manual way to edit the frequency response is to position the mouse pointer on the plotting area and press LEFT mouse button. Keep the button depressed and simply trace (draw) the frequency response on the screen. The resulting frequency response will be coarse, but then you can fine tune it using the cursor keys. Use "Edit Amplitude" button frequently to clean-up the plotting area and confirm, that none of the data points were left out. This process may seem time consuming. It does, however, need to be performed accurately because errors acquired during this initial phase, must affect all data processing performed by the other tools. It is performed only once per driver, during the creation of the data library. The better the accuracy of the data the better the design. Finally, amplitude response entered this way, **must be followed by the creating the transfer function**. An example of a fully edited driver is given in Fig 2.2, 2.5 and 2.7. These are the test files included with SoundEasy. The "New" button is used to clear all data fields and the graph plotting area. The Amplitude Model tab allows you to approximate the basic shape of the SPL curve and add up to 50 little ripples onto the curve. You can select High-Pass/Low-Pass slope and corner frequencies to get he basic "band-pass filter" shape and then adjust dips/peaks frequencies and shape using the "Narrow" and "Wide" button. All SPL curves provided in the sample data files were edited using this technique. Having edited SPL curve you need to convert it into the driver's amplitude and phase data. This is called creating a Transfer Function and is accomplished with the help of Hilbert-Bode Transform screen.

**Hilbert-Bode Transform (HBT) Tab**

HBT enables to following functions to be implemented in SoundEasy:
1. **Determination of the Acoustic Centre of the driver.** HBT calculates the minimum phase response of the driver that is subsequently used a reference for distance estimation.
2. **Digital Equalizer function.** HBT is used to alter driver's SPL in a mathematically correct way and consequently eliminate "tails issue".
3. **MLS system**. HBT calculates minimum-phase response for SPL and Zin. HBT also performs filter-like clean-up of the SPL/Phase responses.
4. **Analog Measurement System**. This system does not account for phase. HBT calculates minimum-phase response for all SPL and Zin measurements.
5. **Importing SPL/Phase data**. HBT is used to repair poorly executed phase measurements.
6. **Importing SPL/Zin data**. HBT is used to extend imported data over any desired frequency range.
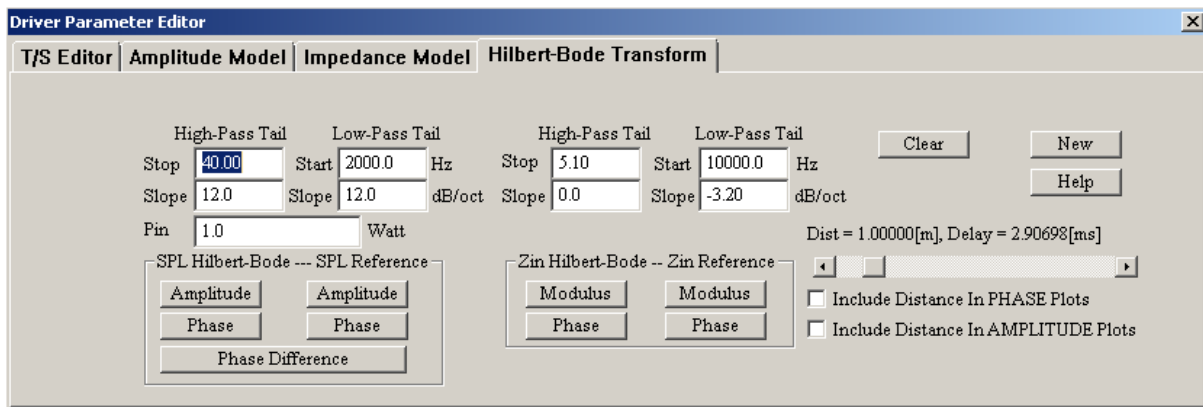7. **Optimization**. HBT calculates phase response for any user defined Target SPL curve.



Fig 2.10. Hilbert-Bode Transform Control tab – note typical HBT parameters for Zin.

2.10

The "Hilbert-Bode Transform" tab has a built in very powerful algorithm - The Hilbert-Bode transform. It allows you to quickly and accurately recreate phase response from the **available amplitude or input impedance response**. The Hilbert-Bode transform really makes importing of the phase response irrelevant. the process of creating the true acoustic phase response with SoundEasy is instantaneous, this is why the imported phase response may only be used as a template. Also, ANY POST-PROCESSING of the amplitude response on the Editor screen will make the imported phase invalid. The minimum phase systems have a unique relationship between amplitude and phase, this relationship is captured the Hilbert-Bode mechanism. **If you need to extend the measured SPL/phase curves beyond the measurement frequency range**, the tool to use in this case, is the Hilbert-Bode Transform group-boxes provided separately for SPL and Zin Transforms. The transforms are driven by 4 editable parameters and they should be selected to obtain the **best match for phase and amplitude/impedance between measured signal and calculated transform over the widest frequency range**. Typically, good match can be obtained between 20Hz and 20kHz. Generally, you would select the parameters to provide initial match for amplitude response and then fine tune the parameters to provide the match for phase. Please note, that "Roll-off" parameters can be as high as +/- 100dB to +/- 120dB if the measured frequency response is highly irregular (resonant peaks) at the extremes of the measurement range.
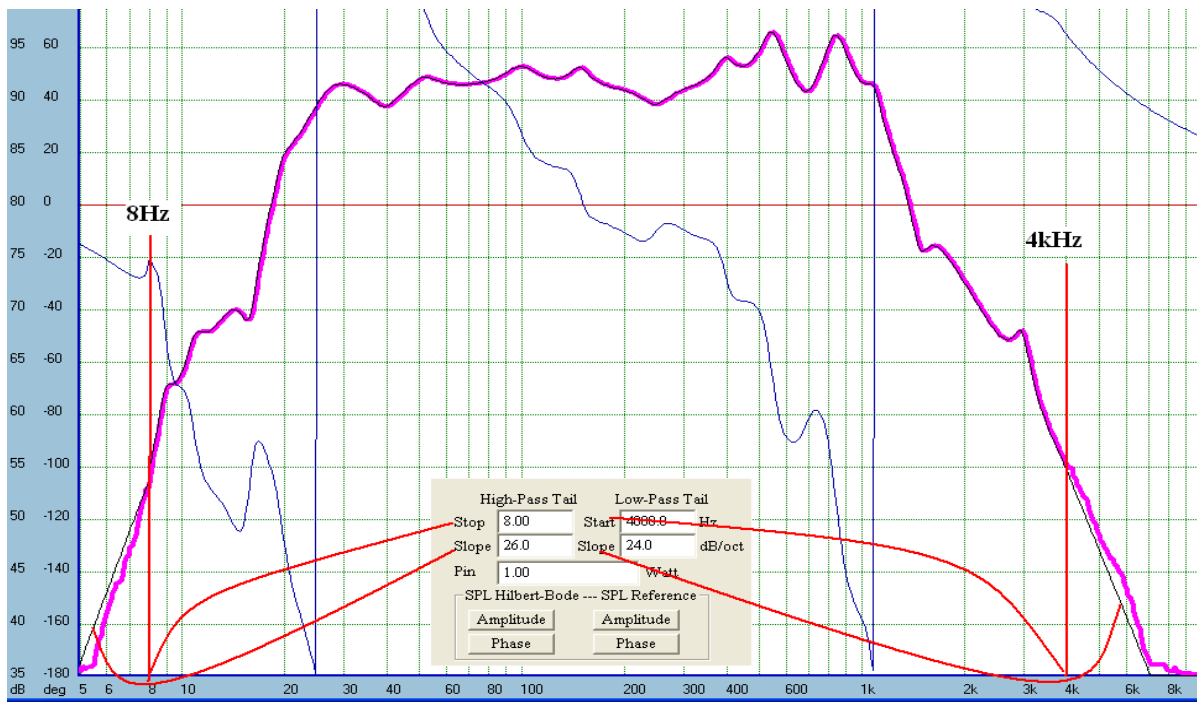


Fig 2.11 Woofer transfer function  - Hilbert-Bode Transform

The program calculates phase using a Hilbert-Bode transform from any magnitude/impedance curve. This is known as a Minimum Phase response and it does not contain any delay or positional information. Because the Hilbert-Bode Transform requires an infinite integral over all frequencies, any numerical computation of minimum phase is necessarily an approximation. Understanding the characteristics of the phase transform and how it works can be very important if maximum accuracy is to be obtained. For some data curves, the transform can be run directly and will provide excellent results with little attention to the original magnitude data. In other cases, a far better result can be obtained by correcting certain areas of the magnitude curve before running the minimum phase transform. Typically, the regions which can cause problems are **at the ends** of the measurement bandwidth. The transform must project the slope of the magnitude curve beyond the measured bandwidth. It does this by taking the last slope found as the curve reaches the low and high ends of the frequency range. It then assumes that: (1) the slope found at the low end will remain constant down to DC, and (2) the slope found at the high frequency limit will remain constant towards infinity. For this reason it is of fundamental importance that the slope of the magnitude curve at the high and low ends of the frequency range be approaching or already at their final asymptotic values. The Transfer Function [HBT] dialogue box has the following controls:

1. **"New"** – use this button to restore default setting for this screen.
2. **"Clear"** – use this button to clear the screen.
3. **SPL Hilbert-Bode**
 - "Amplitude" – use this button to calculate transfer function and display it as amplitude
 - "Phase" – use this button to calculate transfer function and display it as phase.

4. **SPL Reference**
 - Amplitude" – use this button to display amplitude of the imported data
 - "Phase" – use this button to display phase of the imported data
5. **Zin Hilbert-Bode**
 - "Modulus" – use this button to calculate transfer function and display it as modulus
 - "Phase" – use this button to calculate transfer function and display it as phase.
6. **Zin Reference**
 - Modulus" – use this button to display modulus of the imported data
 - "Phase" – use this button to display phase of the imported data
7. **"Distance/Delay"** – use this slider to select appropriate distance between the transducers.
8. Check box to include the distance in amplitude calculations.
9. Check box to include the distance in phase calculations.
10. **High-Pass Tail and Low-Pass Tail group boxes** - The low-end slope and stop frequency, the high-end slope and start frequency. Enter the appropriate data as suggested above for amplitude and impedance.

The Hilbert-Bode Transform is used for amplitude as well as for impedance transfer functions. You need to perform tail corrections for both types of curves. Using HBT tab, one can plot **Phase Difference** between measured and HBT-derived. So this curve (**brown**) acts as the "min-phase" detector. Flat curve - corresponds to HBT phase the same as measured phase. Deviation – corresponds to a non-minimum phase region.
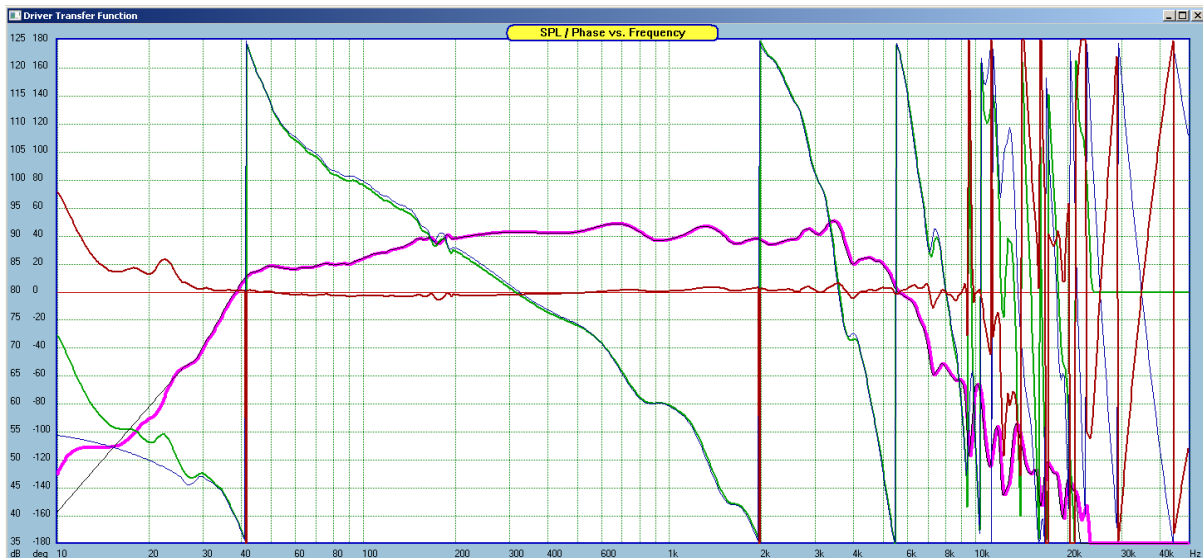

Fig 2.12..Phase difference (brown curve) between calculated and measured phase.
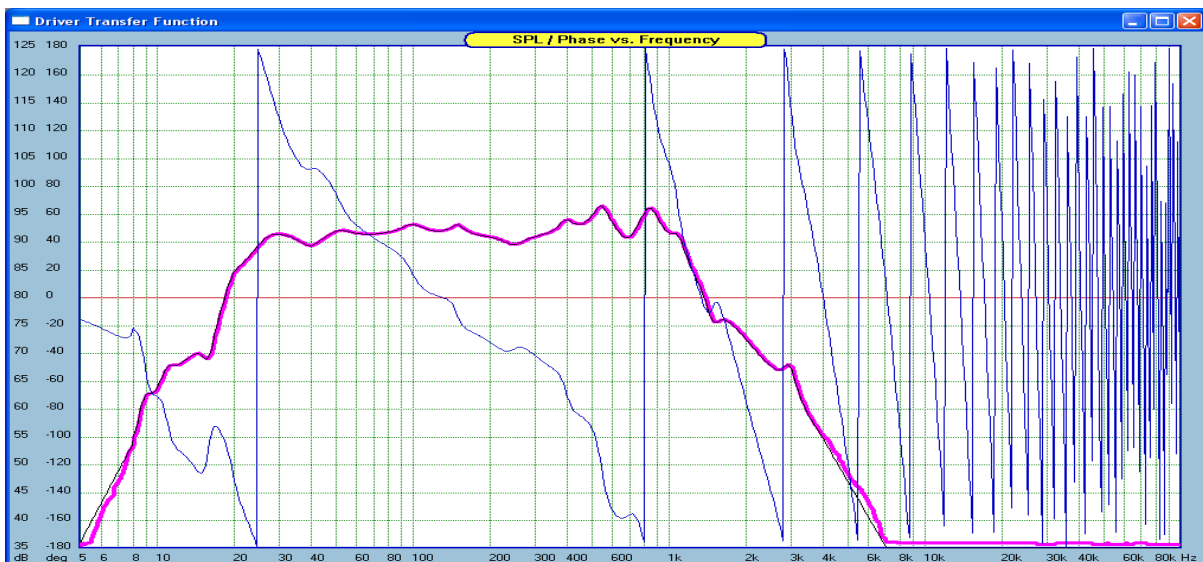

Fig 2.13. Woofer transfer function @ 10cm mike distance – see the "Check" boxes above.

2.12

At times, it may be convenient to **add/subtract time delay** to the imported data or scale the whole amplitude response curve up or down by a fixed amount of dB's. The "Import" dialogue box provides the user with two editable fields: (1) "Delay", which accepts the required positive or negative time delay in milliseconds and (2) "Scale", which accepts the amount of positive or negative shift expressed in decibels. Positive delay means moving the driver away from the test microphone and negative delay means moving the driver towards the test microphone. The third editable field in the dialogue box is the reference SPL level (Efficiency).

The "Delay" and "Scale" data are optional, but the "Efficiency" data must be entered - some of the measurement systems only provide RELATIVE to SPL amplitude response data.

Sometimes, your measurement environment will add 6dB to the amplitude response and in those cases, SoundEasy provides you with some helpful tools to rectify the problem. Having accomplished the above, SoundEasy is ready to import the requested file and then convert the imported amplitude and phase templates to Complex Transfer Function (A+jB) format - see also Appendix - Importing Data Files. Driver's complex transfer function does not include any additional filtering. You would probably hesitate before feeding 1 Watt input power at 10Hz into the tweeter or even midrange driver. Yet, the program does require the transfer function to be determined at those extremes. This is at least one compelling reason for providing several tools that enable the user to recover or recreate these extreme data points. In practice, most of the imported files will be incomplete for the purpose of using them with the program. That is why the imported data is not used directly, but treated as templates for Hilbert-Bode transform.

**HBT Guiding Filter**

A Guiding Filter ( a known minimum-phase filter) can be very handy in guiding the correct asymptotic slopes for HBT algorithm. The dialogue box for design of such filter is invoked by pressing "Create Minimum-Phase Guiding Filter" button located on HBT TAB.
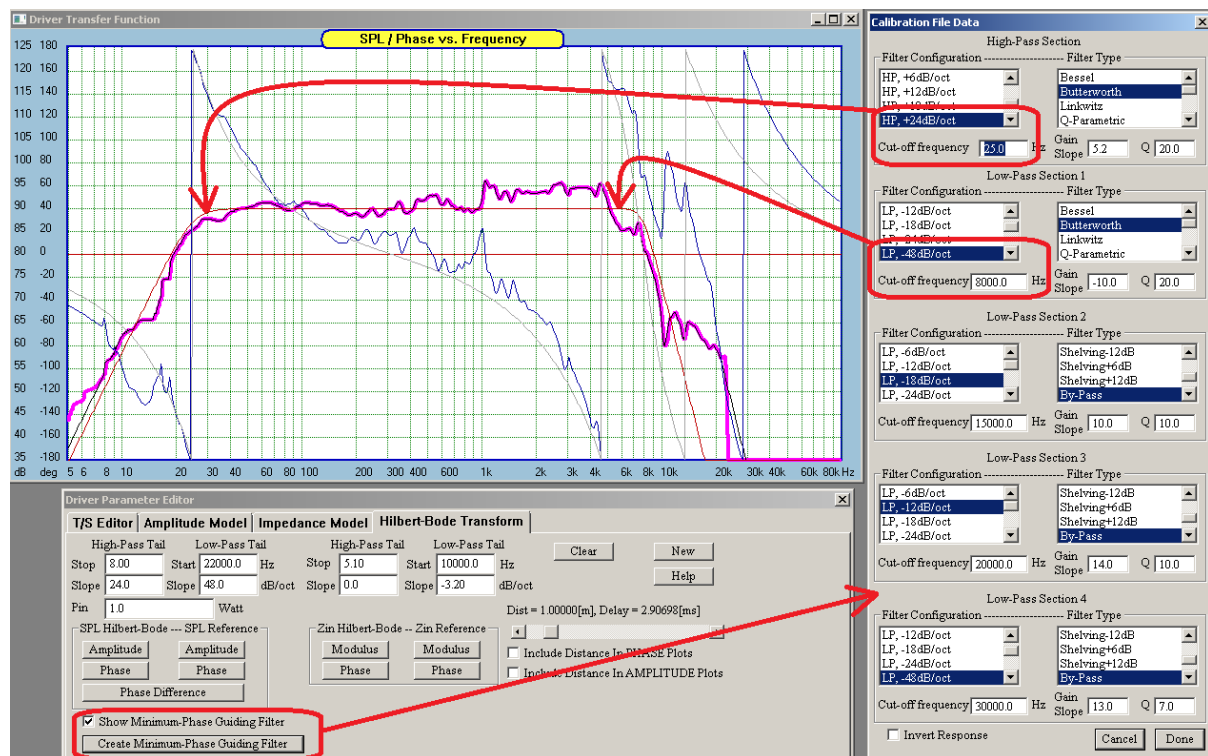


Figure 2.14. Controls for "HBT Guiding Filter" and Filter Design dialogue box.

**Variable Slope Filters**

Accuracy of approximating driver's asymptotic slopes can be improved by employing filters with lopes other than +/-N * 6dB/oct. A selection of Low-Pass and High-Pass filters is now made available for this purpose in the Calibration File Editor dialogue box and in Driver Editor HBT guiding filter.
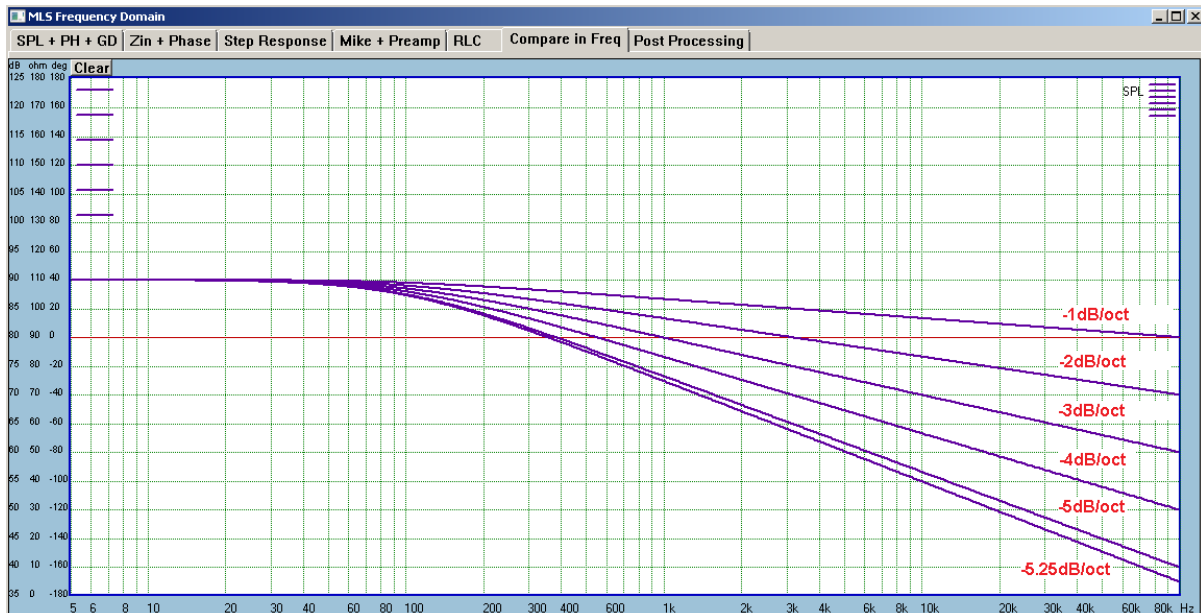
Figure 2.15. Variable slope filters.

**Entering Impedance Data**

Manual entry of impedance curve is accomplished much the same as the previously described amplitude response - drawing the curve and then using cursor keys to fine tune the plot. The default impedance curve is plotted at 8ohm level. At any point of time, the user can flip between frequency response and impedance curve using 'Edit Amplitude' and 'Edit Impedance' buttons. The currently edited curve will be saved and the newly selected one plotted on the screen. Once again, the 'Edit Impedance' button should be used to clean up the display. See Fig 2.16. Once the whole (5Hz - 100kHz) impedance curve is edited, it can be used as a template for recovering complex impedance. Editing impedance curve over the whole frequency range is important. Slope Correction is also provided for the impedance. This is accomplished via 'Hilbert Transform Function' screen, which was also used for recovering amplitude transfer function.

**Impedance Transfer Function**

As with the amplitude transfer function, it is necessary to develop complex input impedance of the driver (or driver+box). Here are a few ways this can be accomplished:

1. Importing impedance/phase data from one of the supported measurement systems. Ideally, the imported data will cover the required frequency range. If not, the user must manually edit missing parts and recover complex input impedance using Hilbert-Bode Transform.
2. Manual entry of the impedance curve - see previous paragraph.
3. Using provided Impedance Models. Once a model is selected and edited, this information must be saved in the data file.

Complex impedance curve or impedance model data will be used by two functions: (1) 'Enclosure Design' screen when plotting impedance of a driver in a designated enclosure and (2) 'Crossover CAD' functions, as a load impedance of the compensation circuit. "Crossover" module will first check if an imported impedance data is available and will use it, if provided. It is therefore necessary to provide quality data. In order to develop complex impedance function, you can start from 'Editor' screen by pressing 'Edit Impedance' button. This will bring up impedance curve onto the plotting area. The impedance curve must have been measured, imported or manually edited before. Next step is to make sure, that whole curve is properly edited over the 5Hz - 100kHz frequency range. If so, the template is ready. See Fig 2.3. Hilbert Transform Function' screen should be invoked next and the complex impedance can be produced by pressing 'Impedance' button under 'Impedance Transform' group of buttons. You will notice, that 'Slope Correction' is not provided for the impedance transform as it is not necessary. The two buttons: 'Impedance' and 'Phase' under 'Imported Data' heading can be used to replot imported curves.

