

# FRD Response Blender and Minimum Phase Extractor Instructions and Tutorial

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About the program: The Blender combines low- and high-frequency amplitude responses into a single wide-band response from which it extracts the minimum phase response. Input to the program is in the form of FRD files, typically frequency responses obtained via measurement, box modeling, or diffraction modeling.

## Program Overview:

The use of the tool can be broken down into three phases:

Phase 1: Gathering data

Phase 2: Blending data and adding tails that simulate the response at the low and high frequency extremes

Phase 3: Generating the minimum phase response from the blended frequency response

## Phase 1: Gathering data to use in the Response Blender

There are three kinds of data that are used by the program:

- High Frequency Response FRD data
- Low Frequency Response FRD data
- Corrections to be added to LF data

The high frequency data is typically a frequency response obtained from a gated impulse response measurement. For the low frequency response data, the user has the option to import a file such as a nearfield measurement or to use a built-in Thiele-Small box modeler that can model either a closed or vented box frequency response. Typically corrections are added to nearfield and box model low frequency data that account for the baffle step response of the loudspeaker, which is not captured in either a nearfield measurement or a box model. The program has a built in baffle step modeler that accounts for baffle size, driver diameter, distance and angle from the driver to the measurement position.

## Phase 2: Blending the data and creating LF and HF tails:

The program combines the baffle step correction with the low frequency data and then blends it with the high frequency data as directed by the user. The user then defines the “tails” of the data. Tails are fixed slope extensions to the data at the HF and LF extremes. This creates a very wideband frequency response that is necessary for calculating the phase response.

## Phase 3: Calculate the minimum phase:

Once the frequency response data has been blended and the tails created, a built in Hilbert-Bode transform is used to calculate the minimum phase response. The amplitude and phase responses are presented in a plot and the data can then be exported into an FRD file for use in other programs.

## Navigating the Spreadsheet

There are several tabbed worksheets in the FRD Blender spreadsheet:



- The **Control** worksheet contains the controls for blending data, creating tails, and extracting the minimum phase response
- The **BlendedMinphseResponseFRD** is where the final blended frequency and minphase response data are found, along with a plot.

- The **HF\_FRD\_Data** worksheet is where the high frequency data is gathered into the program.
- The **LF\_FRD\_Data** worksheet is where the low frequency data is gathered into the program, as imported measurement data or using a built-in modeler.
- The **DIFF\_FRD\_Data** worksheet is where the baffle step response or other correction to the low frequency data is gathered, as imported data or using the built in diffraction modeler.

### Importing FRD files or generating data:

The HF\_FRD\_Data, LF\_FRD\_Data, and DIFF\_FRD\_Data contain buttons that execute VBA macros that streamline and simplify FRD data imports:



Show Import Options

The Clear Data button will clear columns A, B, and C of the worksheet where the buttons are located. The Import FRD File will open a dialog box to select a file and will attempt an import with some default delimiters. If the import fails because non-standard column delimiters are used in the data set, checking the “Show Import Options” will cause another dialog box to open during the import process that provides control over the delimiter type and other import parameters.

On the LF\_FRD\_Data worksheet, another button is found with the Clear and Import buttons:



Clicking on this button will populate columns A - C with the data from the box modeler found at the right starting in column Q.

On the DIFF\_FRD\_Data worksheet, another button is found with the Clear and Import buttons:



Clicking on this button will populate columns A - C with the data from the baffle step diffraction modeler found at the right starting in column N.

### Using the Blender when VBA macros cannot be executed

Although there are several features and conveniences that use VBA macros, the core functionality of the Blender uses formulas located in hidden worksheets. As a result, the program should function in OpenOffice Calc and other spreadsheet programs that can open Excel files. Users who cannot run VBA code will need to manually paste or import FRD data and will not have access to the box or diffraction modelers. To calculate the phase response, the user should follow the directions found in the section “Manual Minimum Phase Calculation Instructions”.

## Instructions and Example

This process will now be illustrated with an example. Additional examples may be added in the future. Usage notes and tips are provided at the end in the section “[Notes and Other Info:](#)”.