**Manually Entering Zin Impedance Data**

Entry of impedance curve is accomplished much the same as the previously described amplitude response - drawing the curve and then using **cursor keys** to fine tune the plot. The default impedance curve is plotted at 8ohm level. Once again, the '**Edit Impedance**' button should be used to clean up the display. Once the whole (5Hz - 100kHz) impedance curve is edited, it can be used as a template for recovering complex impedance.
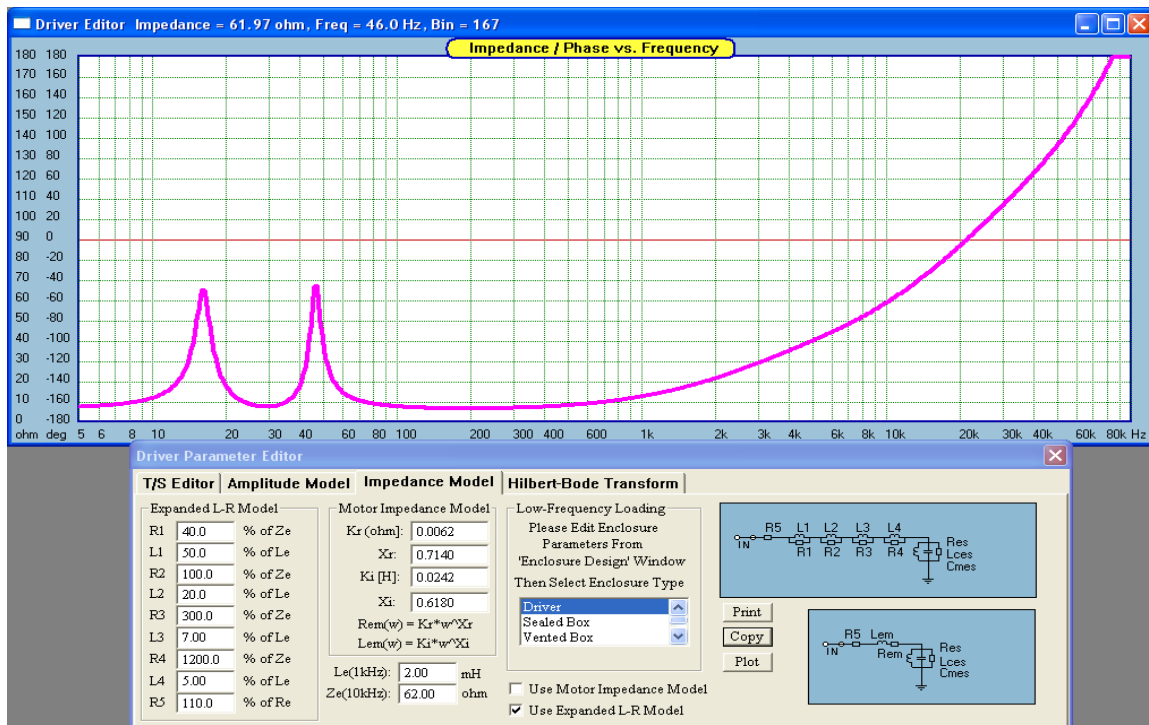


Fig 2.16 Impedance Models

**Impedance Models**

Two editable impedance models: (1) Quad-LR model and (2) Motor Impedance model, are provided and can be accessed via the main menu. See Fig 2.16. The Quad-LR model requires voice coil inductance as provided by data sheets, often measured at 1kHz and impedance minus DC resistance measured at 20kHz. The four LR sections are then assigned a **percentage** of the values above to fit any given impedance curve. Also R5 in the model can be different from the DC resistance of the driver.

The 'Plot' button plots the curve**. Caution !, at this point of time, the imported impedance data is replaced by the data generated by the model**. Component values in this model should be adjusted for each driver individually. This model is useful, when the impedance curve is actually available on the data sheets. The second model - Motor Impedance model - was developed by J.R. Wright in 1989. This model requires specific parameters to be provided and this is best accomplished by specialized measurement system. The "low end" of the impedance curve is determined by the acoustic loading (enclosure) selected for this particular driver. Enclosure type and parameters can be edited from the same dialogue box. You must provide these parameters in order to obtain correct shape of the impedance curve. Tank circuit elements for the driver alone are calculated for both models as follows: $Res = Re*Qm/Qe$;   $Cems = (Ms*Sd*Sd)/(Bl*Bl)$;   $Lces = (Cs*Bl*Bl)/(Sd*Sd)$. If you do not provide data for Le(1kHz) and Ze(10kHz) in the "Impedance Models" dialogue, the program automatically inserts "Coil Inductance" and "Eddy Resistance" values respectively.

If no impedance data is imported, it is essential to select and edit one of the models in order to provide correct data for subsequent modules, secondly, nominating and editing  a model is necessary for plotting impedance and power demand curves of ALL enclosures. Using "Exit" button saves entered parameters, but does not replace imported impedance data.

We suggest, that you open the "Impedance Model" dialogue box and select an impedance model for "driver"  before entering the enclosure design window. You may also select the Motor Impedance model at this point as the parameters of the model are provided as default values and do not require additional input.

2.15

**Speaker-Microphone Distance**

Driver's transfer function would normally be measured using a microphone placed 1 meter away from the driver. This distance is controlled by the scroll bar at the bottom-right corner of the screen. The actual distance and time delay for the sound to travel this distance is shown next to it.  The Phase Response plotted by the module is the phase difference between the signal produced by the signal source (your amplifier) and the acoustical pressure developed by the speaker and measured at the specified distance. The distance is simply included in the phase delay. SoundEasy defaults to 1 meter distance and 1 Watt of the input power to the loudspeaker. The speaker-microphone distance can be varied within 0.0mm to 10.0 meter range. You will notice however, that as the distance gets shorter, the frequency response will be moved higher up on the plotting area. The sound level will increase by 6dB per half the distance. In order to keep the recovered amplitude response over the pink "template" you need to reduce the input power to the loudspeaker, when the microphone is placed closer to the speaker. Fig 2.13 shows a case, where the microphone was placed 10cm away from the speaker and the input power held at 1 Watt. Please note the difference in the amplitude and phase responses. Now, since the distance is 10 times shorter, there can only be a few wavelengths between the microphone and the speaker, as opposed to the 1 meter separation. You can also **INCLUDE/EXCLUDE** the speaker-microphone distance from the transfer function by selecting this option from the two "Check" boxes at the bottom of the screen.

**Input Power and Rg**

The mechanical structure closest to the voice coil is the magnet system and the thermal interaction between these two determines **Rvc**, the voice coil-to-magnet thermal resistance. Once the magnet heats up, it will radiate the heat directly into the surrounding air. The losses of this process are modeled by **Rmt**, the magnet-to-air thermal resistance. As one can see, the magnet, being larger structure and directly exposed to the air, has lower thermal resistance. The structure of the magnet will lose some of its flux due to the raise of its temperature. This process is reversible, but will cause reduced SPL level. Another factor reducing the SPL is the raise of the voice coil resistance. The resistance increase per degree C is given but the **Ktmp** factor. For copper and aluminum wires **Ktmp**=0.00393 and for a 100.0 deg C temperature raise, there will be almost 40% increase in voice coil resistance (Re), ( **Rtot = Rvc+Rmt** ). Increased Re will cause less current to be drawn from the amplifier and also increase in electrical Q-factor (Qe). All the data entered on the "Power Compression Analyzer" are real, positive numbers. Magnet type determines the rate of the flux loss. Generator's internal resistance should be entered into the **"Rgen"** field. Input power into the modeled loudspeaker is edited from the **"Pin"** data field. "**Zmin**" is the nominal speaker impedance and should be entered as one of the standard impedances such as: 2 / 4 / 8 / 16 ohms.



Fig 2.17. Power Compression Calculator
2.16

**Suspension System - Spiders**

Loudspeaker spiders are most often made from resin impregnated cloth. The cloth has corrugation rolls pressed into it, to allow for vertical (ideally) extension of the spider and voice coil movement. There are three major spider profiles in use today.
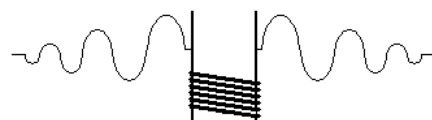
**1. Linear spider -** This spider has flat profile and has average linearity.
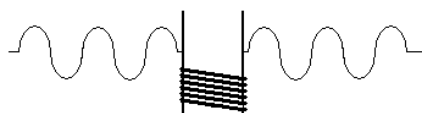


**2. Progressive spider -** Progressive spider offers "soft clipping" effect. It produces more distortion at low frequencies, but stops the voice coil from "jumping out of the gap" at high power levels.
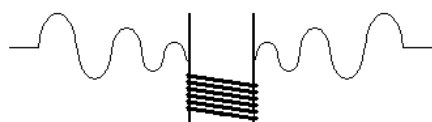


**3. Regressive spider -** Regressive spiders offer the best (most extended) linearity



For example: Spiders with **outside radius = 52mm**, **inside radius = 13mm** would offer the following maximum excursions due to spiders:

**Standard:**        **14.4 mm,**
**Progressive:**    **11.0 mm**
**Regressive:**     **21.0 mm**

**4. Estimating Xmax due to Cas(x)**

If you disregard the actual value of the stiffness of the spider (this is given as 1/Cms anyway), Hutt offers a clever way of estimating spider maximum excursion. The idea is based on Pythagorean Theorem and the formula is given below:

$$X\max = 0.5\sqrt{CL^2 - (Or - Ir)^2}$$

Where: CL = Cloth Length, Or = Outside radius and Ir = Inside radius of the spider. You simply take 50% of the maximum excursion where the cloth length is straight – see Figure 2.14 (the depiction is not perfect, but we are sure, you get the idea).
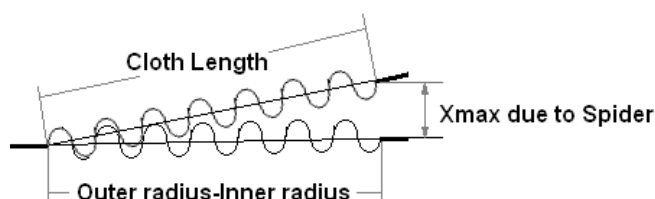

Figure 2.18. Estimation of Spider linearity

**NOTE: If you have difficulties assessing Xmax due to Cas(x) please use default value of 10mm for 30cm (12") woofers, 13mm for 38cm (15") woofers and 16mm for 46 cm (18") woofers. These vales are a crude approximations only, but will allow you to perform basic analysis. For midrange drivers the default value would be 2mm.**

**Enclosure Dimensions**

A simple rectangular enclosure calculator is shown on Figure 2.15 below. The calculator is not intended to provide you with a CAD quality drawings of your enclosure. However, dimensions calculated by the dialogue box are accurate enough for you to take this printout to the local hardware store and have the timber cut to size.

In the current implementation, the dialogue is only a simple calculator, and settings are NOT saved to the data file. Furthermore, our carpentry skills are at amateur's level, therefore, we strongly encourage you to treat the drawings as and informative guidance only. We have assumed, that the box will be finished with some form of veneer cover. Secondly, the bottom (and top) panel provide the footprint of the enclosure. Finally**, all joints are braced** with the timber dimensioned by you. The "Rectangular Enclosure Dimensions" dialogue box is invoked from the main menu under "Enclosure Details" option. This dialogue is designed to use as much information as would be already keyed into the program, therefore it "cooperates" with other SoundEasy's screens and data fields. You will notice the following:

1. **"Enclosure Volume"** – editable data field is the same as "Rear Box Vb" on the "Enclosure Design" screen.
2. Port length/volume calculations are based on **"Port Diameter" and "Rear Box Fb"** data fields on the "Enclosure Design" screen.
3. **"Front Baffle Size"** – editable data fields and sliding gadgets are the same data as "Front Baffle Dimensions" on the "Enclosure Diffraction" dialogue box.
4. **"Brace Dimensions"** – editable data fields for entering cross-sectional dimensions of the bracing timber.
5. **"Wall Thickness"** – editable data field for entering thickness of the material used for all panels.
6. **"Driver+Extra Volume"** – editable data field for entering parasitic (that is, volume of ALL objects that will be placed inside the enclosure and must be subtracted from the required enclosure volume).
7. **"Driver's Cut-out Radius"** – editable data field for entering front baffle cut-out for the driver.
8. Number of drivers on the baffle, corresponds to **"Driver Configuration" list box** on the "Enclosure Design" screen.
9. Location of the drivers on the baffle corresponds to **"Location of Driver 1,2,3,4"** on the "Enclosure Diffraction" dialogue box.
10. Location of two ports can be edited from this screen as well.
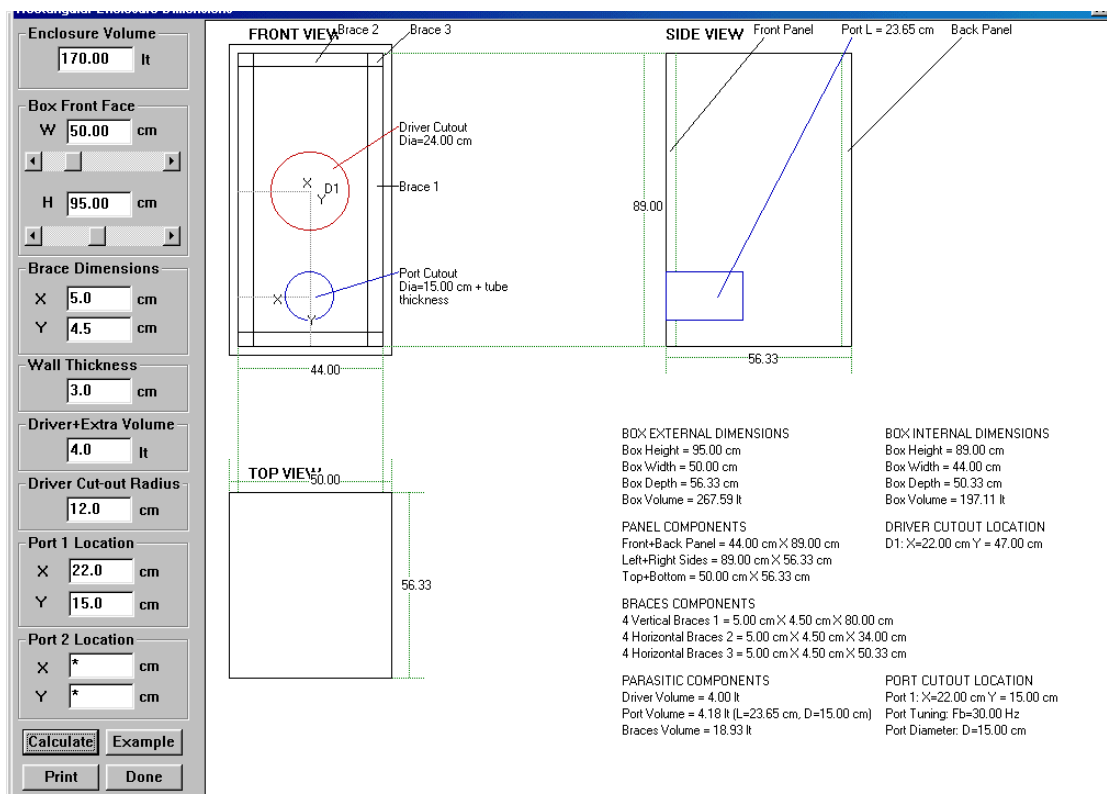


Figure 2.19 Enclosure Dimension

2.18

There is no scaling of the graphics in the current implementation of this calculator, therefore "clipping" will occur if your enclosure is large in one or more dimensions. The largest baffle size displayed on the screen would be around 1.0m x 1.0m with total volume of 700liters. The basic job this calculator is to provide you with instant dimensions of all major panels and bracing used for the enclosure, while you make adjustments to the size of the front baffle. **The reference parameter is the required enclosure volume.** Therefore, we suggest, that you do not change the **"Enclosure Volume"** data field provided on this screen. And if you do, please key-in the original value when finished.

Operation of the dialogue is fairly simple. You need to supply the required data to be keyed-in and then you can use sliding gadgets to obtain front baffle dimensions that meet your design goals. You will see all dimensions and the drawings refreshed automatically. There are number of parameters calculated by this dialogue box – see Figure 2.20. There may be instances, where you use really heavy bracing. For instance, bracing also the opposite panels in their midpoints. The dimensions of these braces should be calculated by-hand and their volume lumped together with driver's volume – in the **"Driver+Extra Volume"** data field. The program will automatically increase the internal volume of the box to account for this extra material and more than one driver. The side view of the enclosure shows the size of the port extending into the enclosure from the front panel. This visualization allows you to maintain the recommended minimum distance of the back-end of the port from the back wall ob the enclosure.

The cut-out for the port is located automatically by the program. When you change the data on any of the editable fields, please click on the "calculate" button, or move the sliders to perform calculations and refresh the screen. The example shown on Figure 2.20 indicates, that there will be additional 29liters needed for the enclosure to account for the driver, port and bracing volumes. This figure is the difference between "Enclosure Volume" field (170.0 lt) and "Box Volume" (199.44lt) field calculated under "BOX INTERNAL DIMENSIONS" column.
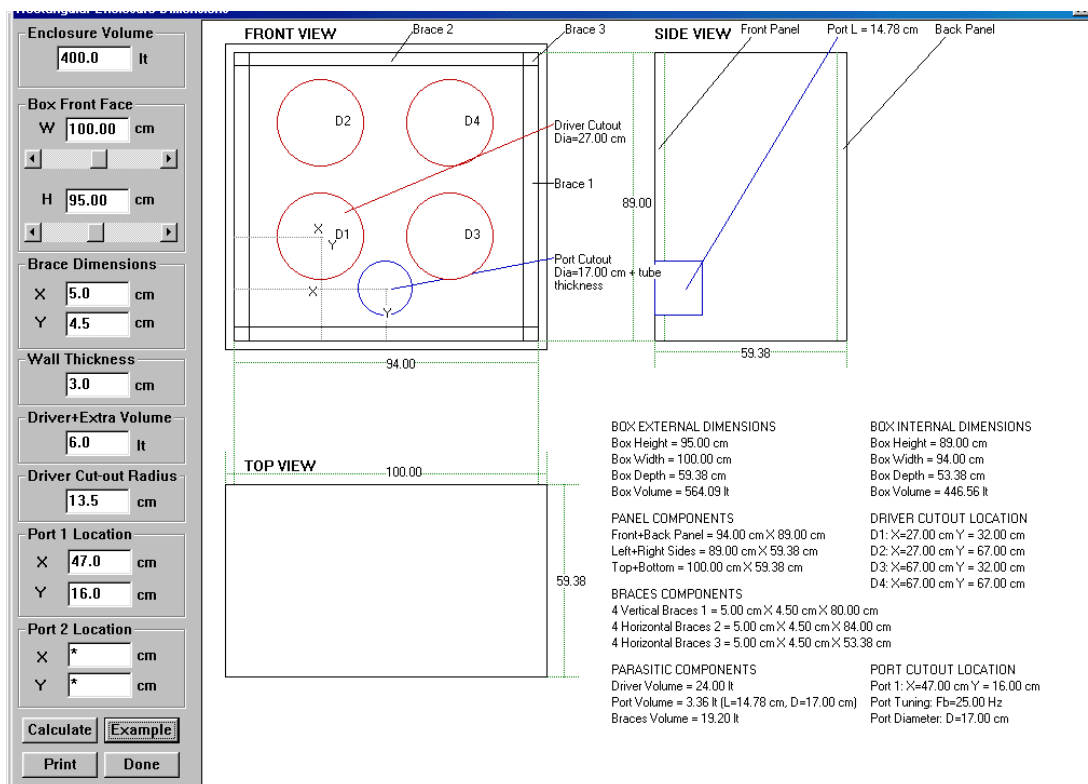


Figure 2.20. "Example" button was pressed.

In the second example, shown on Figure 2.16, is a "quad-box". The box is quite large (400 lt) and would be suitable for 4 x 13" low-frequency drivers intended for a bass guitar application. Bracing used is the same type as in the first example. Please note, that the port required to do the job, is actually quite short (14.78cm) and you could afford to increase the diameter of the port in order to reduce port compression/non-linearity effects.

**Finally, when you press the "Example" button, there will be several changes made to the driver's file data. Therefore, you need to go back to the "Enclosure design" screen and re-edit: (1) Rear Box Vb, (2) Rear Box Fb, (3) Port Diameter, and (4) Driver's Configuration.**

**Quick Assessment of Drivers**

There may be a need for a very quick "evaluation" of drivers in sealed or vented enclosure, without detailed design considerations. You may simply want to "plug-in" some basic Small-Thiele parameters and see what the driver is capable of. The program is just capable of doing this. When you open SoundEasy, the program starts in what you may call a **"minimum parameters"** mode.

There are a number of default parameters built-in, that will be set when the program is started. The defaults allow you to make a quick assessment of the driver, but please remember, that for accurate analysis, you must supply all required data **and select and edit one of the available impedance models.** It is becoming more common for the manufacturers these days to provide you with Sd parameter rather than effective diameter ( of drivers like 10", 12" or 15" speaker).

SoundEasy provides you with two data fields for entering both: Sd and Effective Diameter. The Sd is only used for enclosure design, while Effective Diameter is used for driver tilting, driver rotating, polar responses and off-axis responses. Both data fields are locked and mutually dependant – entering data in one field causes the other to be calculated.

On the T/S Editor tab, you are only required to enter**: Re, Qe, Qm, Le, BL, Fs,Vas and Sd or Diameter.** (please note, that Md will be calculated from Fs value).

Parameters like BL could be calculated from other parameters, however, in the interest of cross-checking the data, the program enables you to enter the parameters individually, so they can be checked by the program automatically. You may notice, that the program will modify some parameters while you enter another piece of data.
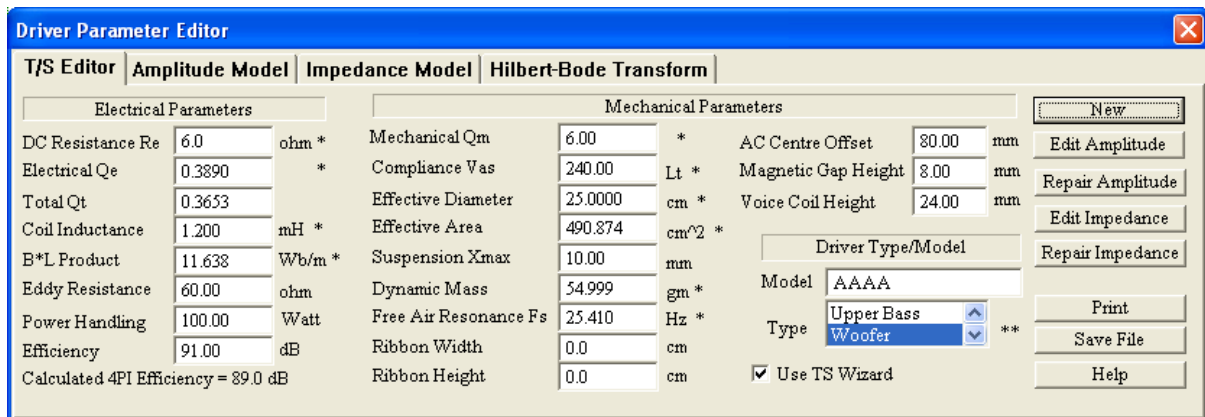


Figure 2.21. Default values with **Re, Qe, Qm, Le, BL, Fs, Vas and Sd.**

If you are missing BL parameter, enter all other parameters (**Re, Qe, Qm, Vas, Sd, Fs – highlighted with asterisks)** and then click on Fs, to get Md calculated and click on Re or Qe to get BL calculated – highlighted in blue. On the Enclosure Design screen, you are only required to enter **Vb for basic sealed box analysis and additionally Fb** (highlighted in red) for basic vented box analysis.
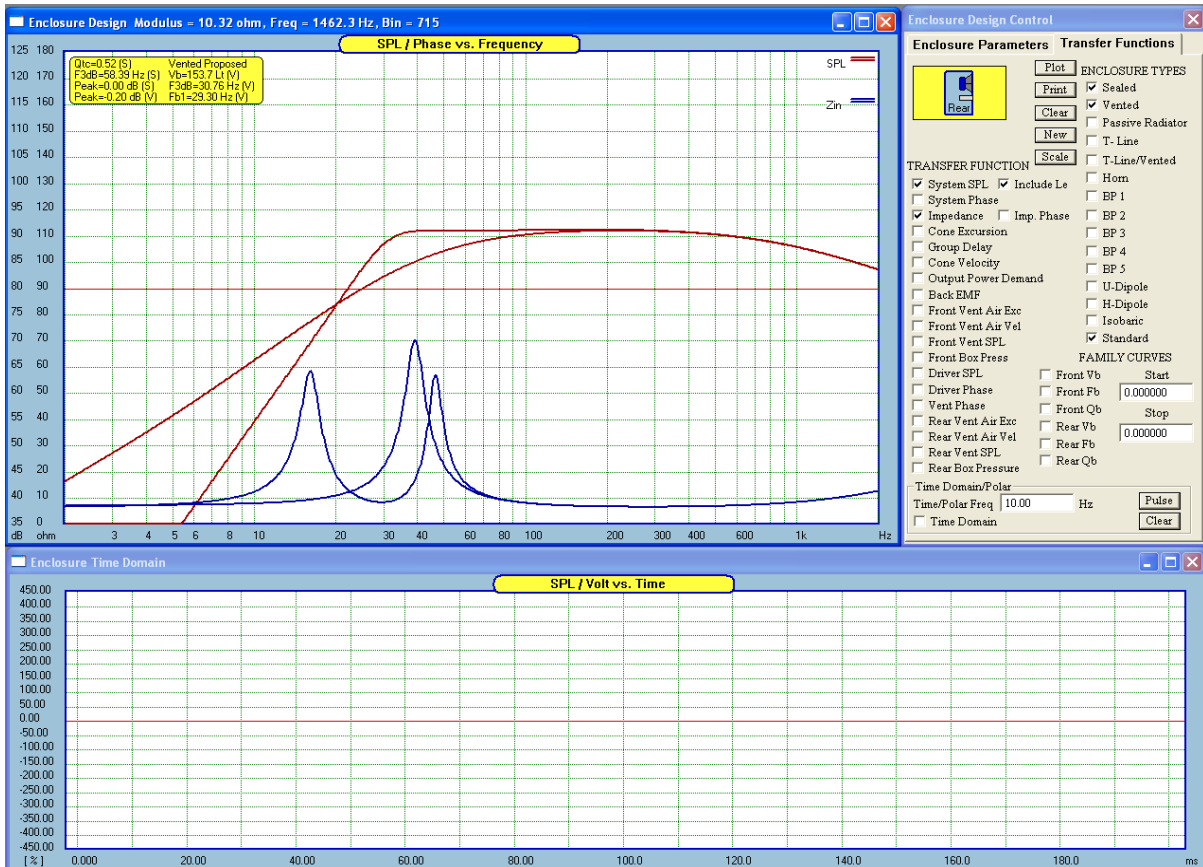
Figure 2.22. Example of Quick Analysis of sealed and vented enclosures.

**Using Enclosure Simulation as Full Transfer Function**

The recommended way of generating an SPL function is to use the Amplitude Model TAB. This way you can incorporate up to 50 dips/peaks onto the "crude" band-pass approximation of the loudspeaker response. The result will be a reasonable approximation of the smoothed driver SPL response. Corresponding input impedance, Zin, can be generated Impedance Model TAB.

At times you may want to quickly generate an SPL and Zin for the purpose of using them as transfer functions in the crossover design. This will still be useful for crossover design. The simplest way to accomplish this is to plot SPL and Zin functions in the Enclosure Design module, with the frequency range of the Box Section set the same as the System Section. Therefore, whatever is calculated in the Enclosure Design section, it will be calculated over the entire frequency range of the CAD and System sections.

Please follow the simple process outlined below:

1. Load your driver file, or enter a minimum of TS + enclosure parameters.
2. Open **Preferences** screen and set Box Frequency Range to be the same as System Frequency Range. Typically the range will be 5-20Hz ……..20-100kHz.
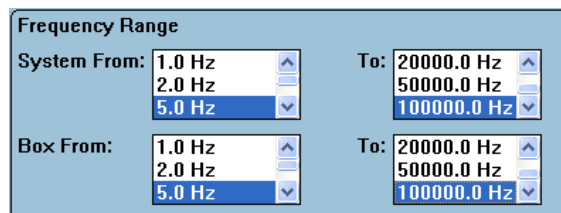


3. Go to **Enclosure Design** section and plot SPL and Zin functions.
4. Go to Driver Editor dialog box and select **Amplitude Model** TAB. There, press "Get SPL + Zin" button. At this stage, whatever was located in your driver's data file for SPL and Zin data vectors, has now been replaced by the data from Enclosure Design SPL and Zin functions.

2.21
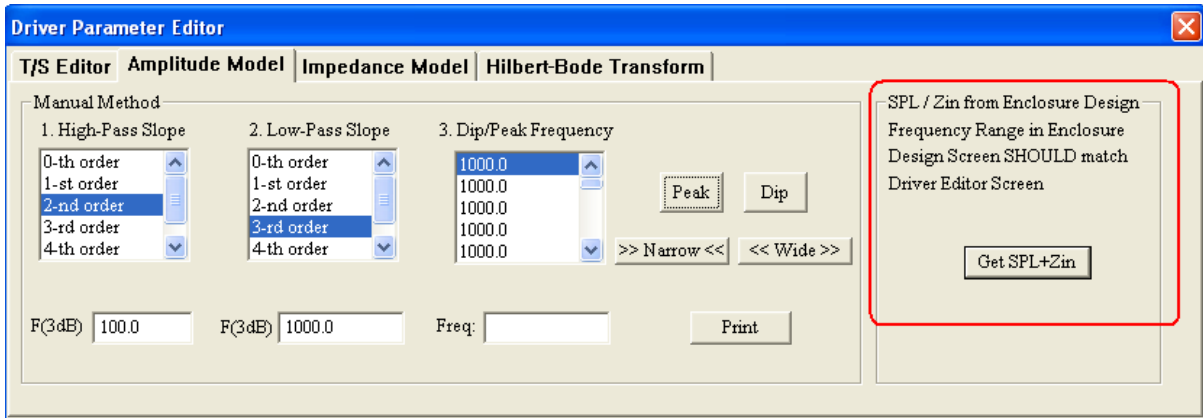
Figure 2.23 Transferring enclosure modelling data to your driver's transfer functions.

5. You can now select **Impedance Model TAB** and review the Zin.
6. Also, you can review box SPL by selecting **Amplitude Model** TAB.
7. Finally, you can preview SPL+phase and Zin+phase plots in the CAD plotting section by selecting "Driver SPL only" list box option on the "Plots" TAB.

Please note, that HBT is not used in this process. The entire transfer function (that is modulus and phase) is calculated by the Enclosure Design screen.

Confirmation of the above is shown in figure below. You can select "Amplitude Model" and "Impedance Model" TABs to review the transferred functions. Finally, the same functions can be plotted in the CAD plotting system – as seen on Figure 2.20
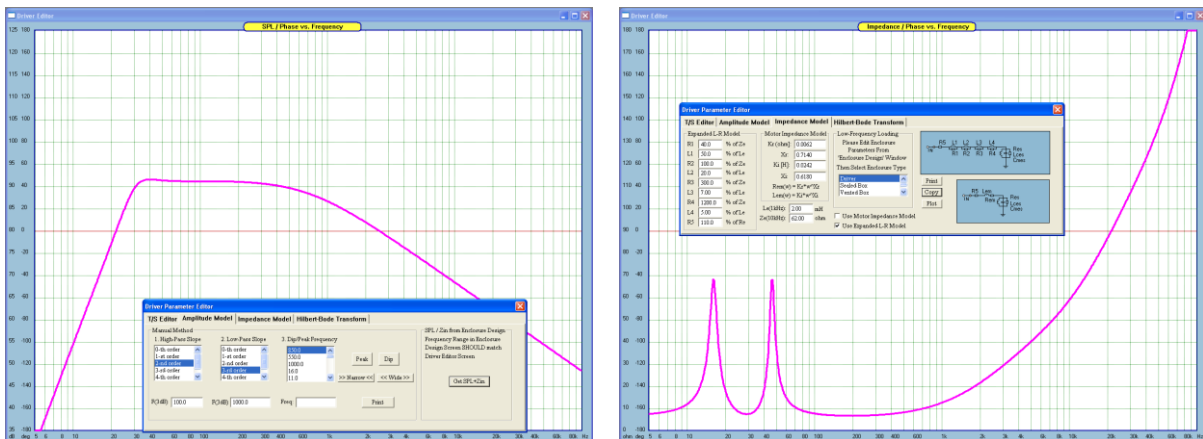


Figure 2.24 SPL + Zin transfer functions generated by the Enclosure Design screen.
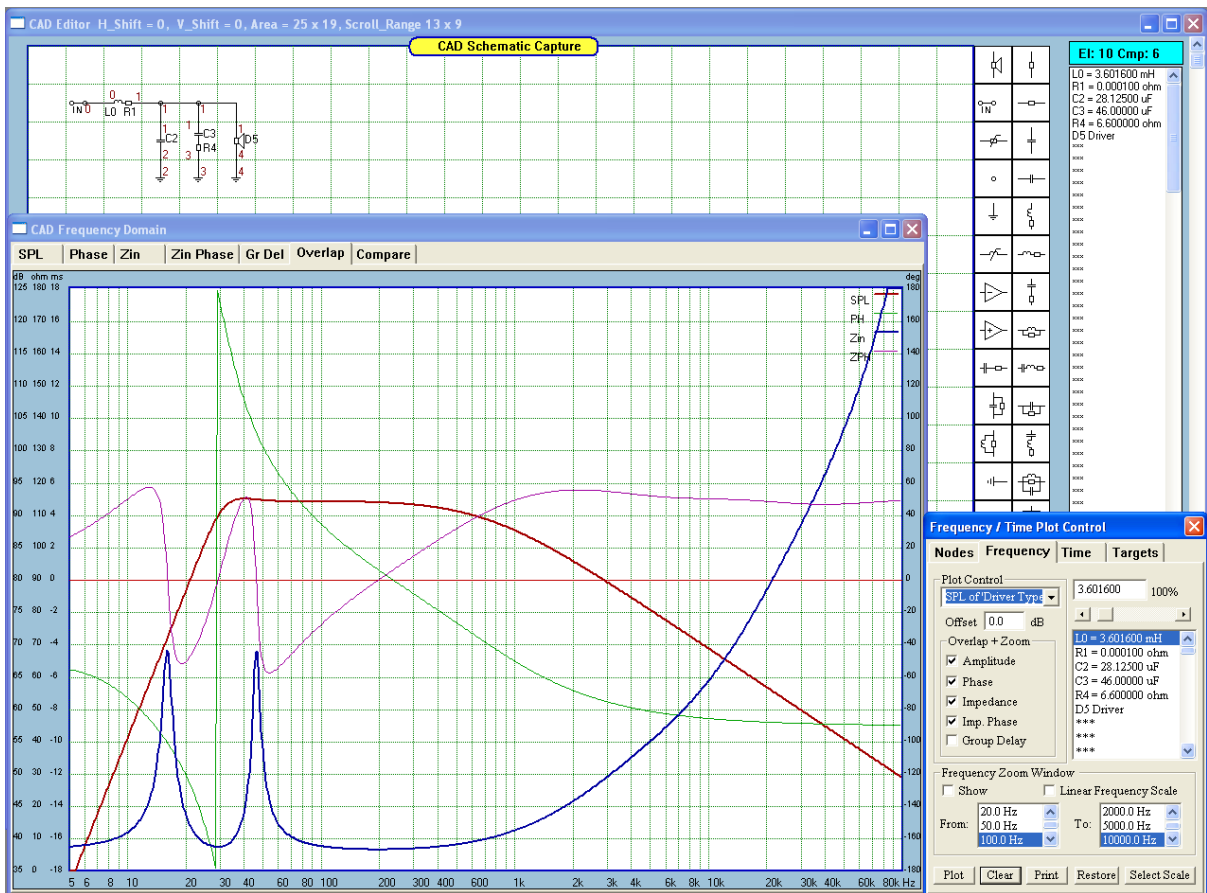
Figure 2.25 Enclosure SPl and Zin used and driver's transfer functions.

**Splicing Measured And Modelled Frequency Responses**

Since the measurement of low-frequency response can be challenge, a simple short-cut to obtaining a full transfer function of the driver has been implemented. **The low-frequency response is modelled and the high frequency response is measured.** This is possible because typically, the low-frequency modelled response follows quite close the anechoic low-frequency response. So, for the "first-cut design", this approach could yield satisfactory results. Please follow the steps described below.

1. Set frequency range for Box and System to the same values.
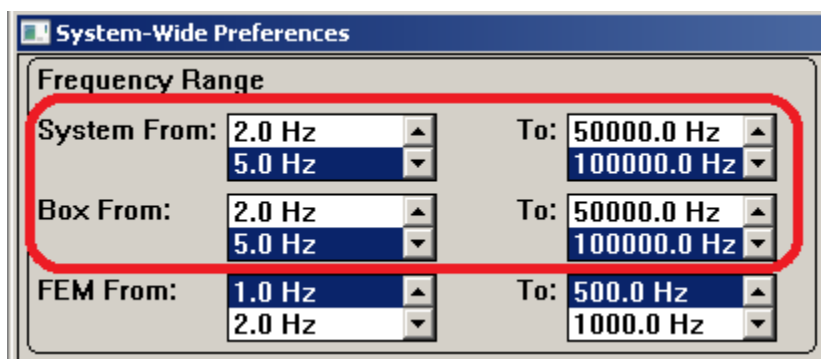
2. Edit driver's TS parameters



3. Select enclosure parameters and plot SPL and Zin
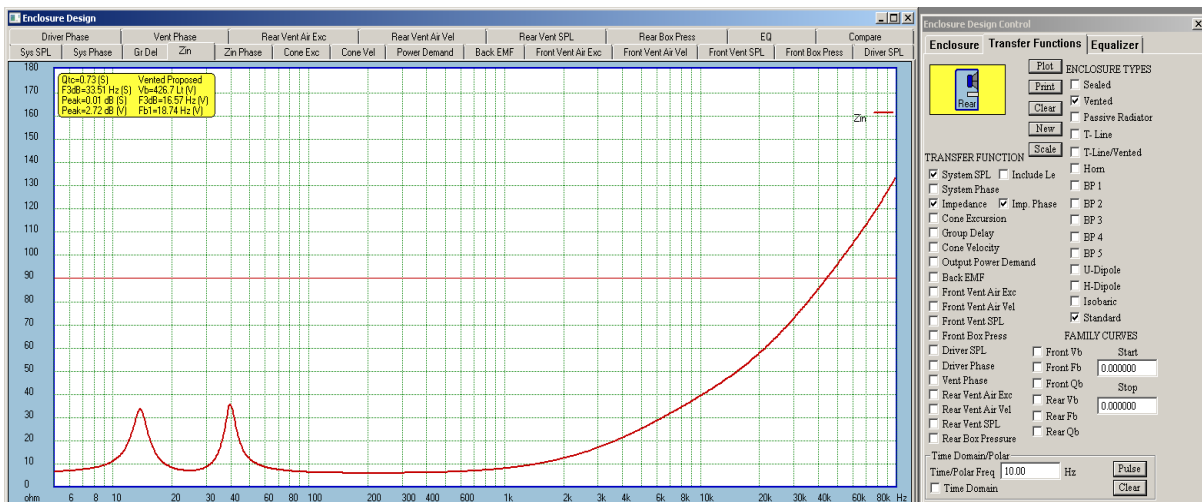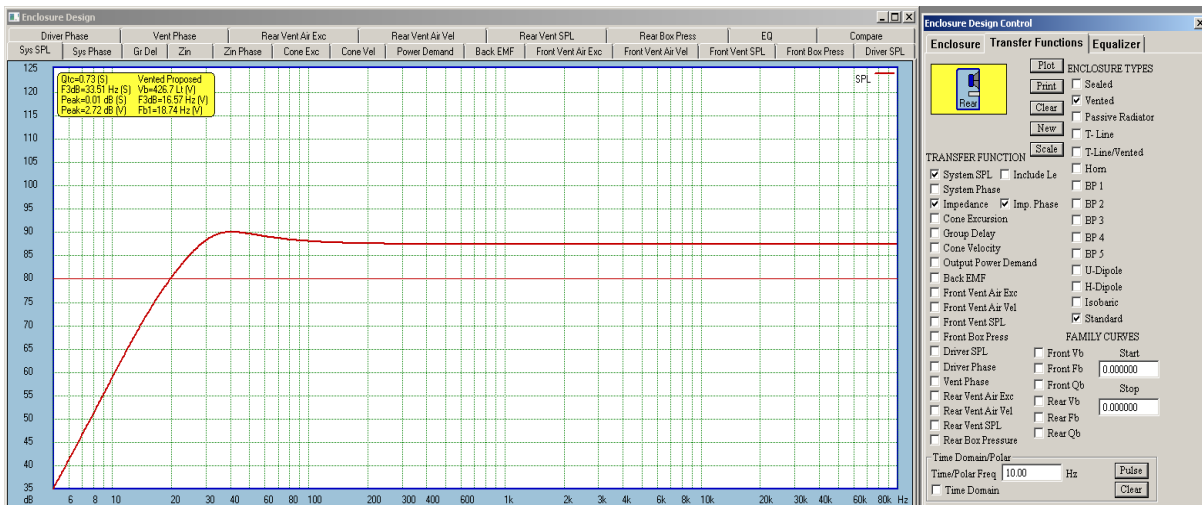




At this stage, we have modelled low-frequency section of the SPL/Zin curve, and have basic data at LF.

4. Select front baffle, position the driver and microphone and plot diffraction curve.
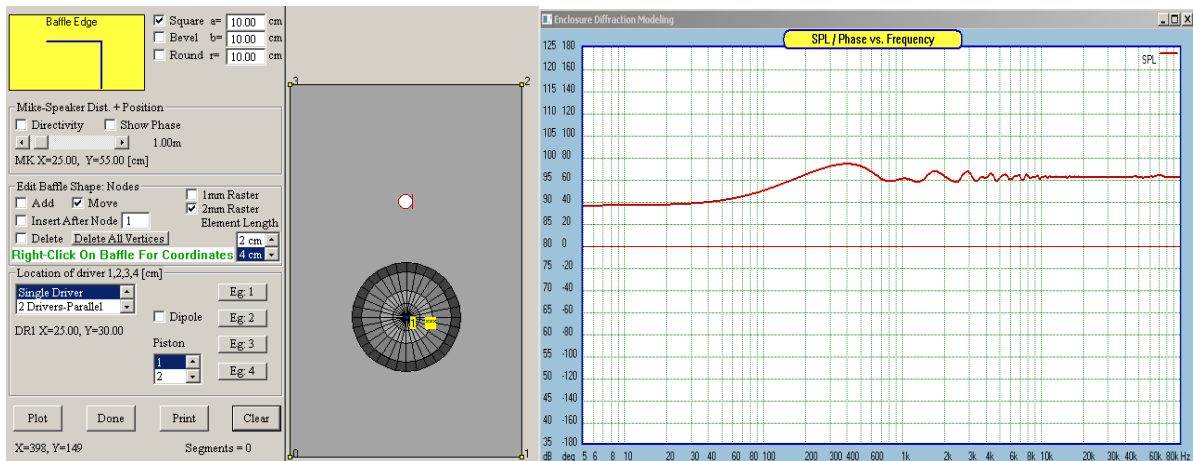


5. Measure frequency response of the driver, making sure, the high-frequency section to be spliced into the box-designed SPL is well represented. Make sure, you check "Save As System" checkbox before plotting SPL.



6. We now have all components needed to create "spliced" frequency response.
We have (1) SPL and Phase of the driver's transfer function, (2) Input impedance Zin, (3) diffraction of the front baffle, and (4) measured high-frequency response of the actual driver.

**SPL / Phase vs. Frequency**

**Splice frequency**

This SPL section was designed using Enclosure Design + Diffrection Analyser

This section was measured using MLS system, and required -4.2dB drop in SPL to match the low-frequency section
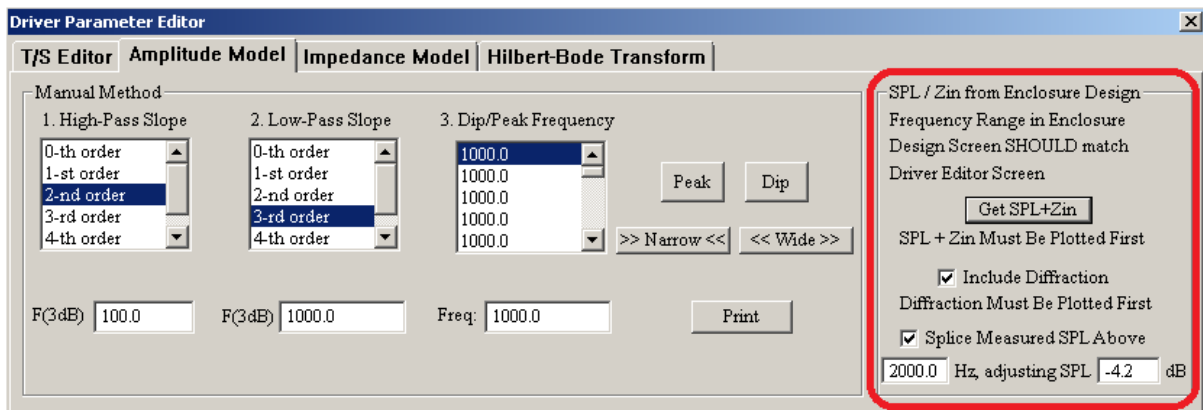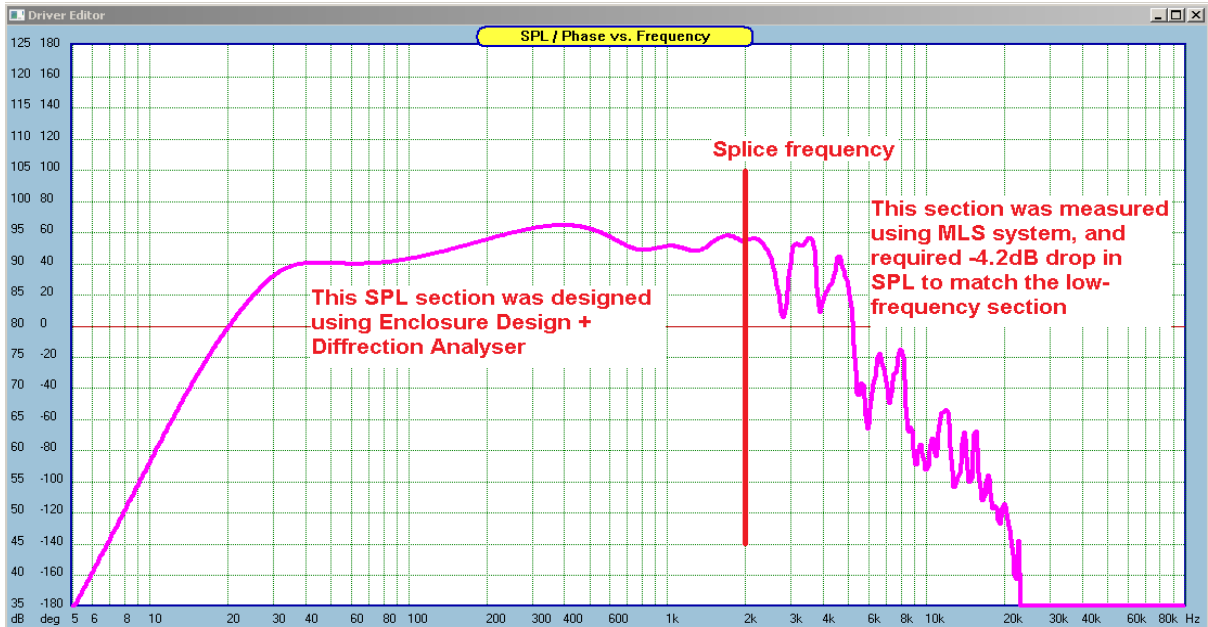
7. Phase response is calculated automatically.

We can now review fully edited driver file and save it into hard disk for future use. Go to "Driver Tools" and select default driver for display.



**Driver Type = Woofer**

SPL
PHA
ZIN
ZinPha

**Driver T/S Parameters**

DC Resistance = 5.60 ohm
Electrical Qe = 0.5548
Mechanical Qm = 5.0
Total Qt = 0.4994
VC Inductance = 2.0 mH
Force Factor = 10.000 N/A
Eddy Resistance = 60.0 ohm
Compliance Volume = 240.0 Lt
Nominal Power = 100.0 W
Efficiency 1W/1m = 90.0 dB
Piston Area = 490.874 cm^2
Effective Diameter = 25.0000 cm
Max Linear Excursion = 10.0 mm
Dynamic Mass = 70.003 gm
Free Air Resonance = 22.523 Hz
Dynamic Mass = 70.003 gm
Accoustical Offset = 10.0 mm
Magnetic Gap = 10.0 mm
Voice Coil Height = 20.0 mm
Thermal resistance VC-Magnet = 1.00 ohm
Thermal resistance Magnet-Air = 0.280 ohm
Thermal resistance Total = 1.280 ohm
VC Thermal Coefficient = 0.00393 mm
Magnet Type = Alnico 5
Z min = 8.0 ohm
Driver Type = Woofer
Driver Model = Woofer 1

Driver Files

**Driver Volterra Parameters**

Nonlinear_BL0 = 4.9
Nonlinear_b1 = 82.0
Nonlinear_b2 = -20000.0
Nonlinear_K0 = 28.8
Nonlinear_k1 = -6067.0
Nonlinear_k2 = 9000000.0
Nonlinear_Le0 = 0.0015
Nonlinear_l1 = 0.0873
Nonlinear_l2 = 10.0
Nonlinear_Rm = 2.6
Nonlinear_m = 0.014
Nonlinear_Eg = 17.0

Non-Linear Diff-EQ Parameters

Asymmetry BL (A1) = 0.00000
Flat/Peak BL (A2) = -0.02000
Wide/Narrow BL (A4) = -0.00050
Shift BL (AS) = 0.00000
Asymmetry Cas (B1) = 0.00000
Flat/Peak Cas (B2) = -0.00002
Wide/Narrow Cas (B4) = -0.00150
Shift Cas (BS) = 0.00000

Figure 2.26. Fully edited driver. LF was generated by SOundEasy. HF was measured by SoundEasy.