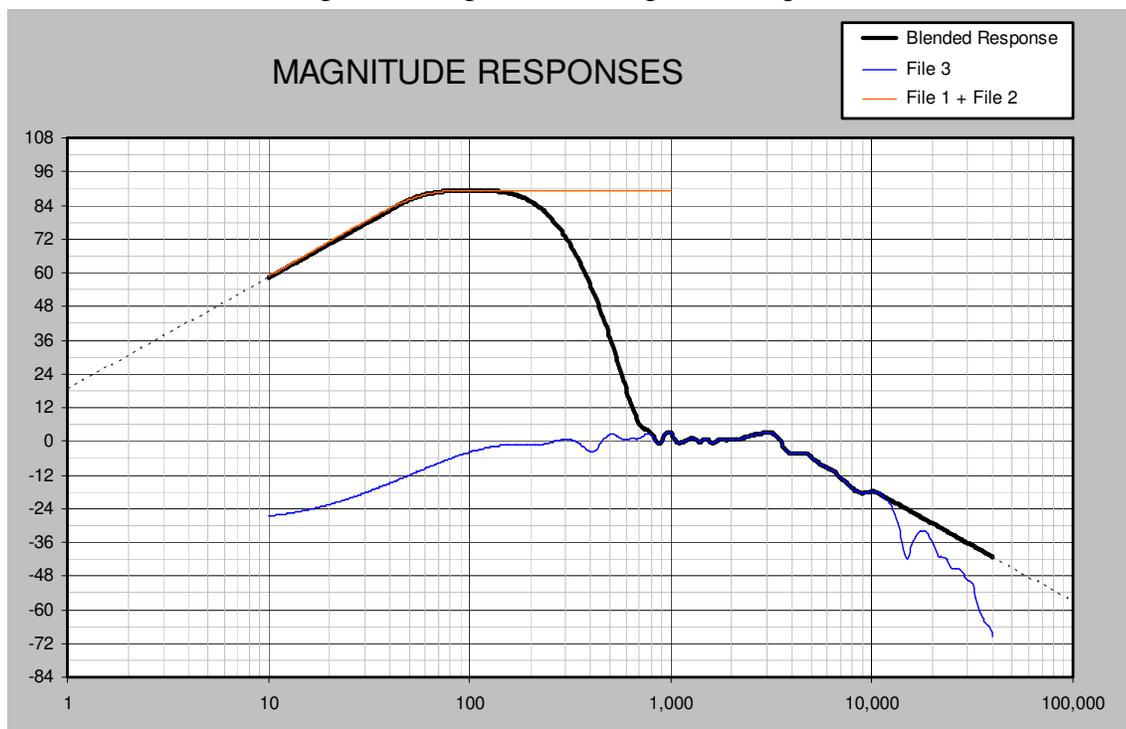
### Example 1 – a midwoofer:

This 6.5’ diameter driver has a frequency response extending from well below 100 Hz to almost 10,000Hz. It would be difficult to capture this accurately in one measurement. A quasi-anechoic frequency response was generated, and is valid above 200Hz. This was obtained from a gated impulse response using ARTA. It includes most of the diffraction signature.

The frequency measurement data file is imported using the import buttons and low frequency data generated using the box modeler. Because the measurement already captured the baffle step, the diffraction data set is not needed and that worksheet is left blank.

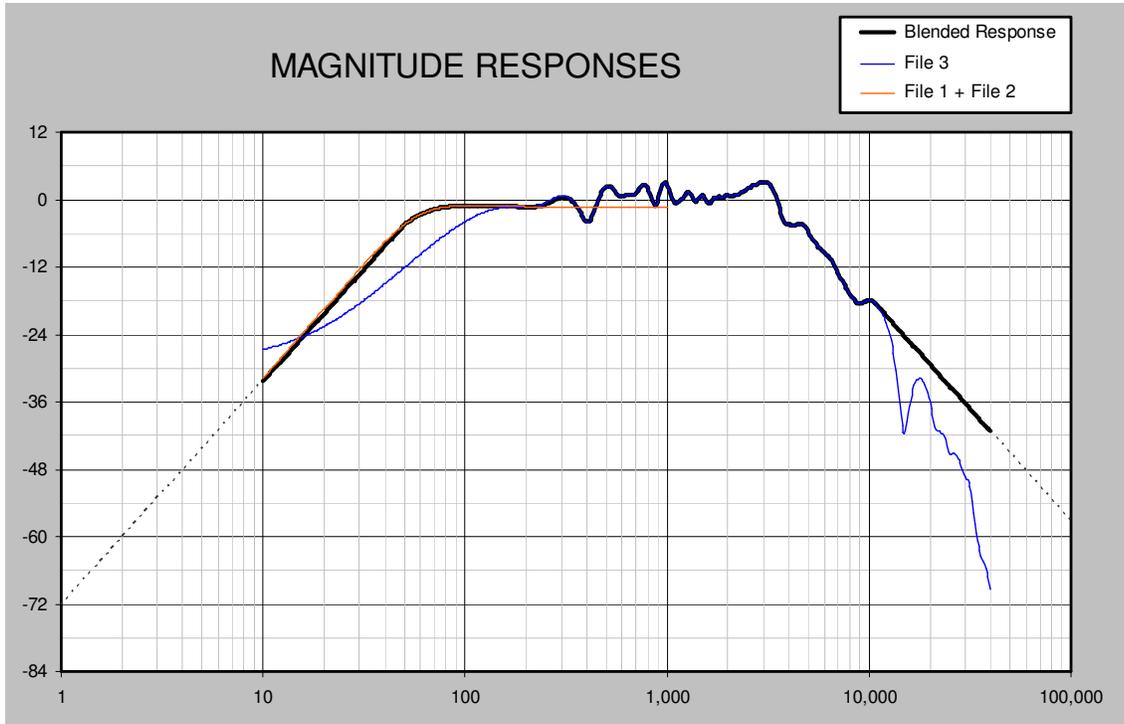
Next, choose the frequency range within which the new blended SPL and minimum phase data will be generated. These are entered in cells B15 and B16. The default values are fine but feel free to change them as you see fit.