8. Phase discontinuity between MLS measured portion of the combined SPL plot and modelled SPL plot can be corrected using HBT function. Correctly measured phase response should be the guiding template for the total phase and for selecting HBT parameters.
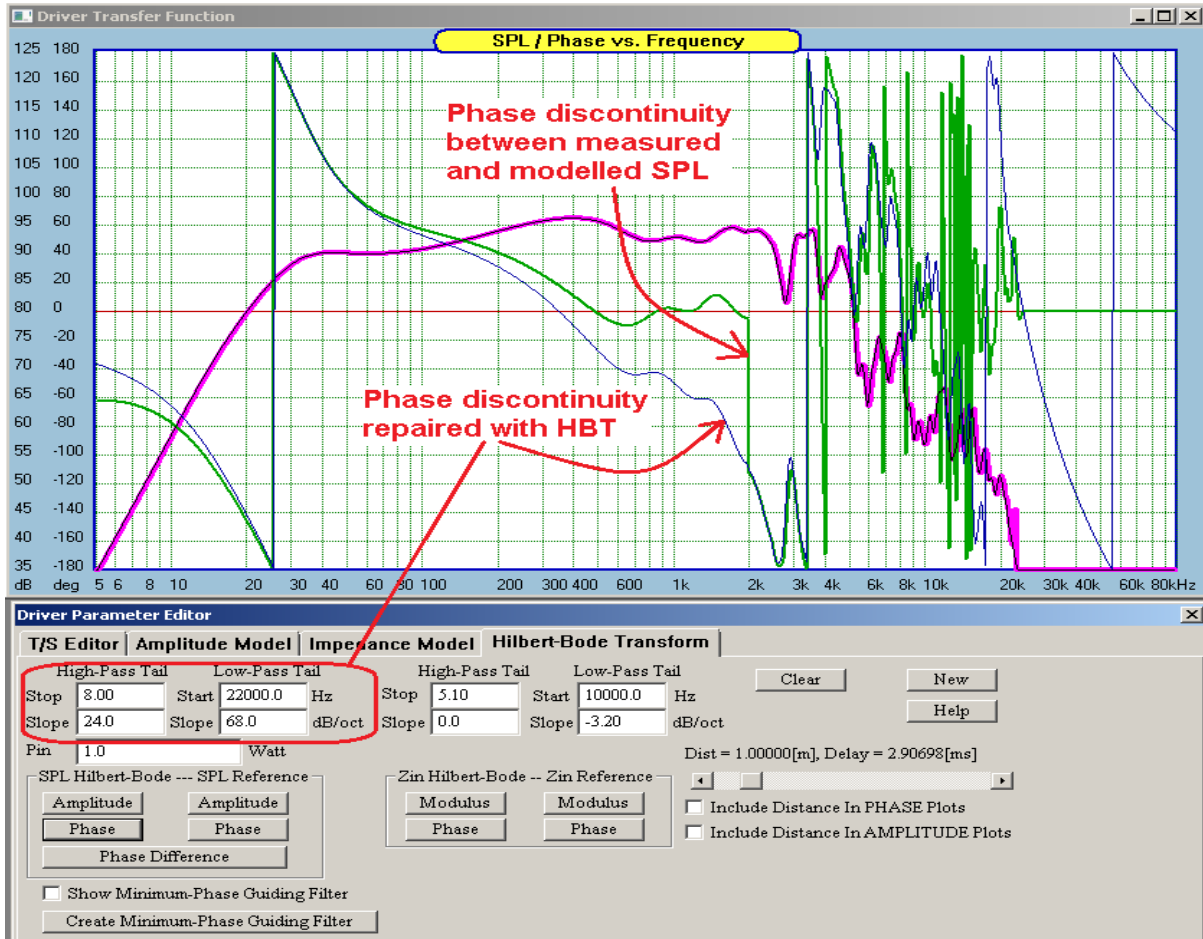


Figure 2.27. correcting phase discontinuity.

**Semi-Inductance Impedance Model**

The Semi-Inductance Model has been proposed by K. Thorborg, A.D. Unruh and C.J. Struck in 2007 in their AES paper "An Improved Electrical Equivalent Circuit Model for Dynamic Moving Coil Transducers".
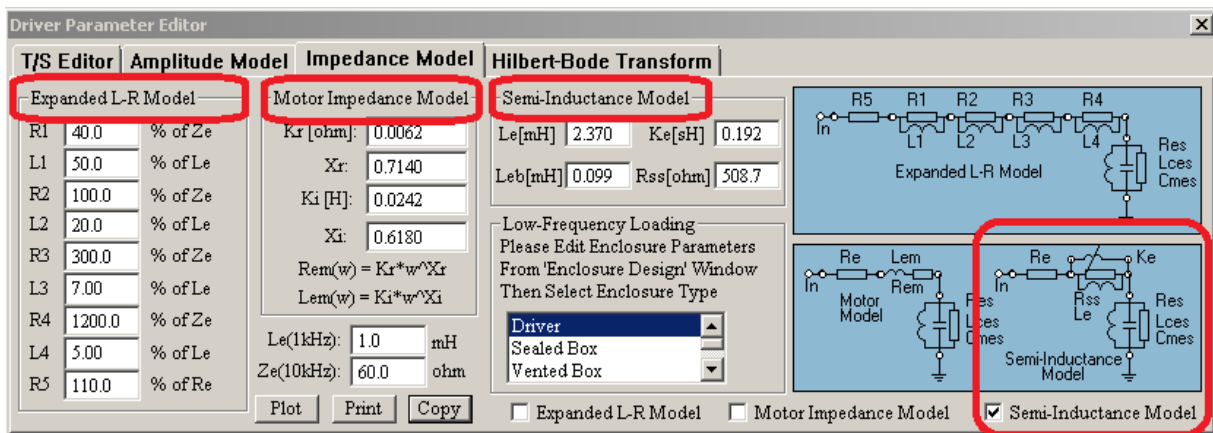


Figure 2.22. Three available Impedance Models.

Models are selected by checking one of the three check boxes on the Impedance Model TAB – see Figure 2.22 above. For more information, please see Chapter 16.3.

2.27
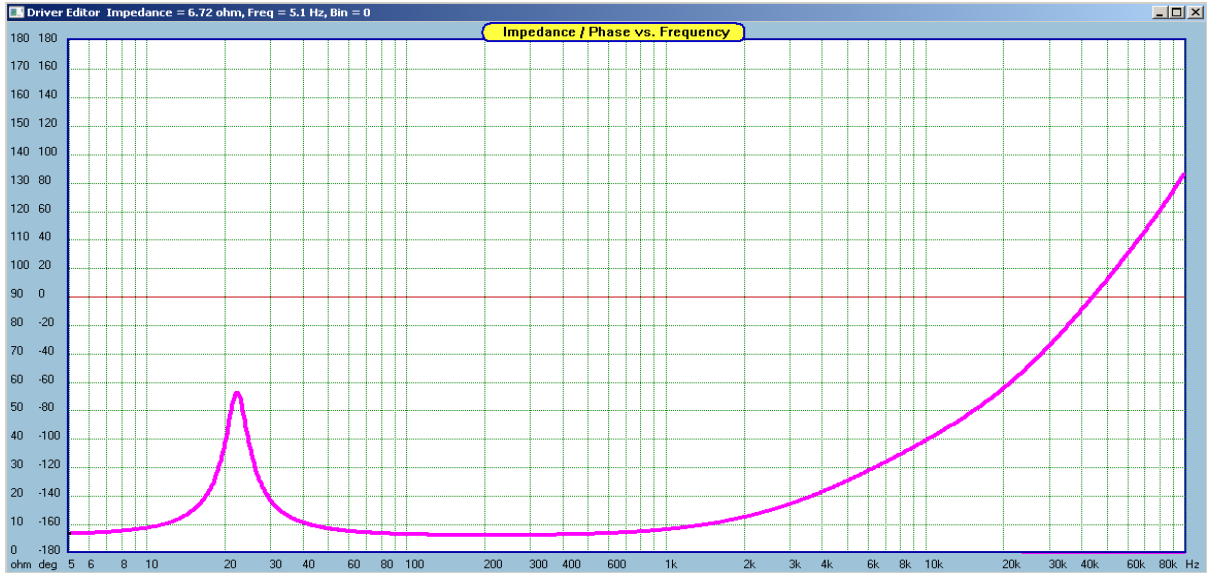
Figure 2.23. Expanded L-R Model
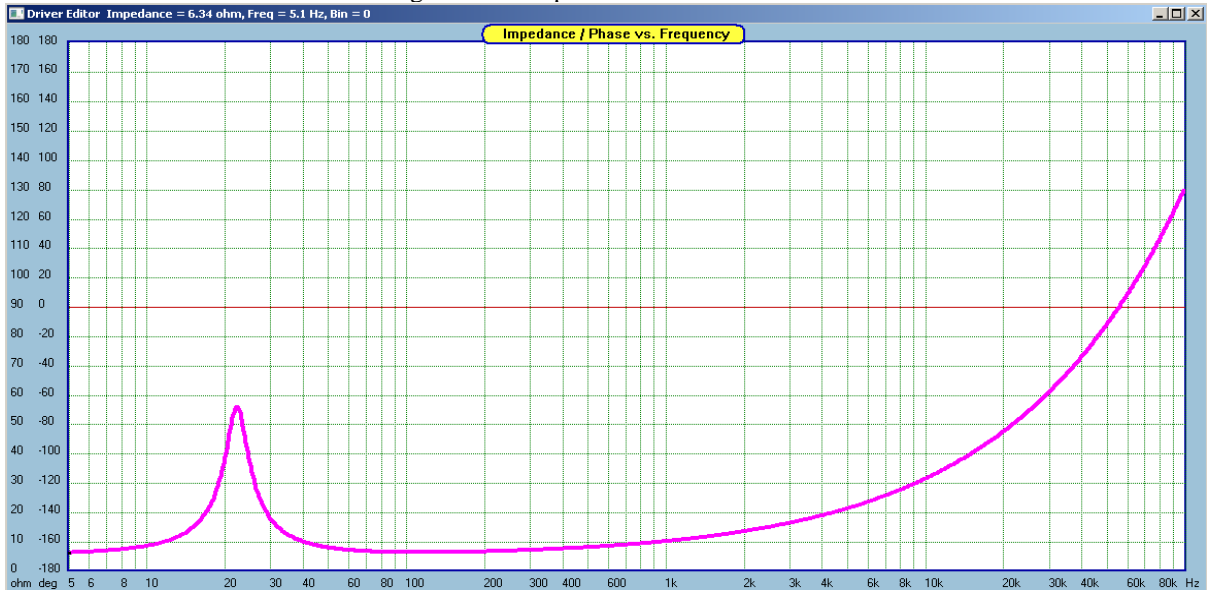

Figure 2.24. Motor Impedance Model.


Figure 2.25. Semi-Inductance Impedance Model.

2.28

**Adding / Subtracting Diffraction to Driver Transfer Function**

Shown below is an example of a driver's SPL, or transfer function.
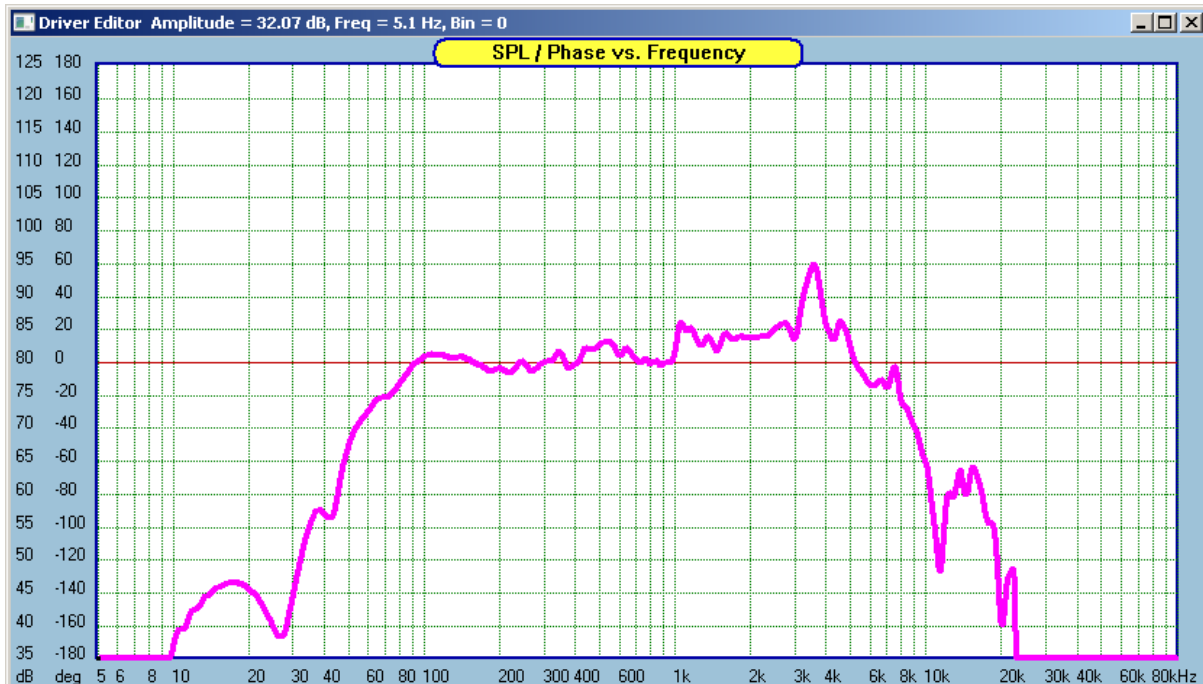

Fig 2.26. Example of driver's SPL curve

There may be situations, when you need to subtract or add enclosure diffraction to the SPL curve. Should this be the case, please go to Baffle Diffraction system and construct the desired baffle size, position the microphone correctly, and plot the resulting diffraction curve, using Piston = 4 or 5 setting for good diffraction approximation..
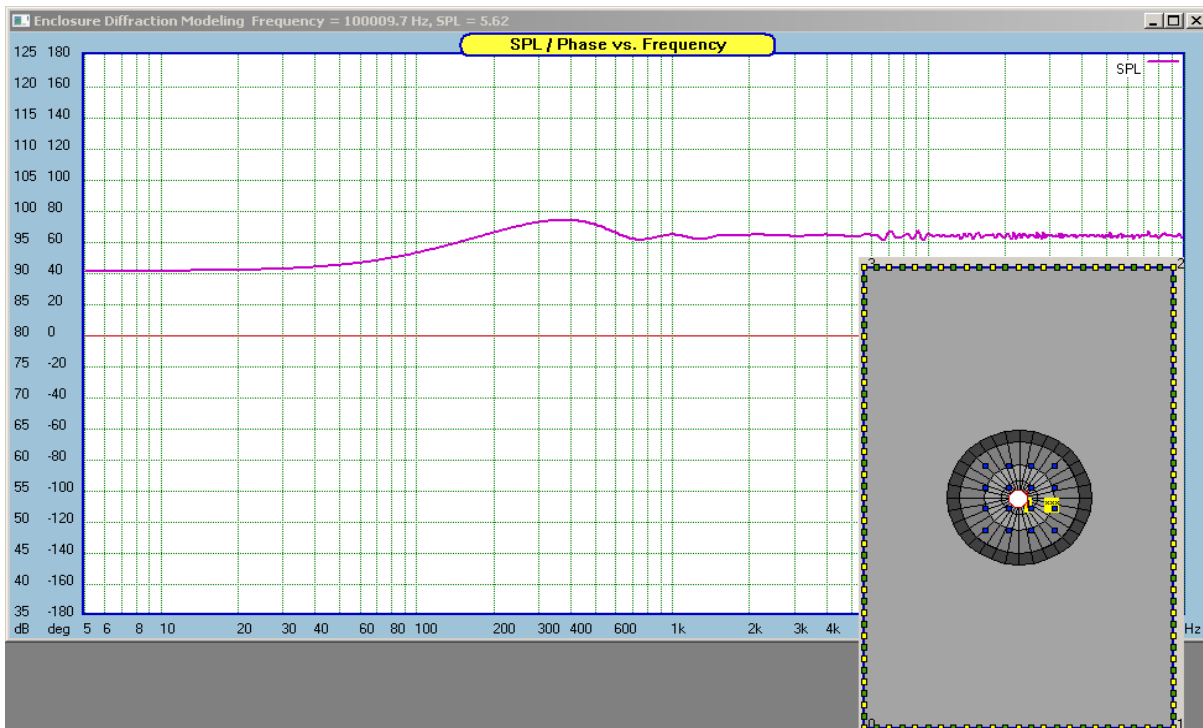

Fig 2.27. Pre-calculated diffraction curve

Now, please return the the Driver Editor screen and you can now subtract the newly calculated diffraction curve from driver's SPL.

2.29
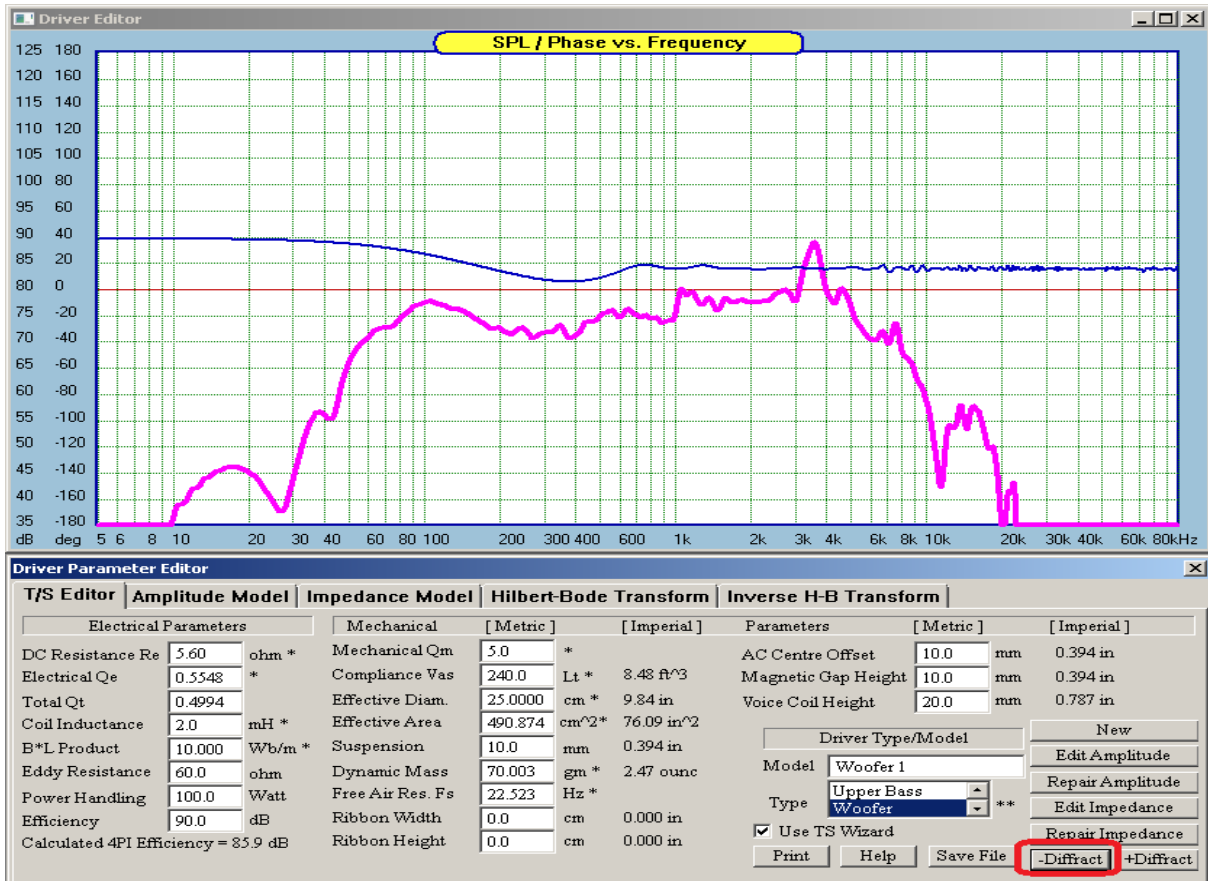
Fig 2.28. Diffraction curve subtracted from the driver's SPL curve.

Or, you can now add the newly calculated diffraction curve from driver's SPL.
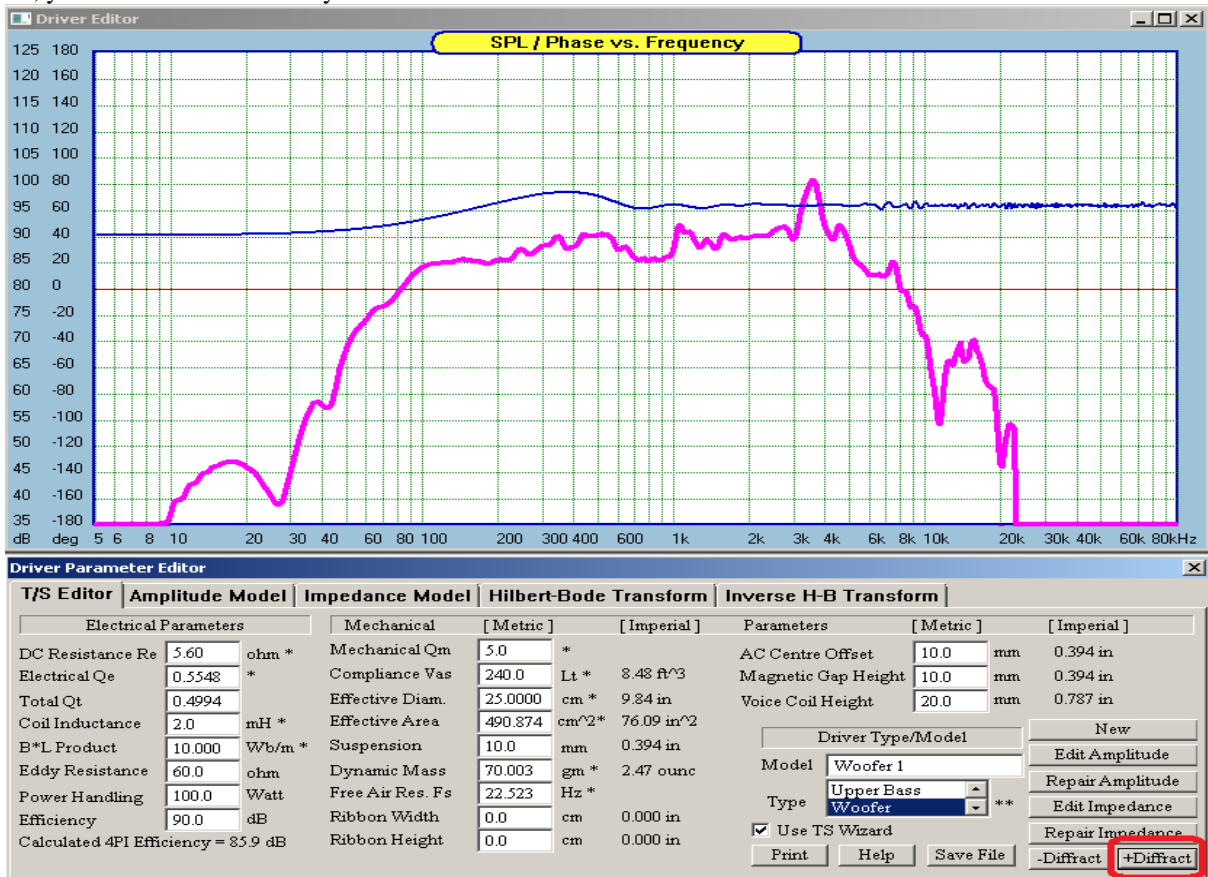


Fig 2.29. Diffraction curve added to the driver's SPL curve

2.30

**SoundEasy Labelling System**

Majority of the curves plotted on SoundEasy screens are **parametric curves**. The curves take on different shape when one or more parameters are changed. For instance, the SPL of a vented enclosure will change when the box tuning, Fb, is changed. In this case, the box tuning is the changing **parameter** of the plotted curve. It would be beneficial to have the "before" and the "after" curve displayed at the same time and to have each curve associated with the changed parameters in a clear and unique manner. This way, it is immediately observable which way the performance is moving: are we improving or deteriorating the performance. Project documentation should be easier accomplish when implementing this approach.

The labelling system implemented in the program attempts to address these issues. However, not without some limitations. Some of the plotted curves depend of a number of parameters and capturing all of them for the purpose of displaying them in the curve's label will prove too cumbersome. For instance, drivers in a complete system can be tilted, rotated, repositioned on the front baffle, the microphone can be moved around and the crossover can be modified – all these parameters would need to be displayed and associated with the corresponding curve, so we can identified each parameter's influence on the shape of the curve.

Given the above, the labelling display system is split into several groups. In one group the labels display crossover component dependency. In another group the labels display microphone 3D location dependency. Some screens would also display driver file name loaded for analysis, and this is particularly handy when comparing performance of different drivers in designated enclosures. Another group would indicate which off-axis curve is being used for analysis. Yet another group would display which drivers are active in a multi-way system, and so on….This approach helps to provide some clarity in otherwise quite congested display screens.

Shown below are several examples of labelling system implemented throughout the program. Please note, that the labelling system will be expanded and improved in subsequent releases.