After the two files are imported, the plot of the magnitude responses looks like this:



The blue line is the “high frequency” measurement data and the orange line is the box model data. The thick black line is the combined (blended) response using the default parameters. Because of scaling differences, the two data sets have very different SPL levels. This is fixed by bringing the SPL level of the low frequency data until it matches the SPL of the high frequency data in the blending zone. Use the zoom button when trying to fine tune this SPL adjustment.

We need to move the SPL of the box model level from about 89dB down to about -1.5dB. The value to ADD to the SPL level of the box model (-90.5) is entered in cell B25. The plot now looks like this:



We have now scaled the box model data so that it overlaps with the high frequency data around the frequency where the blending will take place. The blending point is usually chosen based on how low in frequency the high frequency data set is valid (200 Hz in this case). This frequency can be the center or low frequency end of the blending zone, although it is better to choose somewhat higher frequencies. The blending is done using a linear combination of the two data sets.

Next, let's check the response tails. These are the dashed lines in the plot. The tails approximate what happens as the frequency continues above and below the current response regime and are important for correctly calculating the minimum phase response. The default settings are for 12dB/octave tails for both the low and high frequency extremes. Because the high frequency tail is sloping downwards, we enter this as -12 for -12dB/octave. The transition points are already set for 50 Hz (low end tail) and 11,000 Hz (high end tail), and these are satisfactory so we will not change them in this case. You will want to choose where the tails join the data so that there is no discontinuity at the join point. In some cases the HF tail may be much higher than -12dB/oct. Unfortunately there are no clear guidelines on the proper slope for the HF tail, however, there is often some hint of the proper slope in the HF data.

At this point the blending of the amplitude data has been completed and we can proceed to the calculation of the minimum phase response. The controls used for this purpose are shown below:

Extract Minimum Phase

dB

Save Blended Result to  
FRD File

The “Extract Minimum Phase” button will execute the phase calculation. The phase will appear in the plot below the controls. If desired, the SPL level of the blended data can be adjusted at this time. Finally, click the “Save...” button to save the blended minphase data to an FRD file.