1.  Driver Name Displayed on All Enclosure Design plot tabs. Curves are labelled as per enclosure parameters.
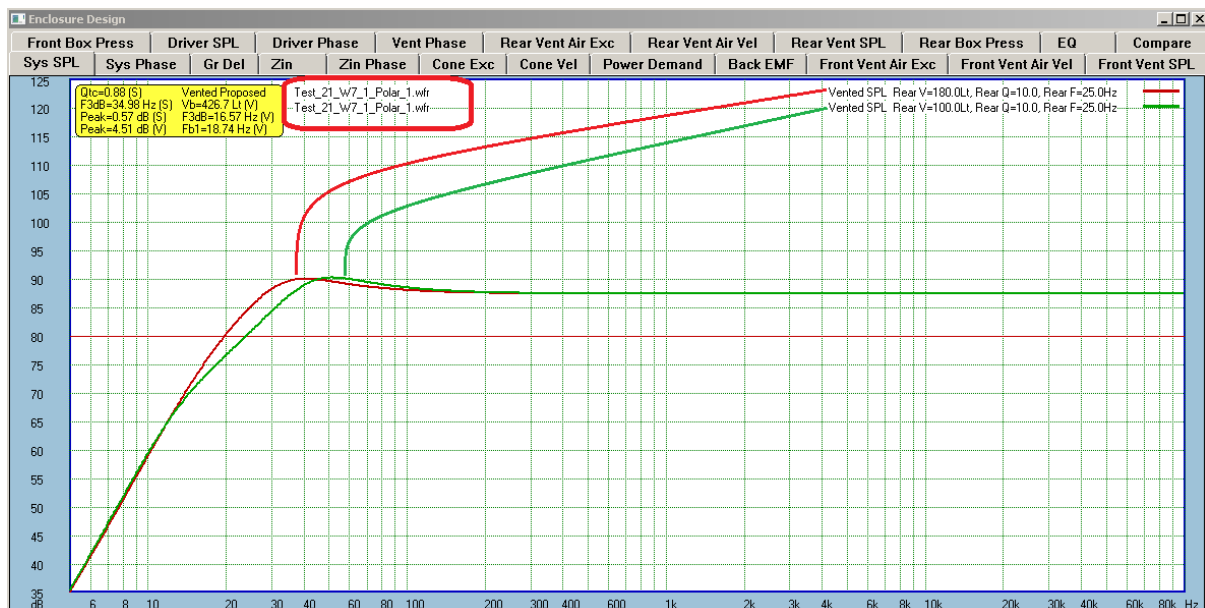


Fig. 2.30. Driver Name Displayed on All Enclosure Design plot tabs. Curves are labelled as per enclosure parameters

2. SPL polar curves labelled for mike location and distance
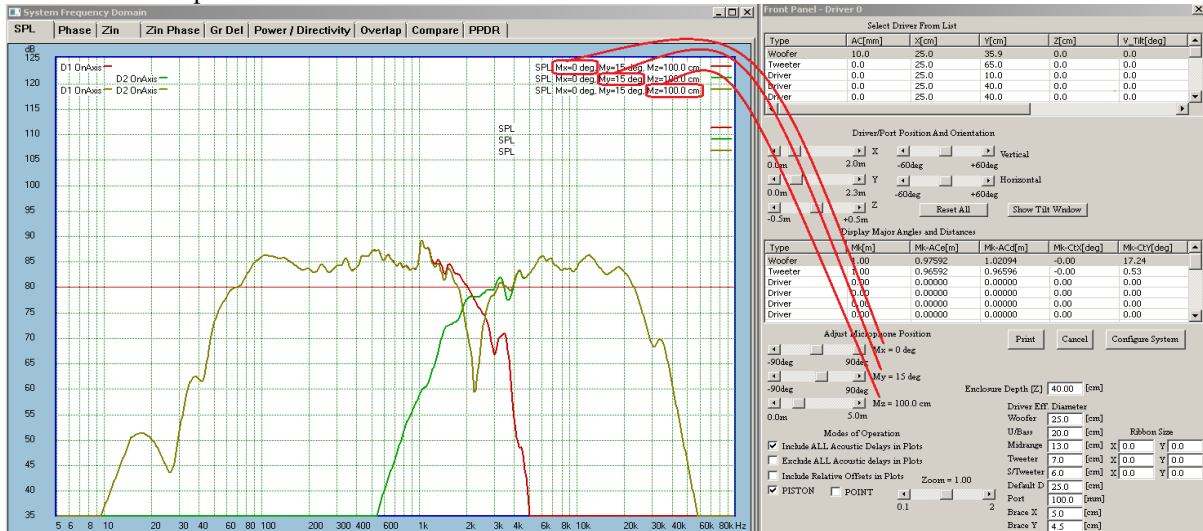


Fig 2.31. SPL polar curves labelled for mike location and distance

3. Labelling individual drivers and combined response
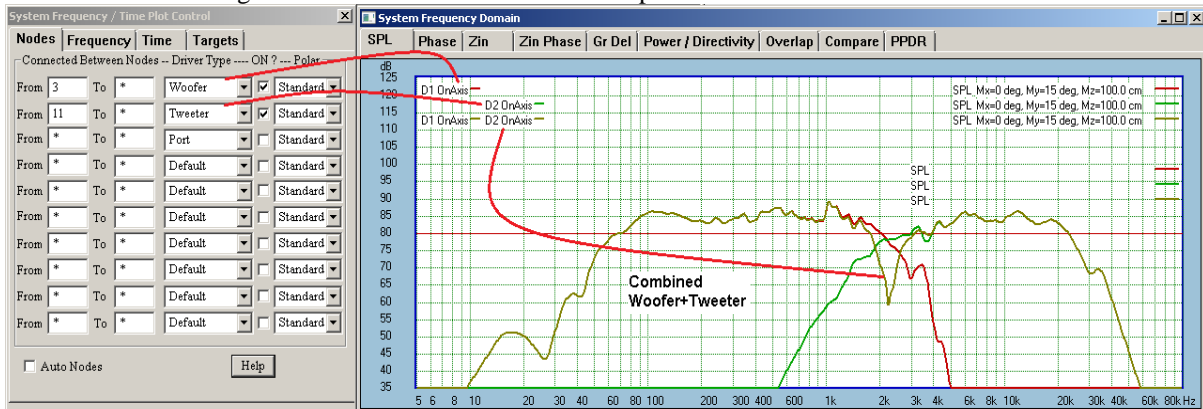


Fig 2.32.  Labelling individual drivers and combined response

4. Room Image Method - added colour cycling and extensive labelling.
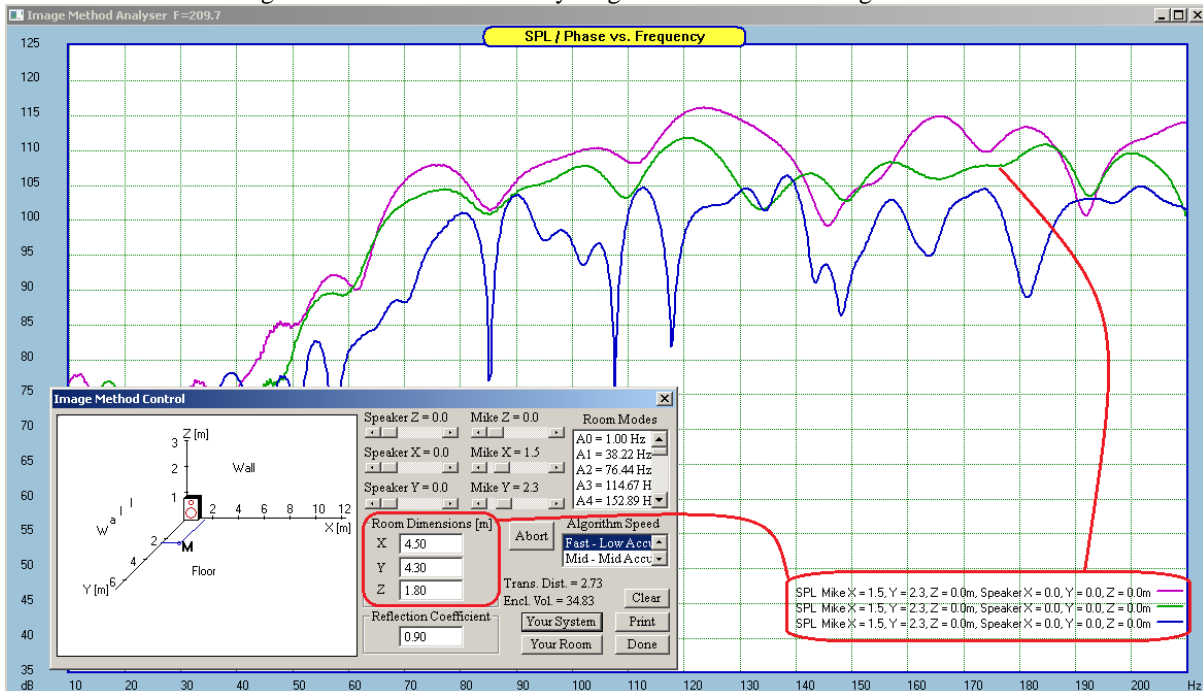


Fig 2.33. Room Image Method - added colour cycling and extensive labelling

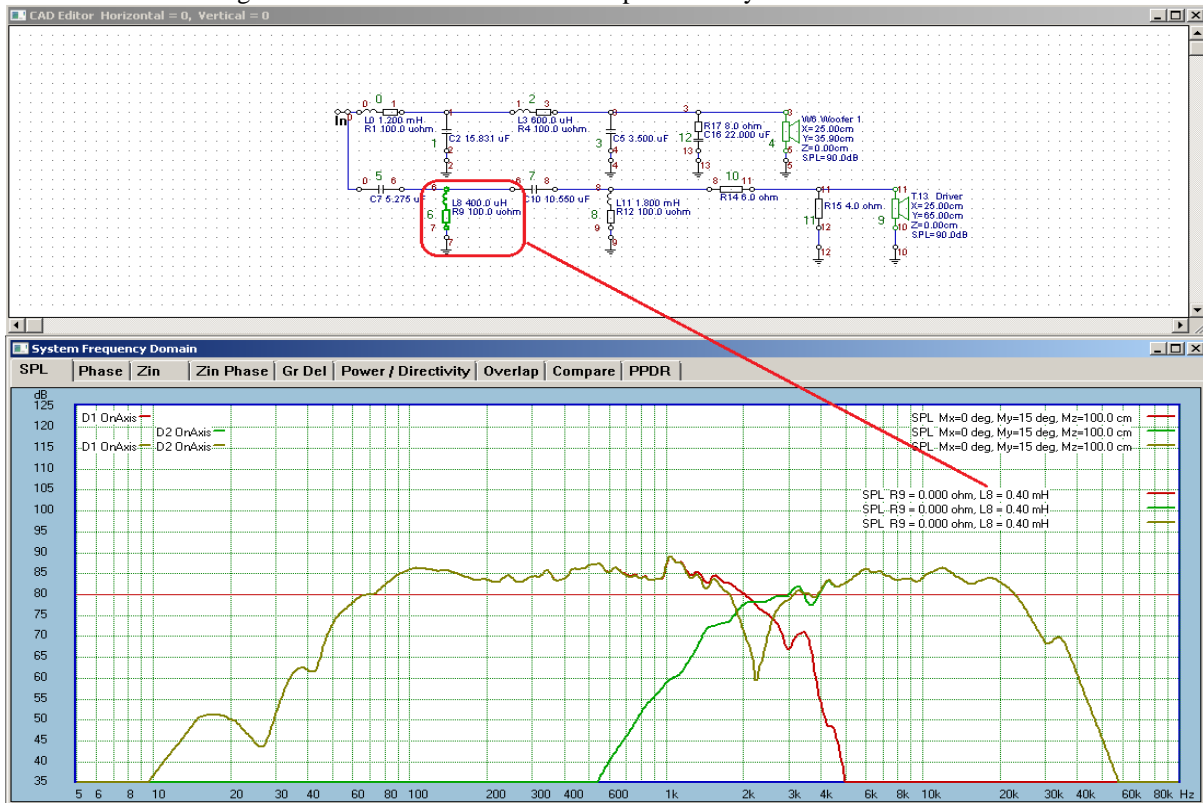5. Labelling SPL curves for the last edited component in System Module



Fig 2.34. Labelling SPL curves for the last edited component in System Module

6. Labelling also works for component tweaking with mouse wheel.
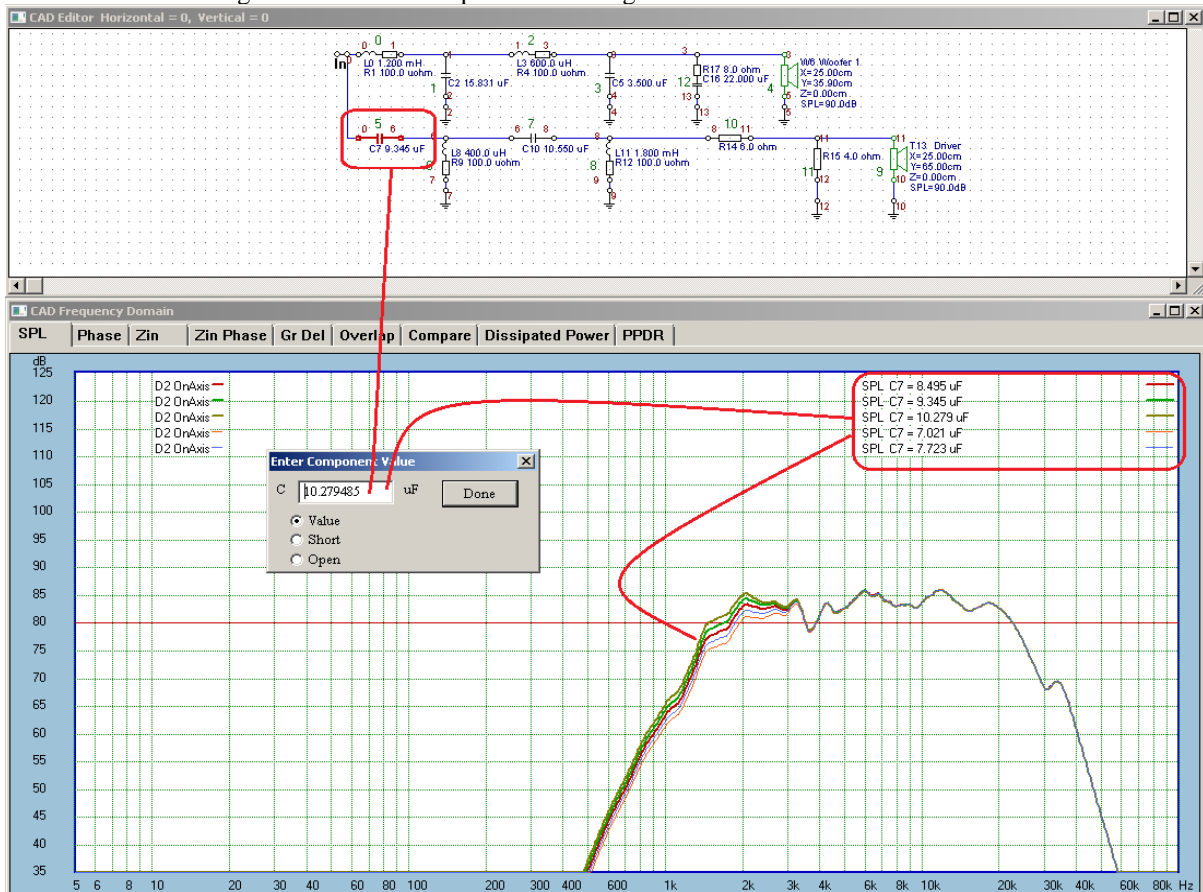


Fig 2.35. Labelling also works for component tweaking with mouse wheel.

7. Time domain labels in CAD and System modules.
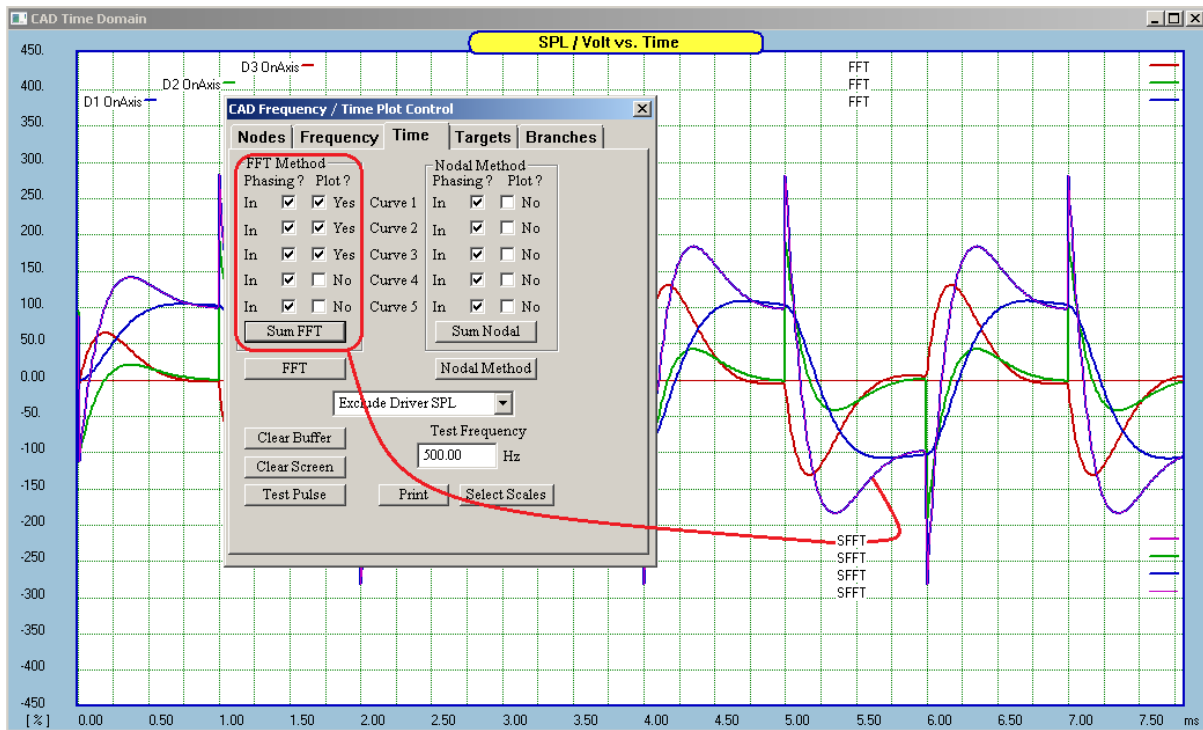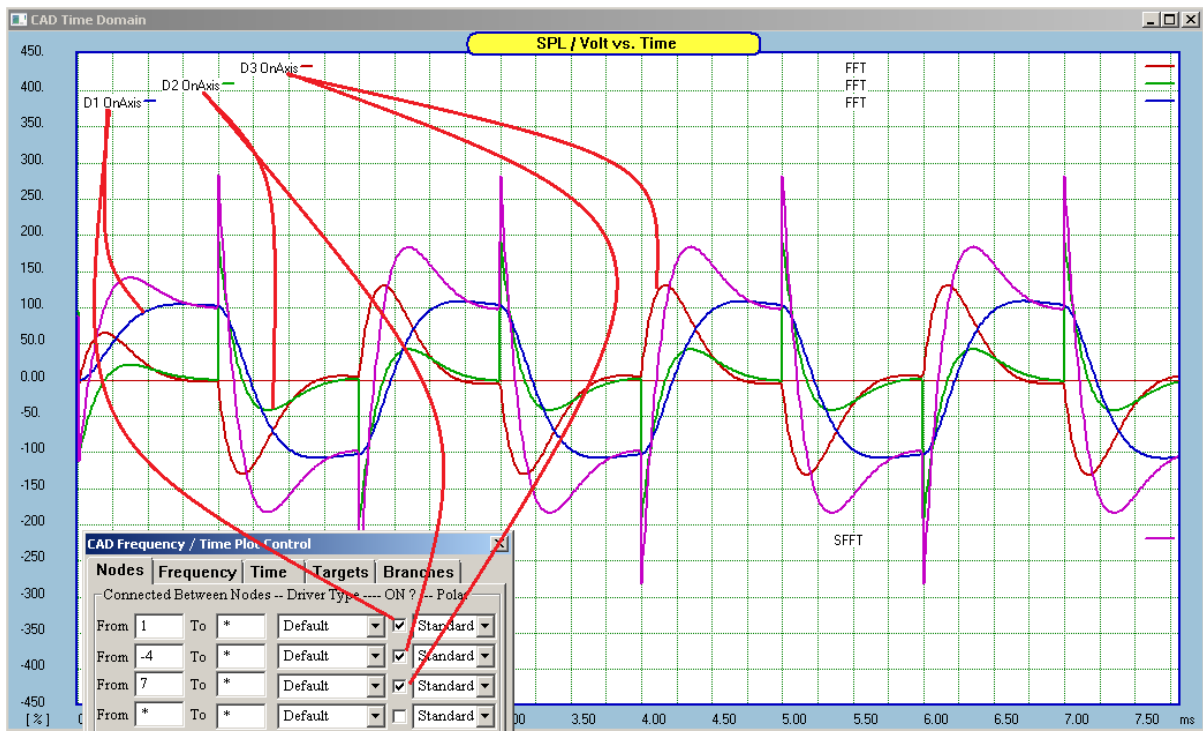




Fig 2.36. Time domain labels in CAD and System modules

## 8. Time domain labels in CAD and System modules
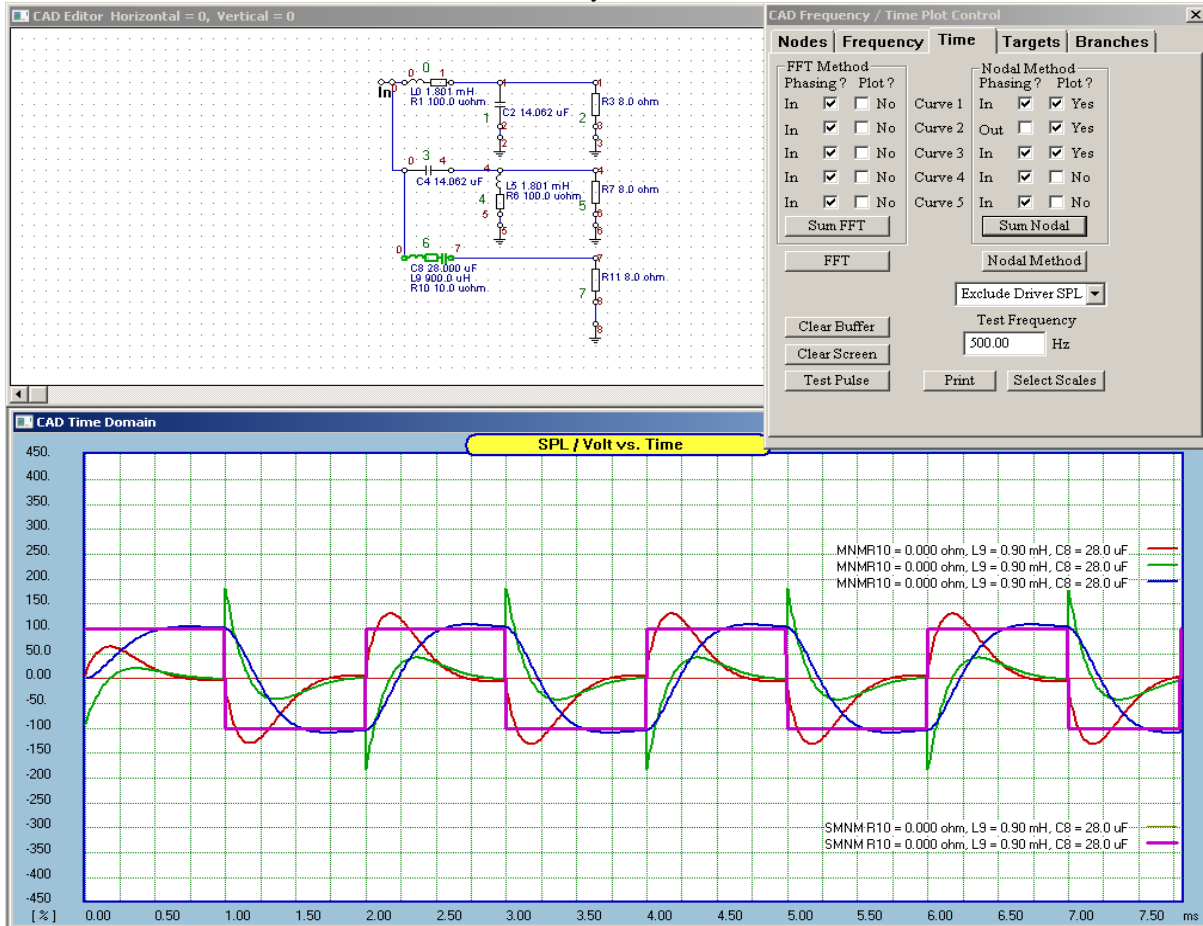


Fig 2.37. Time domain labels in CAD and System modules

## 9. Polar Plot frequency labels for each colour of the polar plots.
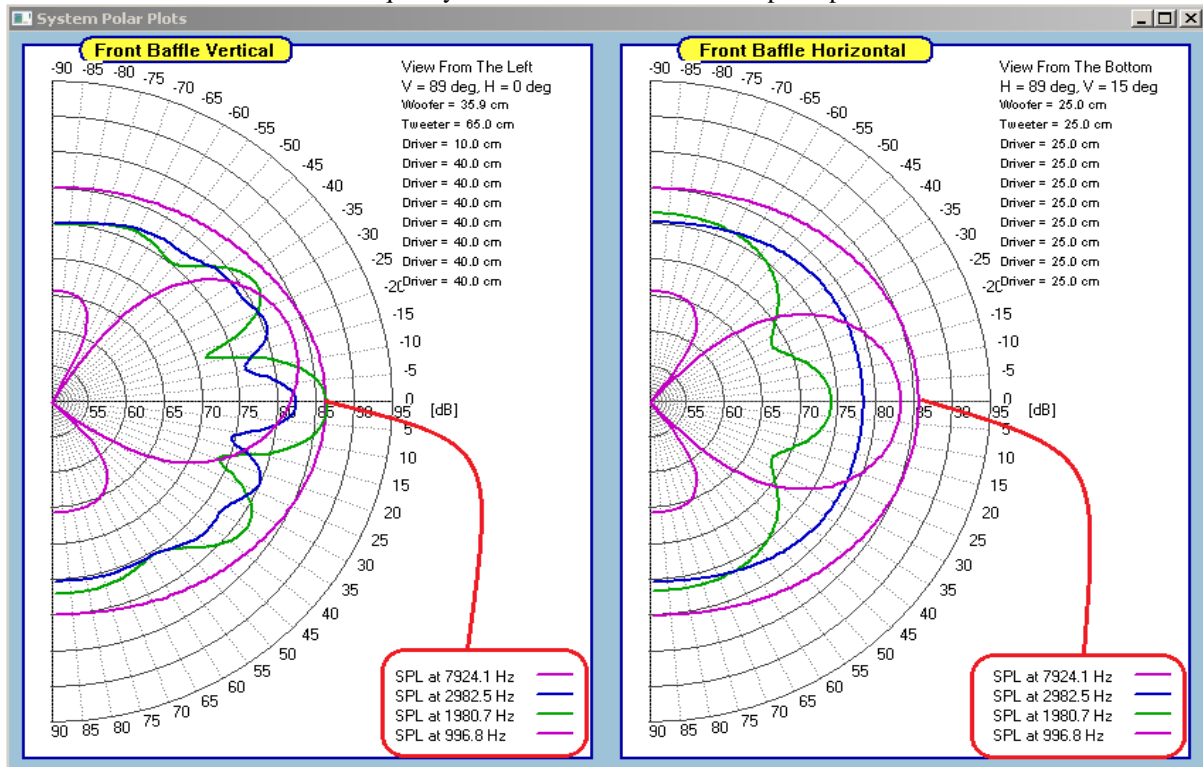


Fig 2.38. Polar Plot frequency labels for each colour of the polar plots

2.35

10.    Labels for the angle and curve colour for each driver's off-axis response in CAD system
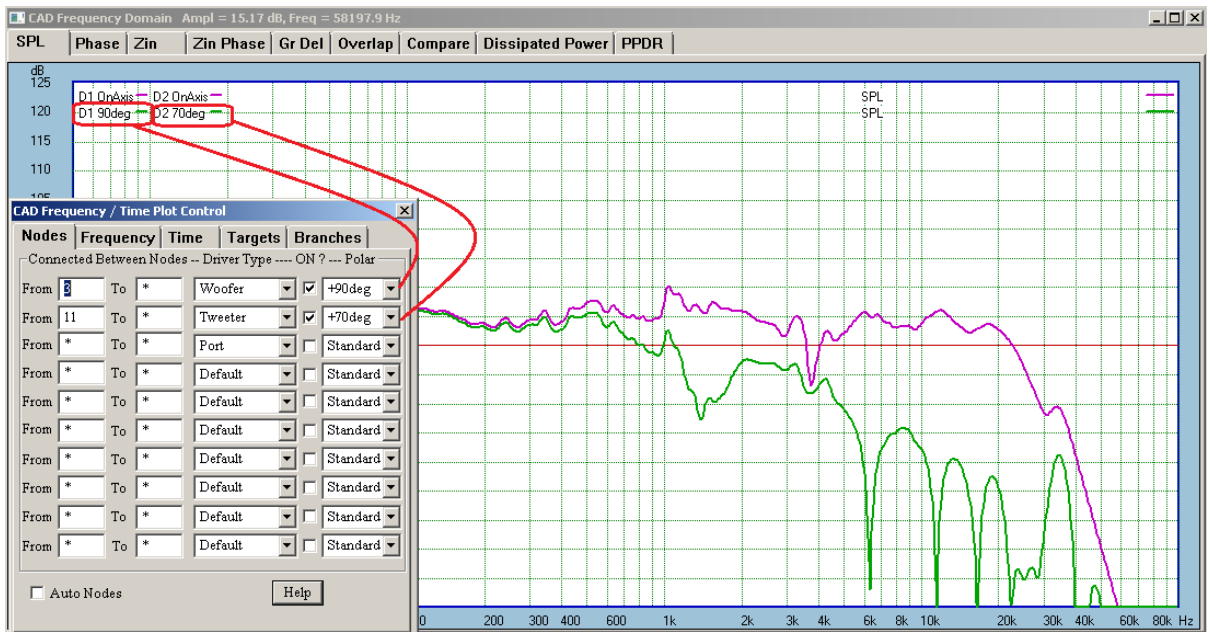


Fig 2.39. Labels for the angle and curve colour for each driver's off-axis response in CAD system


11.  Labelling SPL curves for the last edited component in CAD Module
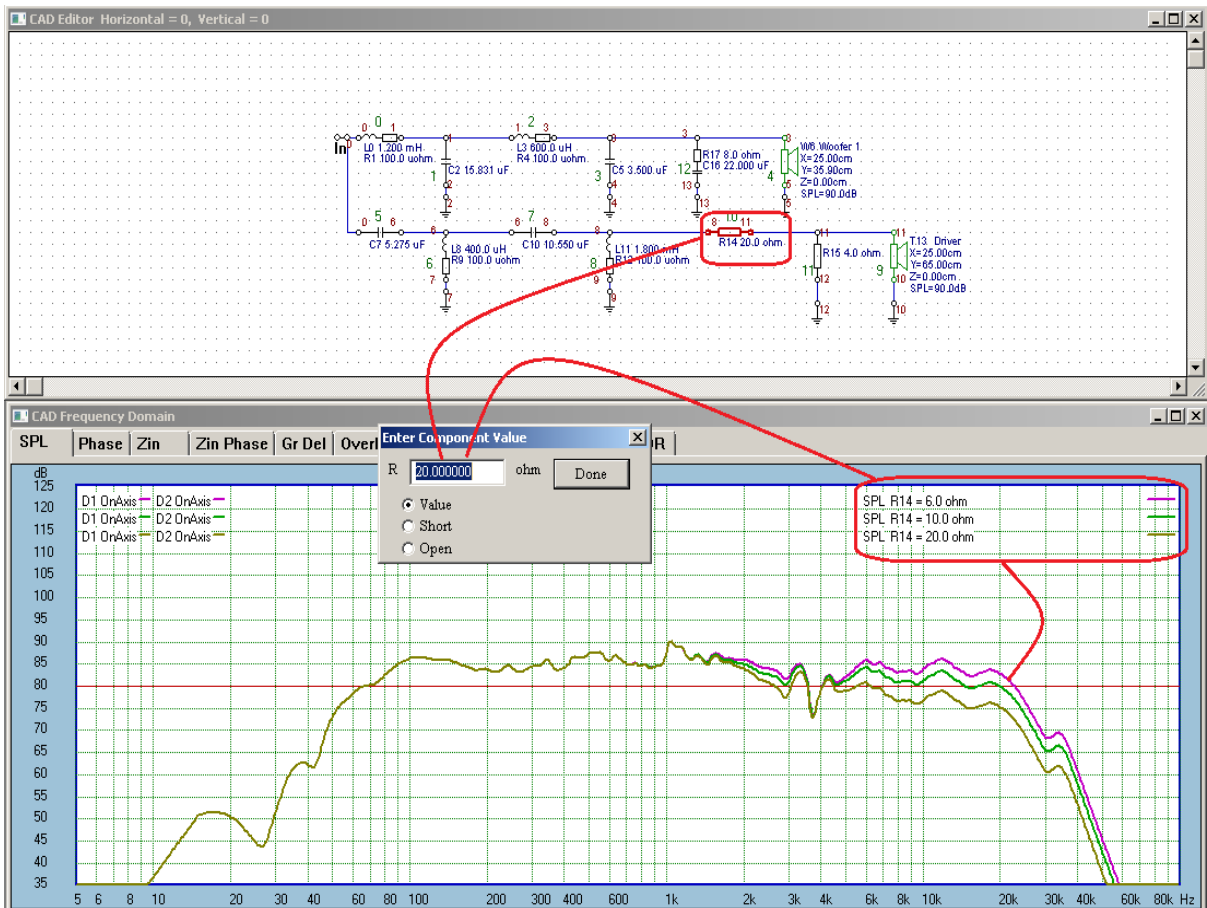


Fig 2.40. Labelling SPL curves for the last edited component in CAD Module

12. "Power Spectrum" display option in CAD and System Modules.
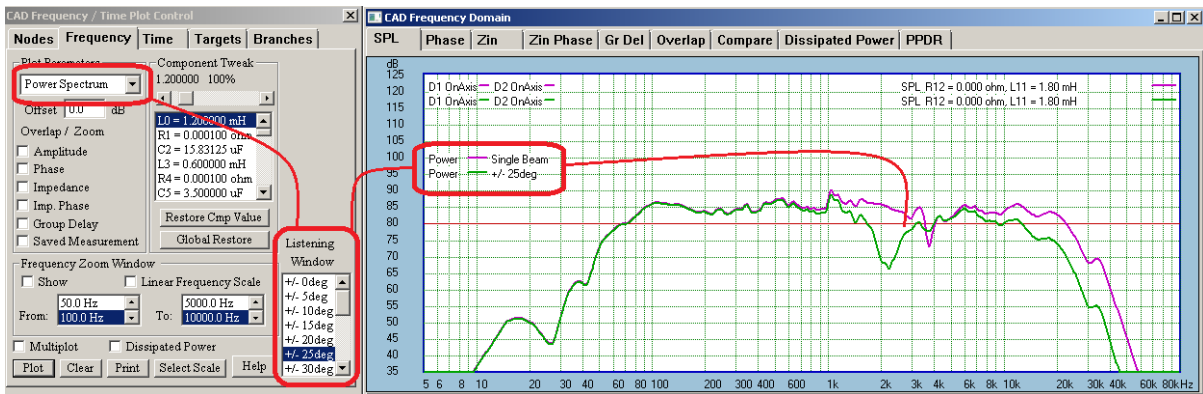


Fig 2.41. Added "Listening Window" option for selecting averaged SPL display over +/-5deg….to…+/-90deg listening angles. Works in conjunction with Power Spectrum option in CAD and System Modules.

13. Labelling of the enclosure equalization curves and EQ circuit file.



Fig 2.37. Labelling of the enclosure equalization curves and EQ circuit file



Fig 2.42. Labelling of the curves in MLS ans ESS measurement systems.

2.37

## Loading Project Files

Project file pulls together all information necessary to design complete, multi-way loudspeaker system. Amongst other data items, the file contains schematic of the crossover and directory paths for all driver files included in the project. Dealing with up to 3 projects loaded at the same time can be a challenging, so this chapter attempts to highlight some of the error messages you may encounter during project loading process. The obvious errors, like errors in project file directory paths will not be discussed here. These are obvious, because you will not be able to load a project file.

**Example 1**.

We start with a **valid project file** and **no errors** in the directory paths for the individual drivers and no errors in driver files. For instance, you attempt to **Open Project 1**, like in the example below:
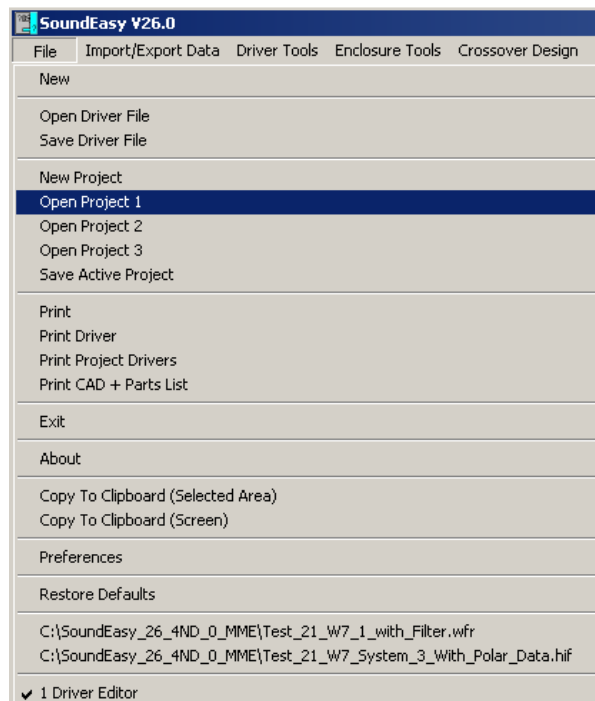


This selection will open a standard Windows File Opening dialogue box, where you can navigate to the desired Project File:
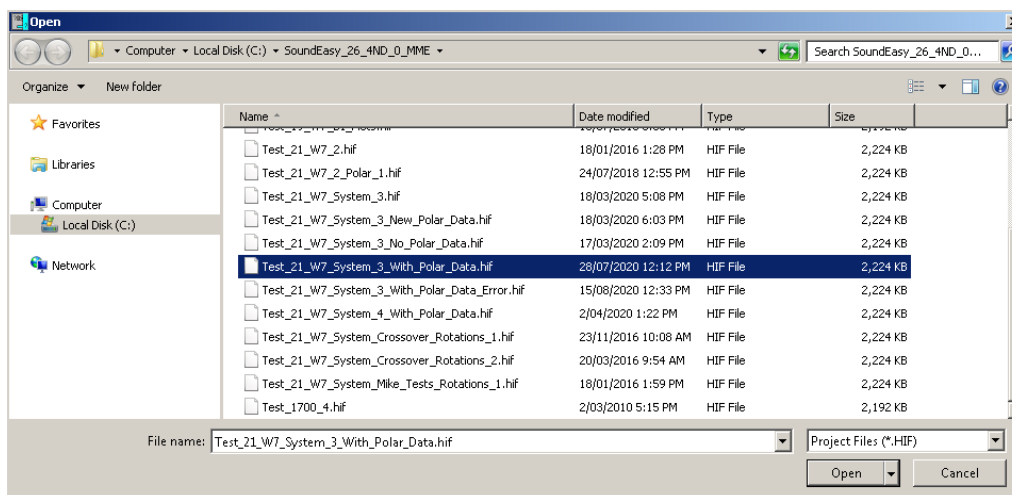


The selected Project File will be loaded into the program, and a dialoge box with drivers' directory paths will be opened:

2.38

**Enter Driver FileNames**

| | | |
|---|---|---|
| Woofer | C:\SoundEasy_26_4ND_0_MME\Test_21_W7_1_with_Filter.wfr | Browse |
| Upper Bass | | Browse |
| Midrange | | Browse |
| Tweeter | C:\SoundEasy_26_4ND_0_MME\Test_21_W7_1_with_FIlter.twe | Browse |
| Super Tweeter | | Browse |

Load    Cancel
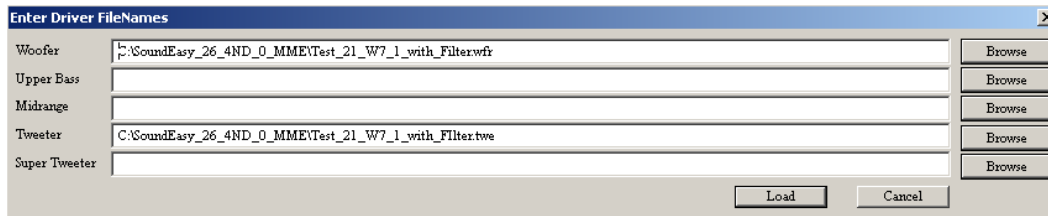
The box allows you to review correctness of the selected driver files, and if you agree, press **Load** button. You will be taken immediately to System section of the program, where the  mechanics of the system design and measurement modelling are available.

**Front 3D Rotation - Horizontal 0deg, Vertical 0deg**

Woofer dia = 30.00 cm
Tweeter dia = 17.50 cm

**Front Panel - Driver 0**

Select Driver From List

| Type | AC[mm] | X[cm] | Y[cm] | Z[cm] | V_Tilt[deg] |
|---|---|---|---|---|---|
| Woofer | 10.0 | 25.0 | 35.9 | 0.0 | 0.0 |
| Tweeter | 0.0 | 25.0 | 65.0 | 0.0 | 0.0 |
| Driver | 0.0 | 25.0 | 10.0 | 0.0 | 0.0 |
| Driver | 0.0 | 25.0 | 40.0 | 0.0 | 0.0 |
| Driver | 0.0 | 25.0 | 40.0 | 0.0 | 0.0 |

Driver/Port Position And Orientation

X   Vertical
0.0m   2.0m   -60deg   +60deg
Y   Horizontal
0.0m   2.3m   -60deg   +60deg
Z
-0.5m   +0.5m   Reset All   Show Tilt Wndow

Display Major Angles and Distances

| Type | Mk[m] | Mk-ACe[m] | Mk-ACd[m] | Mk-CtX[deg] | Mk-CtY[deg] |
|---|---|---|---|---|---|
| Woofer | 1.00 | 1.01000 | 1.05109 | -0.00 | 16.22 |
| Tweeter | 1.00 | 1.00000 | 1.00000 | -0.00 | -0.00 |
| Driver | 0.00 | 0.00000 | 0.00000 | 0.00 | 0.00 |
| Driver | 0.00 | 0.00000 | 0.00000 | 0.00 | 0.00 |
| Driver | 0.00 | 0.00000 | 0.00000 | 0.00 | 0.00 |
| Driver | 0.00 | 0.00000 | 0.00000 | 0.00 | 0.00 |

Adjust Microphone Position    Print    Cancel    Configure System

Mx = 0 deg
-90deg   90deg
My = 0 deg   Enclosure Depth [Z]  40.00  [cm]
-90deg   90deg   Driver Eff. Diameter
Mz = 100.0 cm   Woofer  25.0  [cm]
0.0m   5.0m   U/Bass  20.0  [cm]   Ribbon Size

Modes of Operation   Midrange  13.0  [cm]  X  0.0   Y  0.0
☑ Include ALL Acoustic Delays in Plots   Tweeter  7.0  [cm]  X  0.0   Y  0.0
☐ Exclude ALL Acoustic delays in Plots   S/Tweeter  6.0  [cm]  X  0.0   Y  0.0
☐ Include Relative Offsets in Plots   Zoom = 1.00   Default D  25.0  [cm]
☑ PISTON   ☐ POINT   2   Port  100.0  [mm]
0.1   Brace X  5.0  [cm]
Pivot X = 25 cm   Brace Y  4.5  [cm]
Pivot Y = 65 cm

**This completes a successful  loading of the Project File. Please note, that no error messages were displayed.**

**Example 2.**

In this example, an attempt to load a **non-project file (or invalid project)** is being made.

File   Import/Export Data   Driver Tools   Enclosure Tools   Crossover Design   C
New
Open Driver File
Save Driver File
New Project
Open Project 1
Open Project 2
Open Project 3
Save Active Project
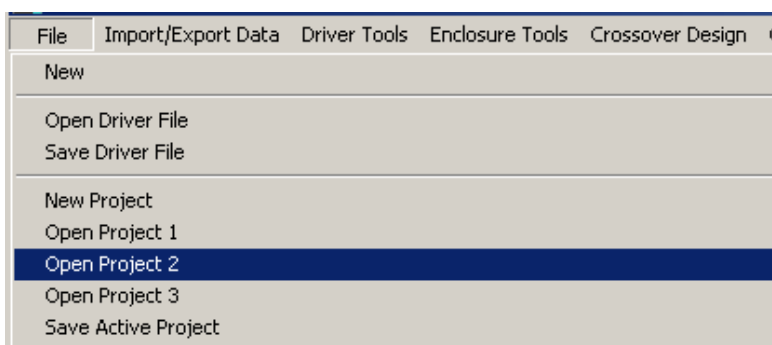
For instance, you attempt to **Open Project 2**, like in the example above. And select invalid project file.
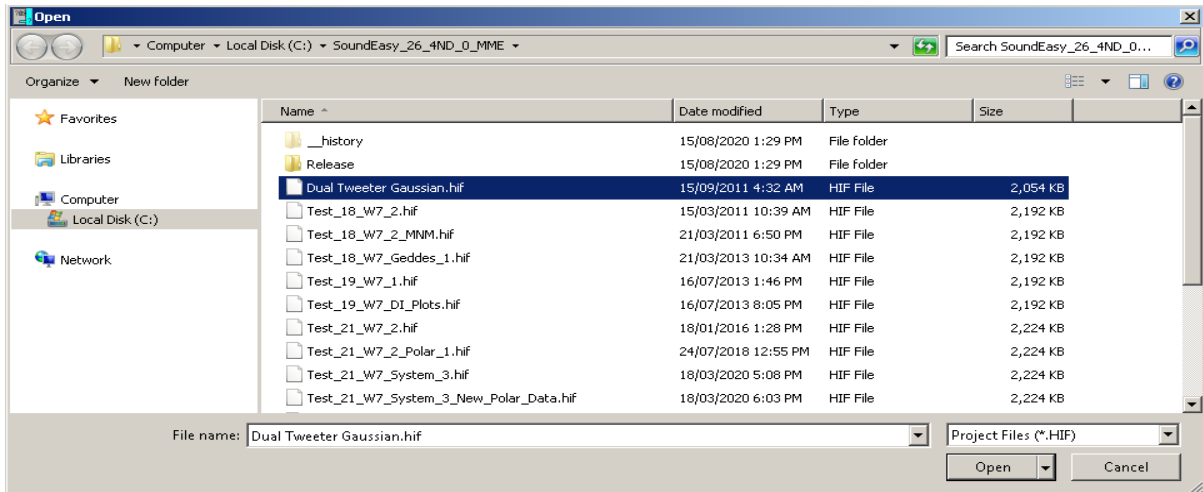
This will result in a Warning Message shown below:
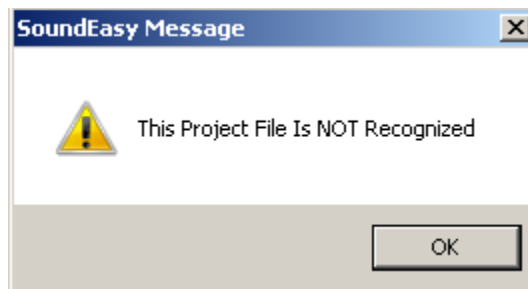


After pressing OK button, no further action will be taken.

**Example 3.**

You selected a valid Project File, but decided to **Cancel the operation**.
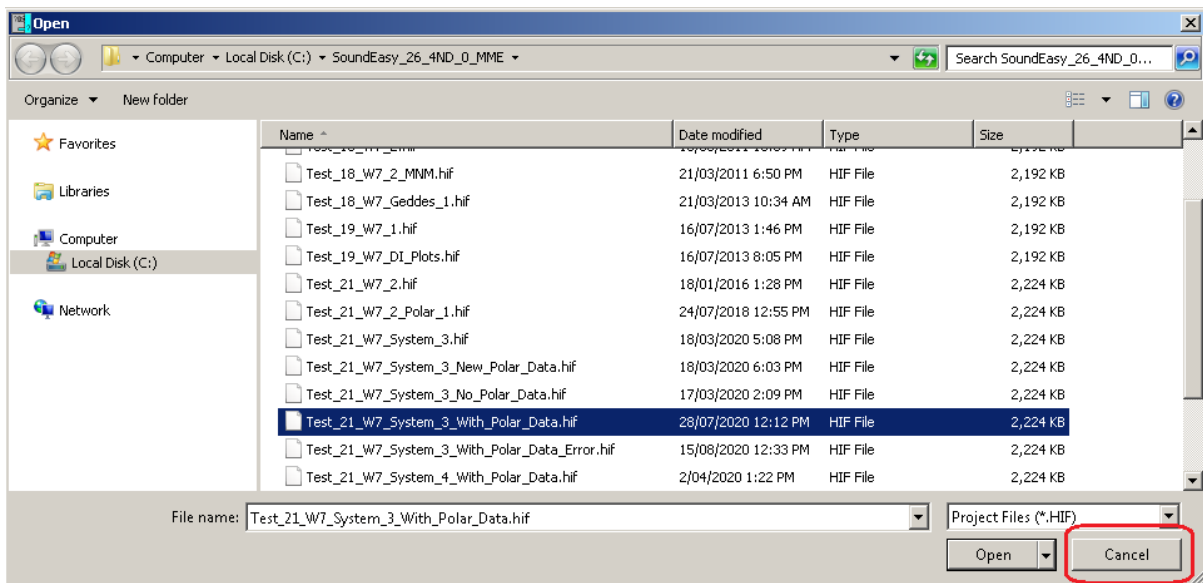
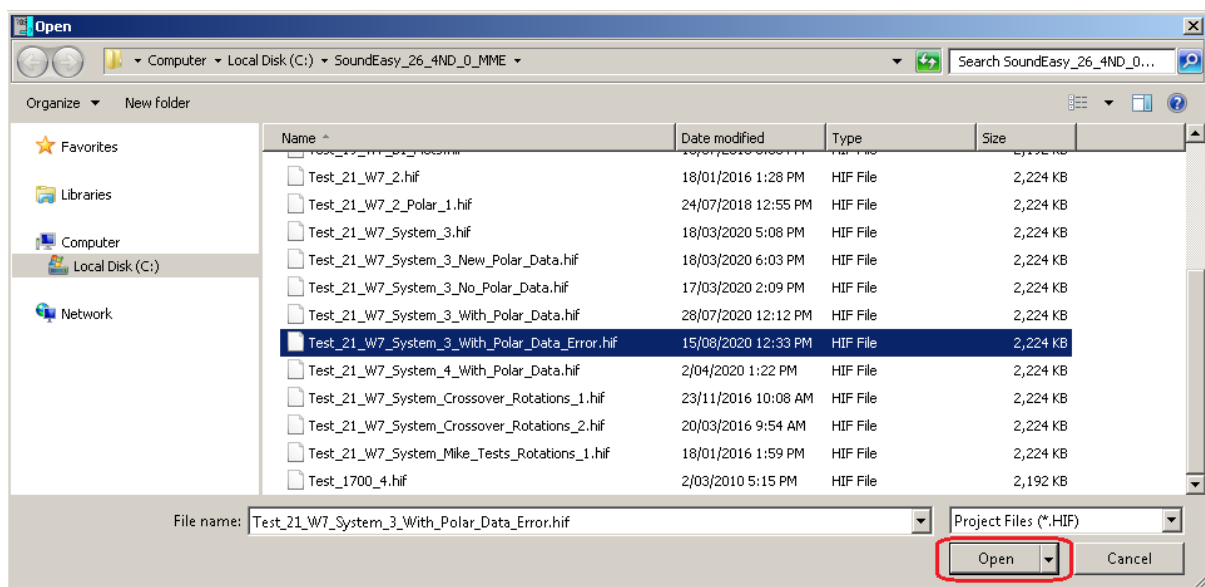

In this case, no further action will be taken.