## Manual Minimum Phase Calculation Instructions

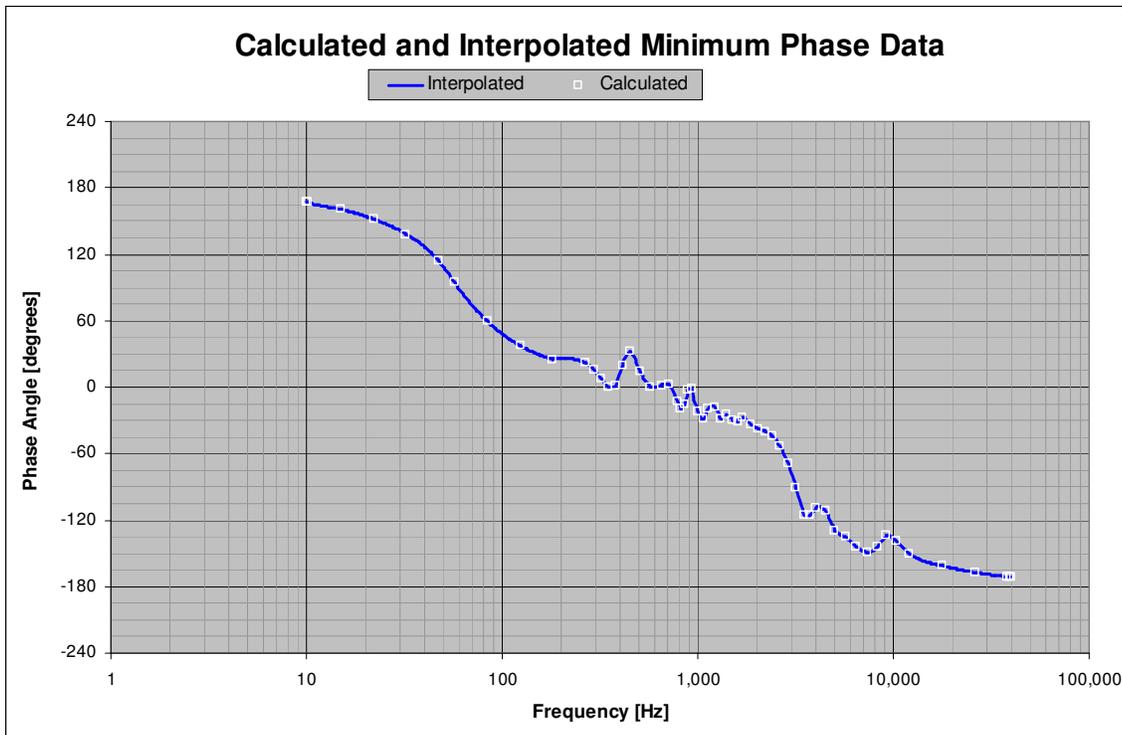
For users who can not run VBA macros, the phase calculation can be executed manually. Scroll down on the Control worksheet to row 85 where the controls for the manual minimum phase extraction are found:

85	MANUAL METHOD: GENERATE THE MINIMUM PHASE FROM THE BLENDED SPL
86	Each time the phase values are calculated, first RESET the values by entering zero, then CALCULATE by entering one in the CONTROL cell
87	
88	<input type="text" value="1"/> PHASE EXTRACTION CONTROL.
89	
90	<input type="text" value="60"/> point density; least dense = 0, most dense = 100
91	
92	
93	STATUS: #N/A
94	
95	

First, enter “0” in cell B88, PHASE EXTRACTION CONTROL, to reset the calculation and clear any existing values. Next enter “1” in cell B88 to extract the minimum phase response from the blended amplitude data.. The status indicator (green area) text will change to the following:

STATUS: PHASE CALCULATION COMPLETED
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The phase data appears in the plot window, which will look like something like this:



The white open squares are the exact minimum phase calculated from the amplitude data and the blue line is an interpolated curve. If you wish to re-run the calculation you must first reset the calculations by entering 0 in cell B88. You can then enter 1 again to recalculate the phase.

This completes the process. Copy the final data out of columns A – C of the BlendedMinphseResponseFRD worksheet, paste it into an editor, and save the file with the FRD extension.

## Notes and Other Info:

The Response Blender can be obtained here:

<http://audio.claub.net/software.html>

The input and output files must use the FRD format. For more information, see:

<http://www.pvconsultants.com/audio/frdis.htm>

### Usage Notes and Helpful Hints:

The data from the imported FRD file(s) should start in row 1 and lie in columns A, B, and C in their respective worksheets. Comment or header lines should not be included on the worksheets. Column A contains the frequency in Hz, column B the amplitude in SPL, and column C the phase in degrees. Column C is optional – the phase data is not used by the program and the column can be left empty.

You don't need all three FRD files. At a minimum the HF\_FRD\_Data must be present. There are other situations where only some of the data is needed.

You **MUST** accurately describe both tails. The tails should smoothly join the rest of the data and should represent the frequency response behavior past the high and low limits of the data.

### Further Reading:

For more information about blending of “high frequency regime” and “low frequency regime” data, see the following articles:

“Merging Near and Farfield Measurements”

[http://www.klippel.de/fileadmin/klippel/Files/Know\\_How/Application\\_Notes/AN\\_39\\_Merging\\_Near\\_and\\_Farfield\\_Measurements.pdf](http://www.klippel.de/fileadmin/klippel/Files/Know_How/Application_Notes/AN_39_Merging_Near_and_Farfield_Measurements.pdf)

Merging Near and Farfield Measurements using ARTA:

[http://www.artalabs.hr/AppNotes/AP4\\_FreeField-Rev03eng.pdf](http://www.artalabs.hr/AppNotes/AP4_FreeField-Rev03eng.pdf)