**Example 4.**

In this example a **valid project file** was selected and there is an **error** in the directory paths for one the individual drivers. For instance, you attempt to **Open Project 3**, like in the example below:
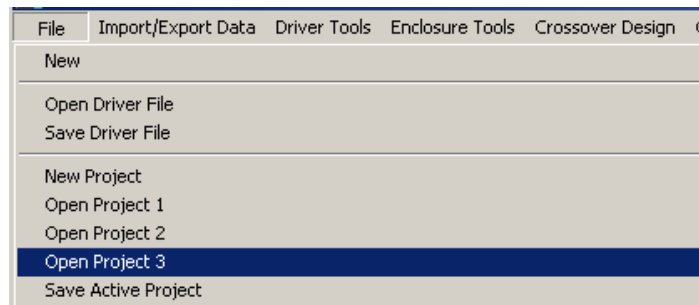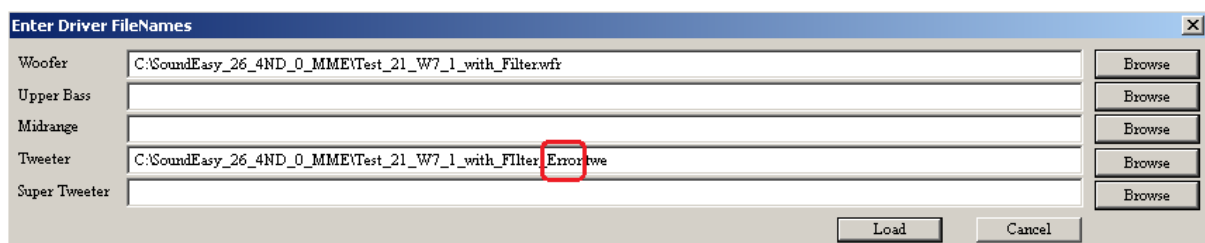


You selected correct Project File and pressed **Open** button



Turns out, that directory path to the tweeter driver file is incorrect,. OR the file simply does not exist, resulting in a SoundEasy Messages shown below:
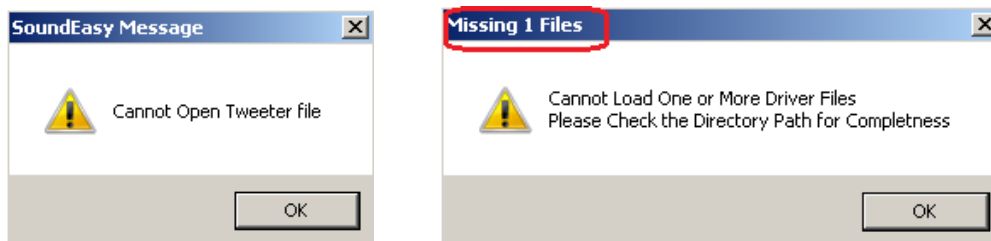


This is not a terminal error, therefore, the program will attempt to help you out by taking you back to the dialogue box with drivers' directory paths.

Where you can re-edit the directory path and press Load to complete the process of loading the project and all driver files. If you make another attempt to re-load the driver file without correcting the path, you will end in a loop of the following steps:


1.


2.


3.
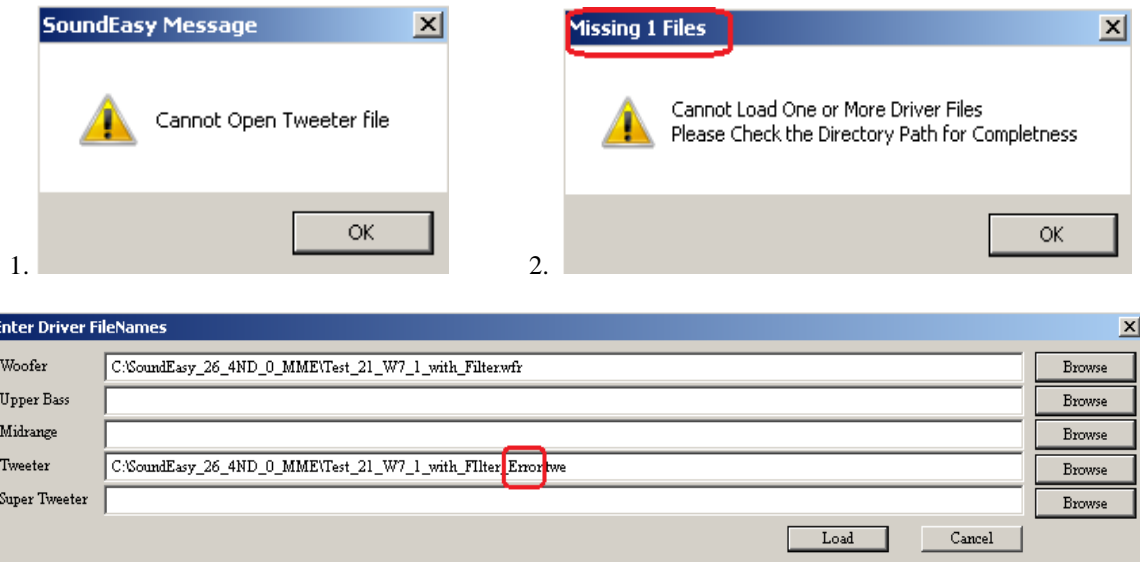
**To break out of the loop, press Cancel button above.**

**Warning: No further action is taken, but the tweeter driver is obviously not loaded into the program.**
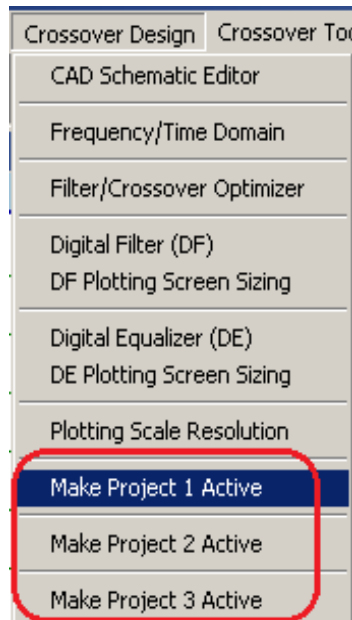


Please note, that NO checks of validity of data files OR validity of compatibility of frequency ranges are performed when you activate any of the pre-loaded projects.

**Frequency Range of the Data Stored in Driver And Project Files**

**Generally, before beginning to use the SoundEasy you should decide on what preferences setting you intend to use**. SoundEasy is unique in that storage of SPL and impedance data in driver files is associated with specific preference settings for the system and box frequency range. Project files are also associated with a specific system frequency range and any drivers loaded into a project must be associated with the same system frequency range as the project. Additionally, when generating and saving a mic calibration file, the calibration data saved is also associated with the system frequency range.

For this reason, it is suggested that when first starting to use SoundEasy you make a decision on what system and box frequency range you wish to use and set these once and then use them for all modeling in this particular project. Once this decision is made, changing the system or box frequency range can be performed but drivers and system files will not display the correct SPL or impedance data until the frequency range preferences are reset to those which were in place when the driver or project file was saved.

If you must change the system frequency range and want to have the SPL and impedance data displayed correctly with this new setting consult main manual and last paragraph in this chapter, regarding exporting and re-importing this data. This is the easy but less accurate way of re-mapping frequency-dependant data from one range to another. However, the most accurate way of re-mapping data is to (1) set preferences to a desired frequency range and (2) re-load impulse response (IR) into the MLS/ESS measurement systems. Then simply convert IR into SPL – as per normal procedure. It may be prudent, to embed the frequency range into the driver's file name for easy identification for future project activities.

The ability to change the frequency range of program's operation is provided to facilitate the design or research activities, that may need to focus on a specific frequency range. So, you are not locked to just one, fixed frequency range. You are strongly encouraged to use this feature as required in any specific case. This would involve creating driver and project files with specifically focused frequency range. Or even changing the frequency range temporarily to perform RLC measurements with better precision. Once you are ready to save the driver and project files, you must adhere to the concept explained at the top of this chapter.

Since it would be difficult for the user to remember the correct settings for all saved driver files, when a driver or project file is opened SoundEasy will warn and, **based on user permission, will change the preferences to those in place when a file was saved**. In addition to the frequency range preferences there are a number of other preference settings which are less important in that they are not related to how data is saved.

**To create and save Project file:**

1. Open SoundEasy.
2. Go to Preferences screen and set the "**System Frequency Range**".
3. Create Woofer Driver File and save it to HD.
4. Create all other driver files and save them to HD one by one.
5. Select "**New Project**" from main "File" menu. A dialogue box with 5 editable fields will be opened.
6. Browse to all driver files and select them into the allocated dialogue box spaces.
7. Load the drivers – there should be no error messages.
8. Save the Project file to HD using "Save Project" option.

If adhered to the above, Driver Files will have the same frequency range data as the newly created Project File. Still, it remains User's responsibility to associate Drivers File with Project File with compatible frequency range. When a Project File with different frequency range is loaded into SoundEasy, the program will display warning message about mismatch in frequency ranges and will give the user an option to Abort. **If Aborted**, no further action is taken. **If continued**, the program will automatically re-set the frequency range in Preferences screen to the one loaded in the Project File. Since Driver Files are compatible with the Project frequency range, there will be no further warning messages. For more information, please refer to Help File.

Several examples of loading project and driver files were already presented above. These examples relate to the filing system, rather than to the mismatched frequency range of the data stored in driver/project files, which will be now discussed further.

**Example 5.**

In this example, a **driver file** with the System and Box frequency ranges of 5Hz-100000Hz is being loaded into SoundEasy set (via Preferences screen) to operate System within 10Hz-50000Hz and Box within 20Hz-20000Hz. So there is System and Box frequency range mismatch.
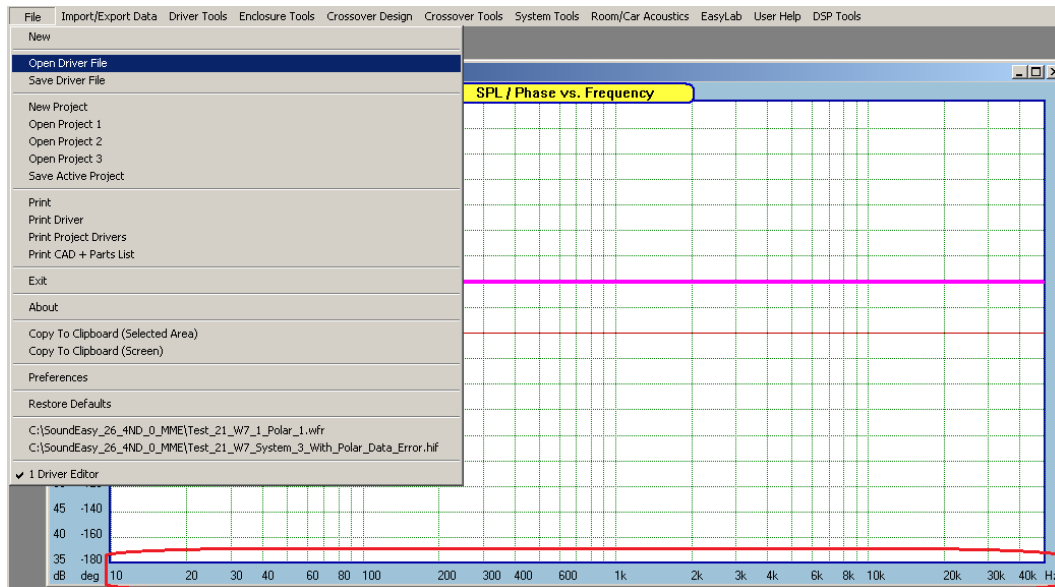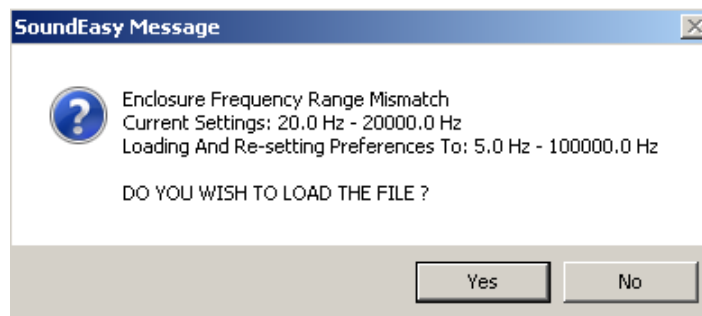


This attempt will results in the following message, describing exactly what is happening.
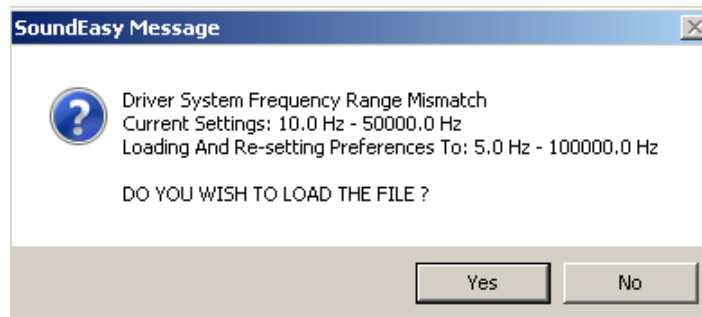


If you select option "**No**", the file will not be loaded and no further action is taken.

If you select "**Yes**", the program proceeds to the next check. In this step, the Enclosure frequency range is checked – as shown below:



If you select option "**No**", the file will not be loaded and no further action is taken.

If you select "**Yes**", the program proceeds to load the driver file and re-sets Preferences settings for System Freqyency Range and Box Frequency Range in the Preferences settings.

Please note, that the check for **Enclosure frequency range mismatch** is ONLY performed for driver files, and not for the project files.

**Example 6.**

In this example, a **Project File** is being loaded with frequency range of 5Hz-100000Hz is being loaded into SoundEasy set (via Preferences screen) to operate System within 10Hz-50000Hz. So there is System frequency range mismatch. No errors or mismatches in the driver files are present.
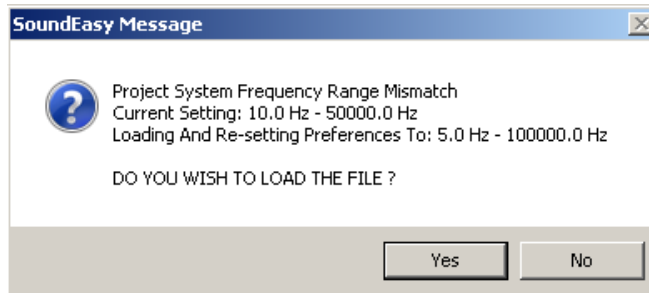


If you select option "**No**", the file will not be loaded and no further action is taken.

If you select "**Yes**", the program proceeds to load the Project File and **re-sets Preferences settings** for System Frequency Range in the Preferences settings. Then you will be asked to confirm the driver files selection:
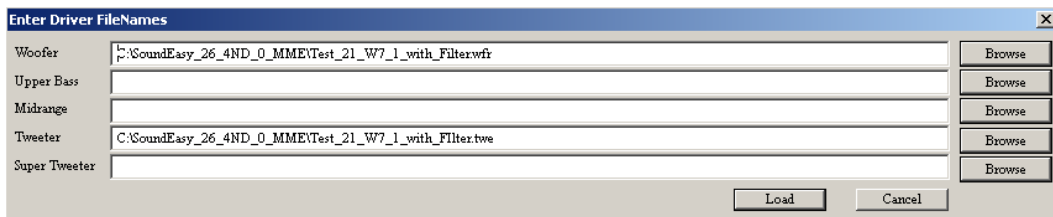


Selecting "**Load**" will load the driver files. Selecting "**Cancel**" will abort loading driver files.

**Example 7.**

In this example, a **Project File** is being loaded with frequency range of 5Hz-100000Hz is being loaded into SoundEasy set (via Preferences screen) to operate System within 5Hz-100000Hz. So, the Project File has a correct frequency range. But woofer Driver File being loaded, has the frequency range of 20Hz-20000Hz. So there is System frequency range mismatch due to woofer driver file.
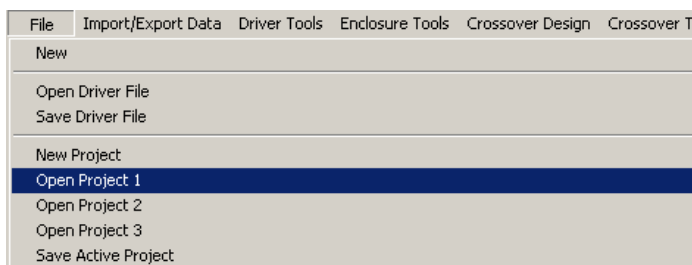


The **Project File** will be loaded because is error-free, but the mismatched woofer file will results in the following **Message 1**:
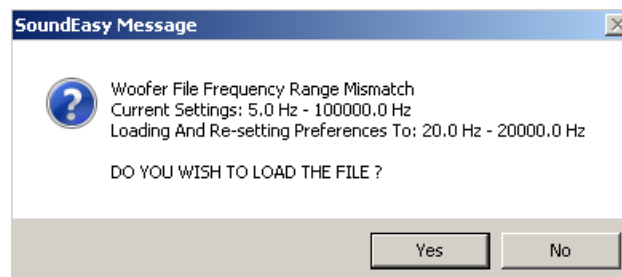
If you select option "**No**" in **Message 1**, the file will not be loaded and you will be given **Message 2** option to load another Driver File.
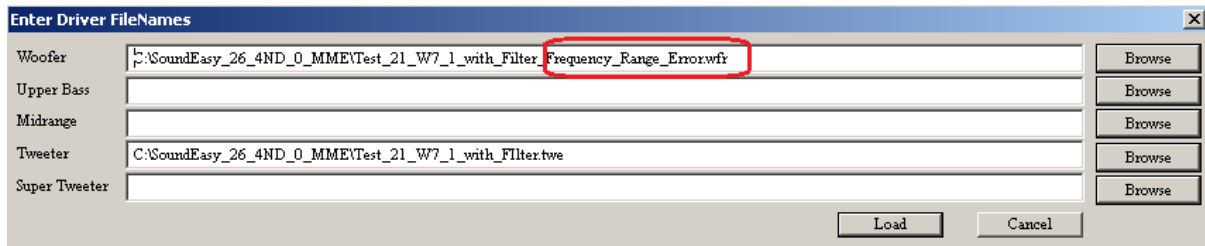


If the problem was with wrong woofer file assigned to this project (as shown above), now is the right time to browse to the correct woofer file. Then press **Load** button
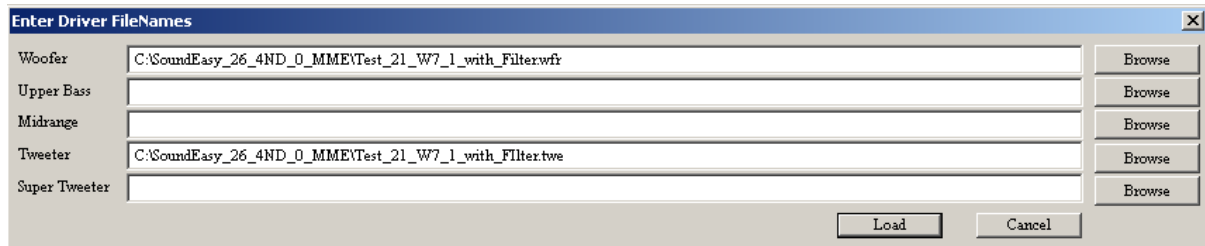


The woofer file and tweeter will be loaded and you can proceed as normal.

If you press **"Load"** button again without correcting the driver file, the dialogue box will re-display for you to try again.

**You are now running in a loop, and to break out, please press "Cancel" button on the dialogue box above**.


**IMPORTANT:**

1. **If you select option "Yes" in Message 1, the Woofer File will be loaded and you now have a woofer with mismatched data frequency range in your project. This is highly undesirable selection, as it will invalidate your project design entirely. Please avoid it.**

2. **Driver Files with incompatible frequency ranges loaded via Project File mechanism do not reset Preferences settings. Only Project File has the authority to re-set Preferences setting in this case.**

3. **Driver Files will re-set Preferences settings when they are loaded as individual files, using "Open Driver File" menu option. This instance was explained in Example 5.**

**Re-scaling Drivers Data To Different Frequency Range**

If you find yourself in a situation, where frequency range of your driver's data file does not match system requirements, here is a simple description of a process, that can be used to re-scale your driver's data range. Please note, that if your driver's data file contains schematic and T/S parameters, the process described below preserves all this information. However, if your driver's data file contained dispersion data ove - 90…..+90deg angles, this data will have to be re-created as well, but the process is more complex. In this chapter, only the re-scaling of SPL and Zin are shown.

**Example 8**

Shown below is a frequency response of a woofer over 5Hz – 100000Hz frequency range. Our goal is to re-scale it to 20Hz – 20000Hz frequency range. **The SPL/Phase will be exported from Driver Editor screen**.
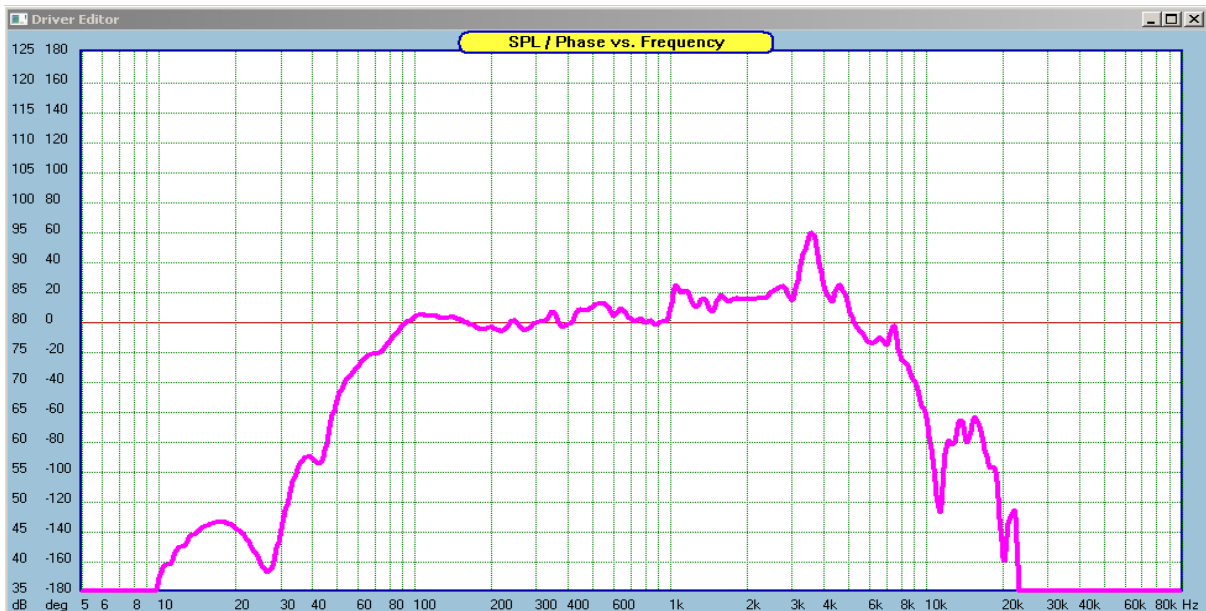


Start by selecting "Export SPL/Phase at SPL dB[ASCII/Text file]" – see below.
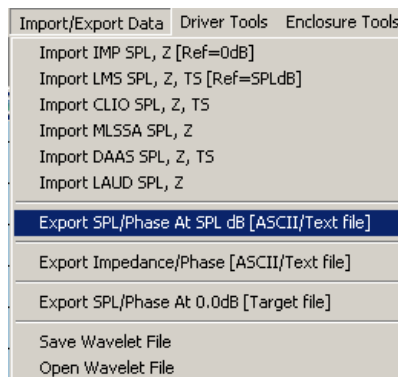


Since we require all other data information to be preserved in this driver file, in the next step, select the desired new frequency range in the Preference screen.
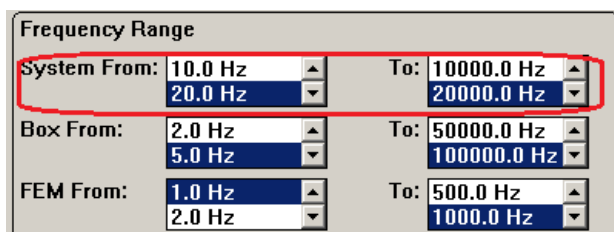
Now, the program is ready to accept imported data into the 20Hz – 20000Hz frequency range.
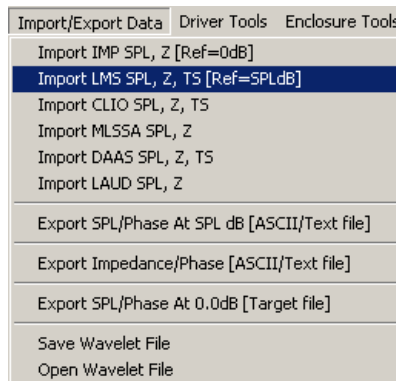


Using the "Import LMS SPL, Z, TS" importing option will open dialogue box shown below, so please select importing option as highlighted below. Press "Amplitude" button to import SPL/Phase.
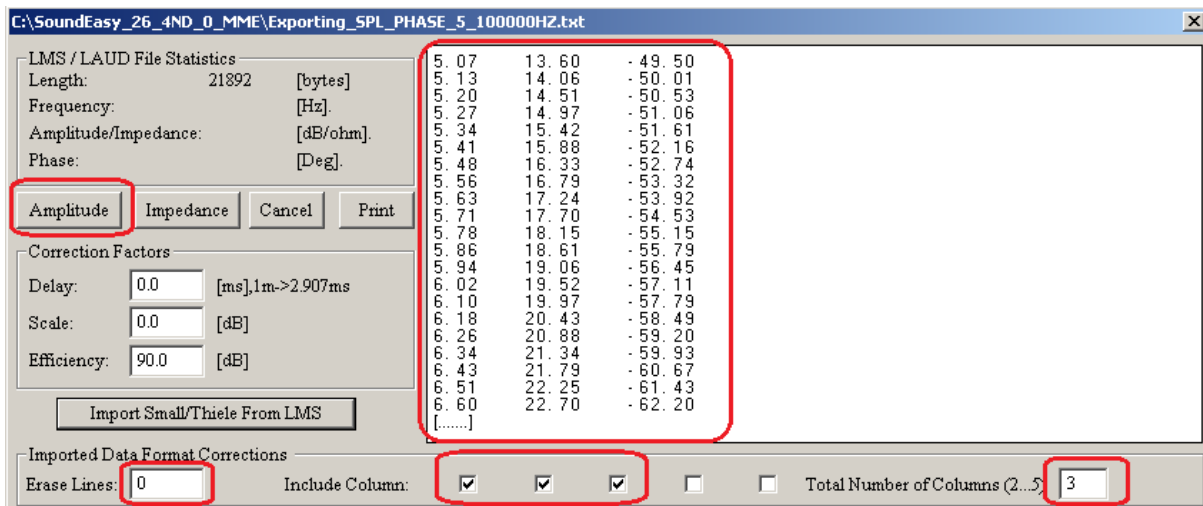


It is to be expected, that frequency bins in two different frequency ranges will not coincide, therefore, straightforward import will produce many missing data point. The missing data will be extrapolated by pressing "Repair Amplitude" button – as shown below.
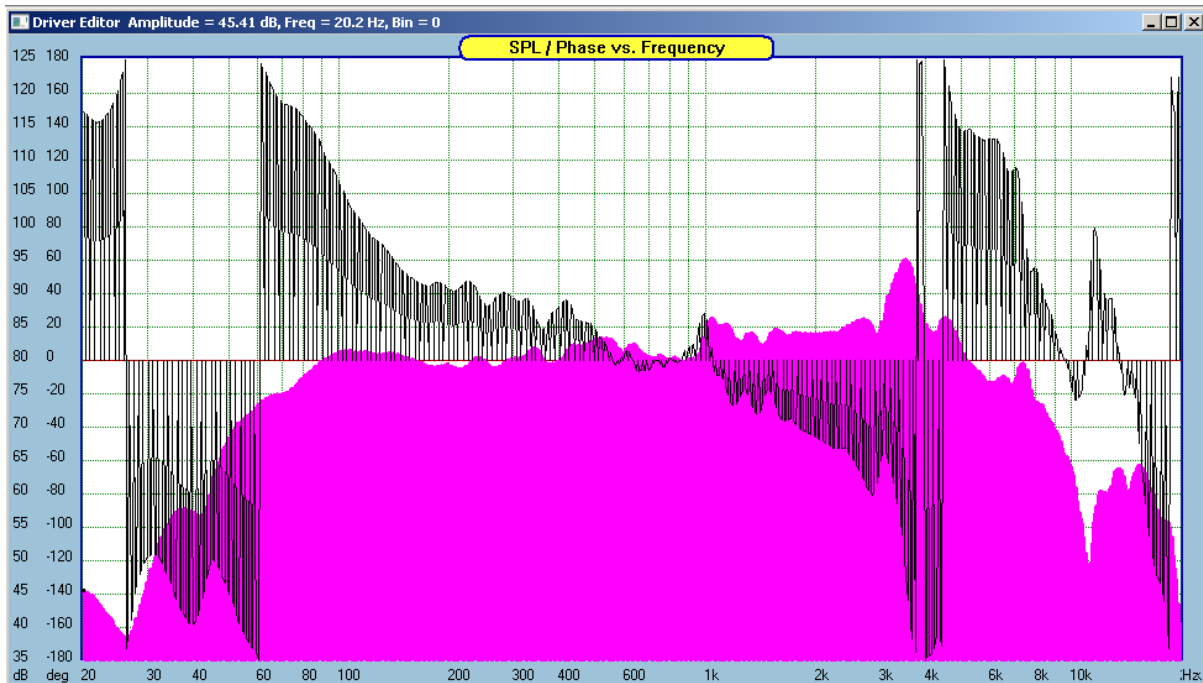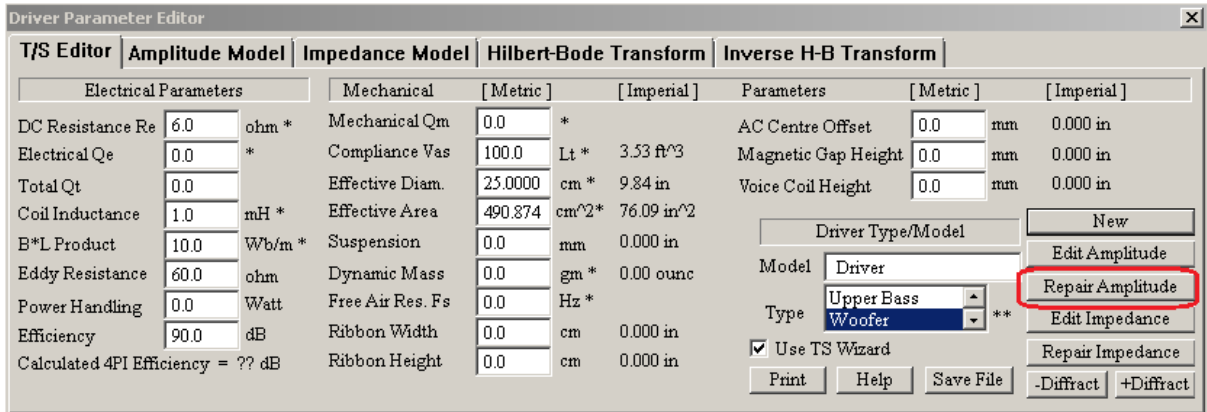
Shown below are two screens: (1) SPL shown in old frequency range of 5-100000Hz and (2) SPL shown in the new frequency range of 20-20000Hz.



The process of re-scaling the SPL/Phase is now completed – please save the driver file.

**Example 9**

Re-scaling impedance data from Driver Editor screen. Shown below is an input impedance response of a woofer ove 5Hz – 100000Hz frequency range. Our goal is to re-scale it to 20Hz – 20000Hz frequency range. **The Zin/Phase will be exported from Driver Editor screen.**



Step 1. Load driver file.



Step 2. Export Zin/Phase

Step 3. Set Preferences frequency range tp 20-20000Hz, and import the file just exported.
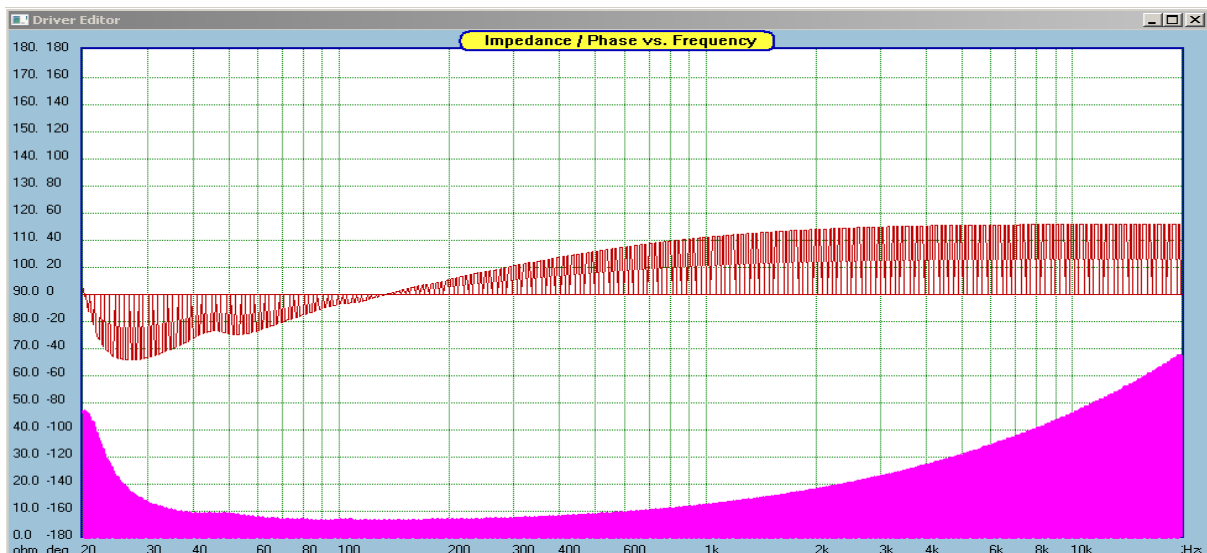


Step 4. Press "Repair Impedance" button.

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Driver Parameter Editor

T/S Editor | Amplitude Model | Impedance Model | Hilbert-Bode Transform | Inverse H-B Transform

**Electrical Parameters**

| | | |
|---|---|---|
| DC Resistance Re | 5.60 | ohm * |
| Electrical Qe | 0.5548 | * |
| Total Qt | 0.4994 | |
| Coil Inductance | 2.0 | mH * |
| B*L Product | 10.000 | Wb/m * |
| Eddy Resistance | 60.0 | ohm |
| Power Handling | 100.0 | Watt |
| Efficiency | 90.0 | dB |

Calculated 4PI Efficiency = 85.9 dB

**Mechanical** [ Metric ] [ Imperial ]

| | | | |
|---|---|---|---|
| Mechanical Qm | 5.0 | * | |
| Compliance Vas | 240.0 | Lt * | 8.48 ft^3 |
| Effective Diam. | 25.0000 | cm * | 9.84 in |
| Effective Area | 490.874 | cm^2* | 76.09 in^2 |
| Suspension | 10.0 | mm | 0.394 in |
| Dynamic Mass | 70.003 | gm * | 2.47 ounc |
| Free Air Res. Fs | 22.523 | Hz * | |
| Ribbon Width | 0.0 | cm | 0.000 in |
| Ribbon Height | 0.0 | cm | 0.000 in |

**Parameters** [ Metric ] [ Imperial ]

| | | | |
|---|---|---|---|
| AC Centre Offset | 10.0 | mm | 0.394 in |
| Magnetic Gap Height | 10.0 | mm | 0.394 in |
| Voice Coil Height | 20.0 | mm | 0.787 in |

**Driver Type/Model**

Model: Woofer 1

Type: Upper Bass / Woofer  **

☑ Use TS Wizard

New
Edit Amplitude
Repair Amplitude
Edit Impedance
Repair Impedance

Print | Help | Save File | -Diffract | +Diffract
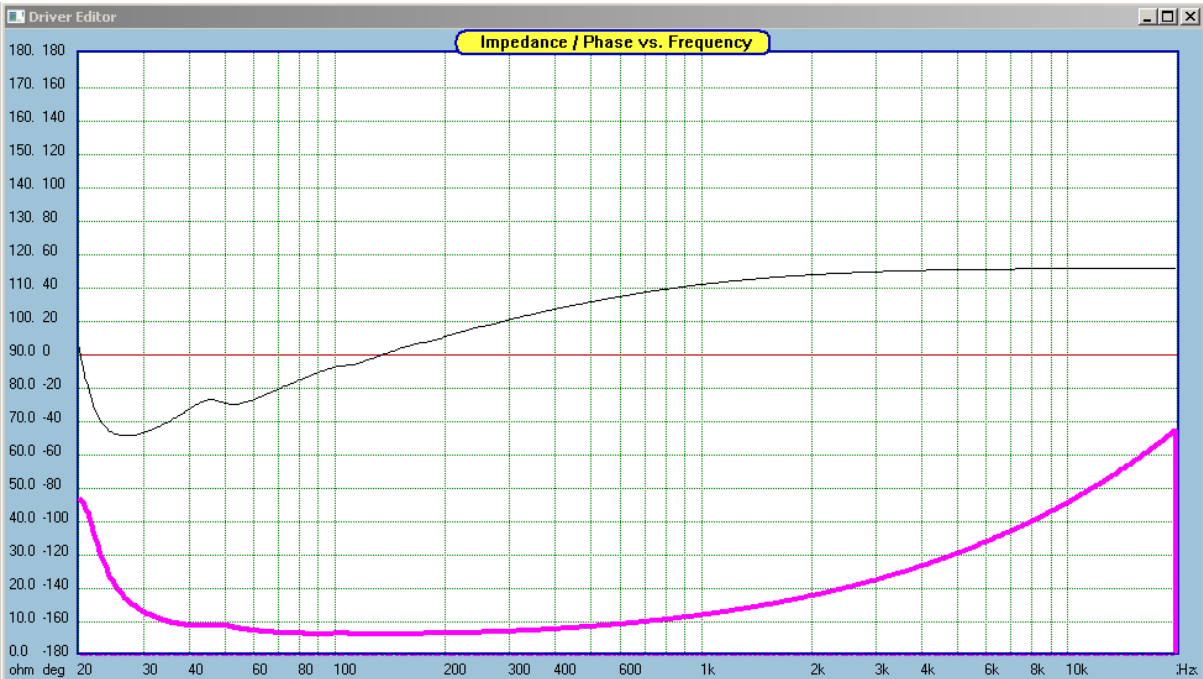


Process of re-scaling impedance data is completed. Please save the file.
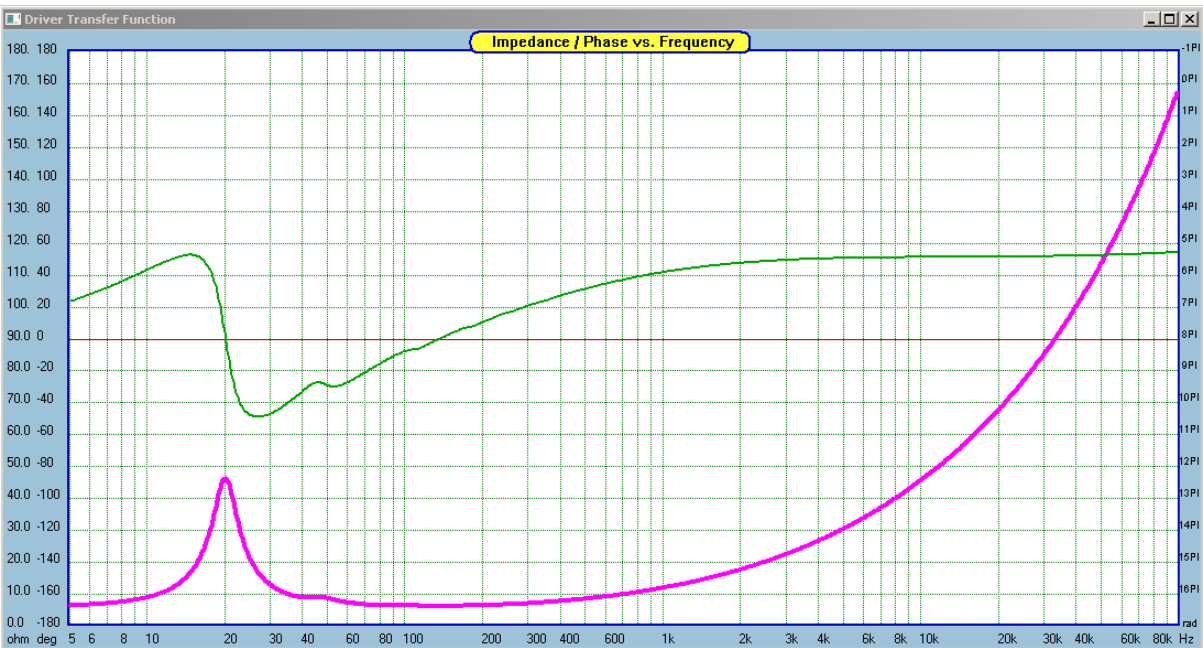


Original Zin + Phase

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**Adjusting driver's sensitivity Outside MLS/ESS systems**

Dealing with driver's sensitivity is best accomplished during MLS/ESS measurement process. Sometimes you may find yourself in a situation, where driver's sensitivity needs to be corrected after the measurement process is completed and driver's SPL is already saved. The Figure below suggests, that the SPL curve needs to be rised by 10dB.
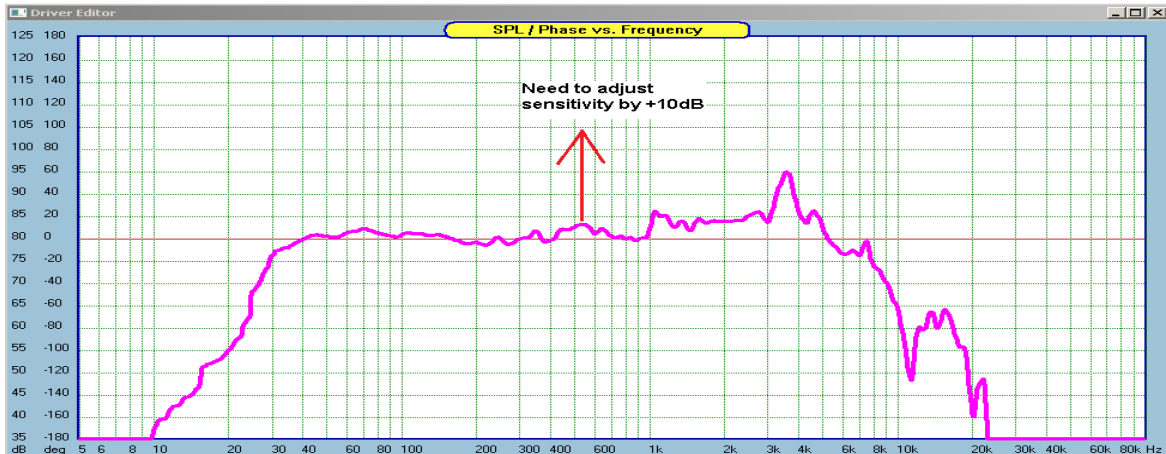


There are two ways to accomplish this.

1. The simplest way to accomplish SPL level shift is to use "Add dBs To Current SPL" button, located on Amplitude Model tab.
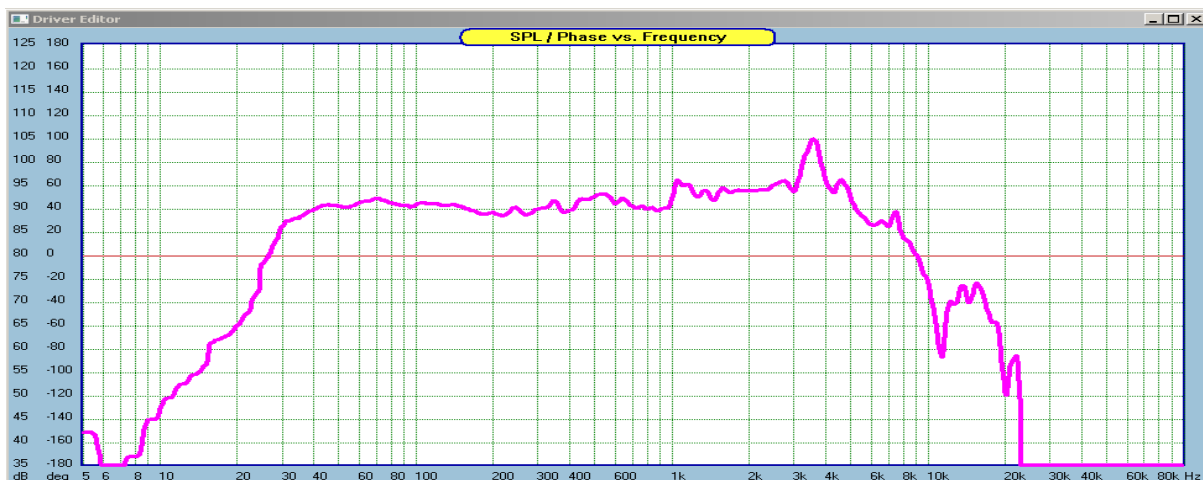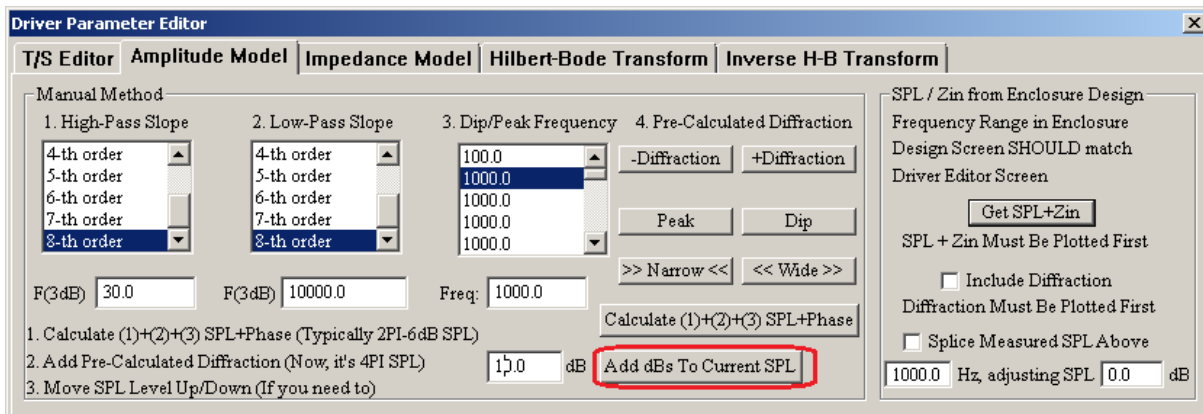




No need to re-run HBT to deliver changed level of the new transfer function. It's done automatically.

2. Second way of changing sensitivity of the driver does not change the measured SPL level (pink curve). However, because SoundEasy uses HBT derived transfer function, this method will change the transfer function of the driver without affectine the saved SPL curve.

Once again, we start with the measured SPL curve and require the sensitivity to be change by +10dB. Please go to Hilbert-Bode Transform tab and plot amplitude of "SPL Reference" and amplitude of "SPL Hilbert-Bode". You should see the following picture on the right:
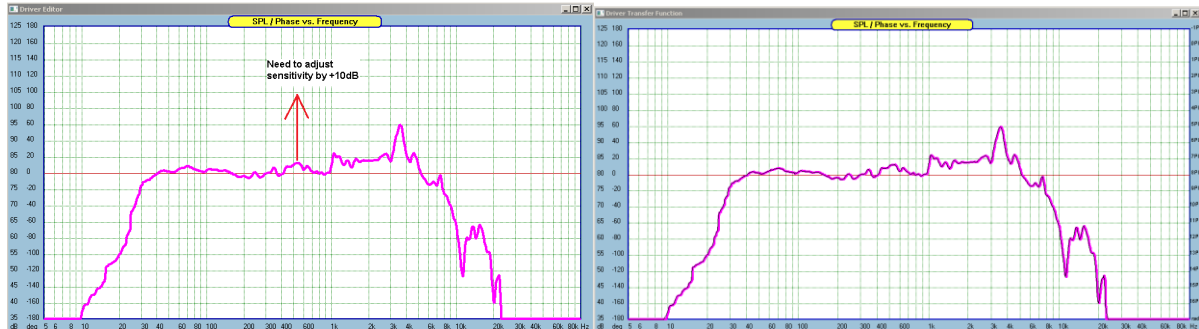


Now, move the microphone from 1m distance to 0.33m distance, and ONLY check the "Include Distance In AMPLITUDE Plots" checkbox. Microphone distance is saved in the driver file.
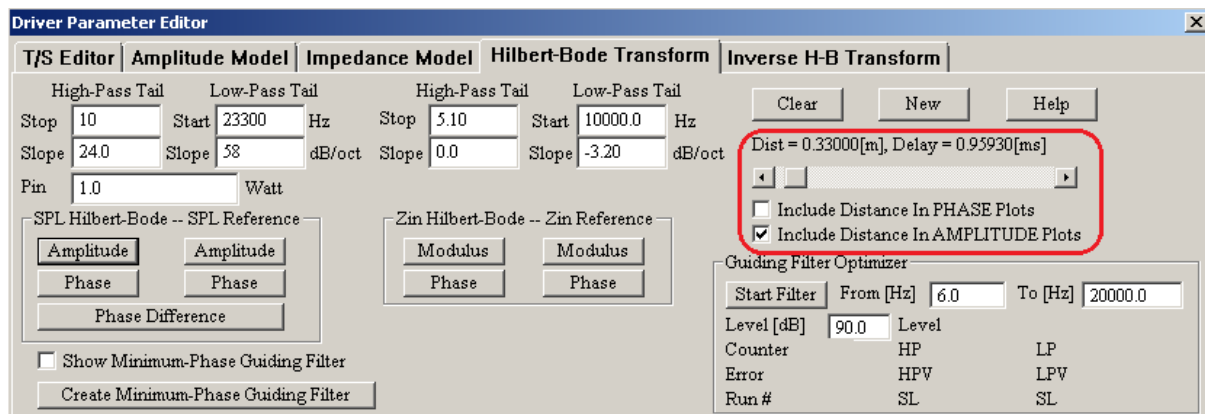


Now, plot the amplitude of "SPL Hilbert-Bode", and the transfer function will be modified without affecting the measured SPL – see below. You can save the driver if this option is more suitable for you.



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