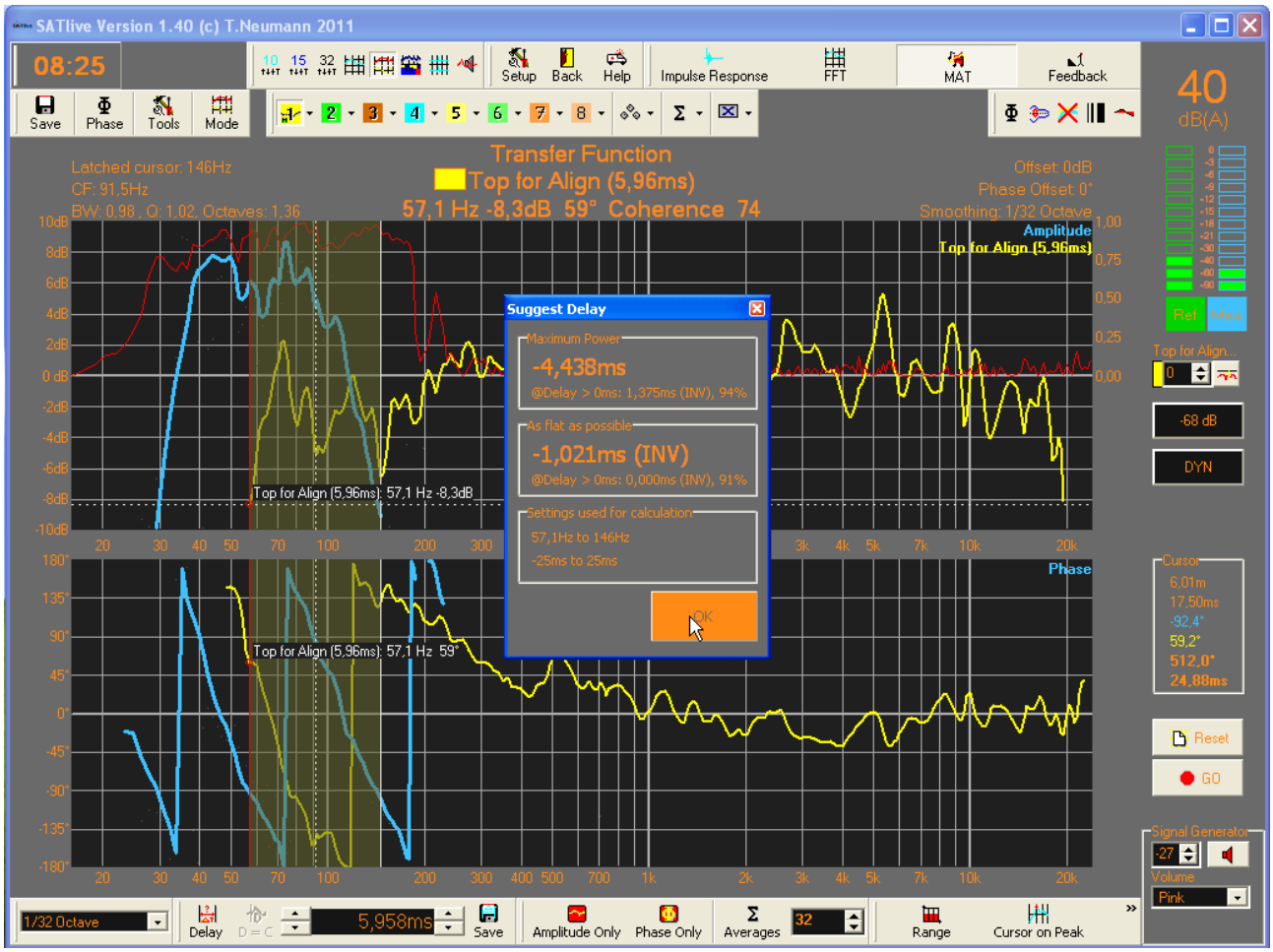
SATlive



Using a maximum Power Approach for Time - Adjustment in Subwoofer Alignment

Target of this info - paper

The so - called 'Time – Alignment' between subwoofers and Mid – High speakers optimzes optimize the performance of a PA system considerably.

The main goal of this procedure is to achieve an arrival of the signals originated by both speakers at the same time in order to get only the positive effect of interference which is an addition of the signal levels.

The most common way to do this adjustment is trying to match the phase-response of the two signals in the cross - over area by adding delay to one of the signals.

Since the measurement at lower frequency is slow compared to the measurement at higher frequencies, this procedure may take some time.

Today the personal computers have developed into fast 'number crunchers', so it becomes possible to use a 'brute force[1]' type of optimization approach where no special algorithm or clever formula is used to compute the delay needed for 'perfect' alignment.

In this scenario all results of the complex addition of the two frequency responses are calculated using a defined range for the delay applied to one of the two traces prior to the calculation. Furthermore the results are calculated for the case of polarity inversion applied to one of the traces prior to calculation.

The software calculates both the energy content and the standard – deviation of each result for a given frequency range, and reports the delay times which yield the highest energy and the lowest standard - deviation. The user sees only the results of the calculation.

This document shows the realization of the concept in the Dual – FFT measurement software SATlive.

The process is documented step by step, and the virtual verification of the results is also shown.

1 This idiom is mainly used to describe the attempt to crack encrypted data by simply trying all possible values, without using any special optimization or algorithm.

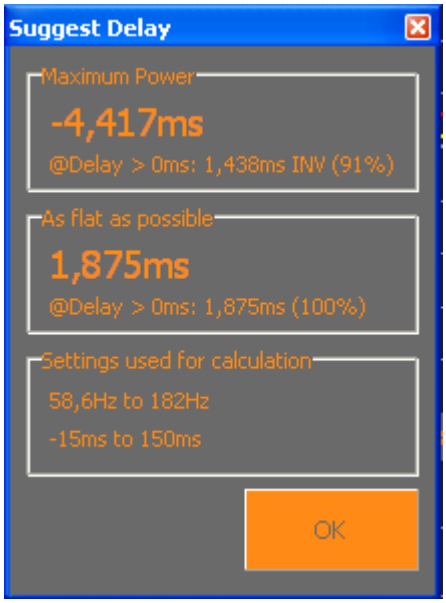
Realization in SATlive

The Dual-FFT software SATlive features a so - called 'Delay – Suggestion Tool' which calculates and displays the results of the search for the delay – values yielding the highest energy or the flattest response of the amplitude trace.

By default the software tests delay – values ranging from – 25 milliseconds up to 25 milliseconds, a range suitable for most of the subwoofer to top alignments, using a sample accurate stepping (steps of 0.021 ms).

This results in a number of 2380 calculations which takes about one second with a frequency range from 57 Hz to 150 Hz.

In addition to the delay-values for the maximum energy and flatness, the software also calculates the delay-values archiving the best results which are greater or equal to zero and therefore can be used as delay values for the currently measured speaker.
The software also displays the relation of the best results achieved to the results achieved with the positive delay values as a percentage.



On the next pages the whole process of alignment is shown step by step.

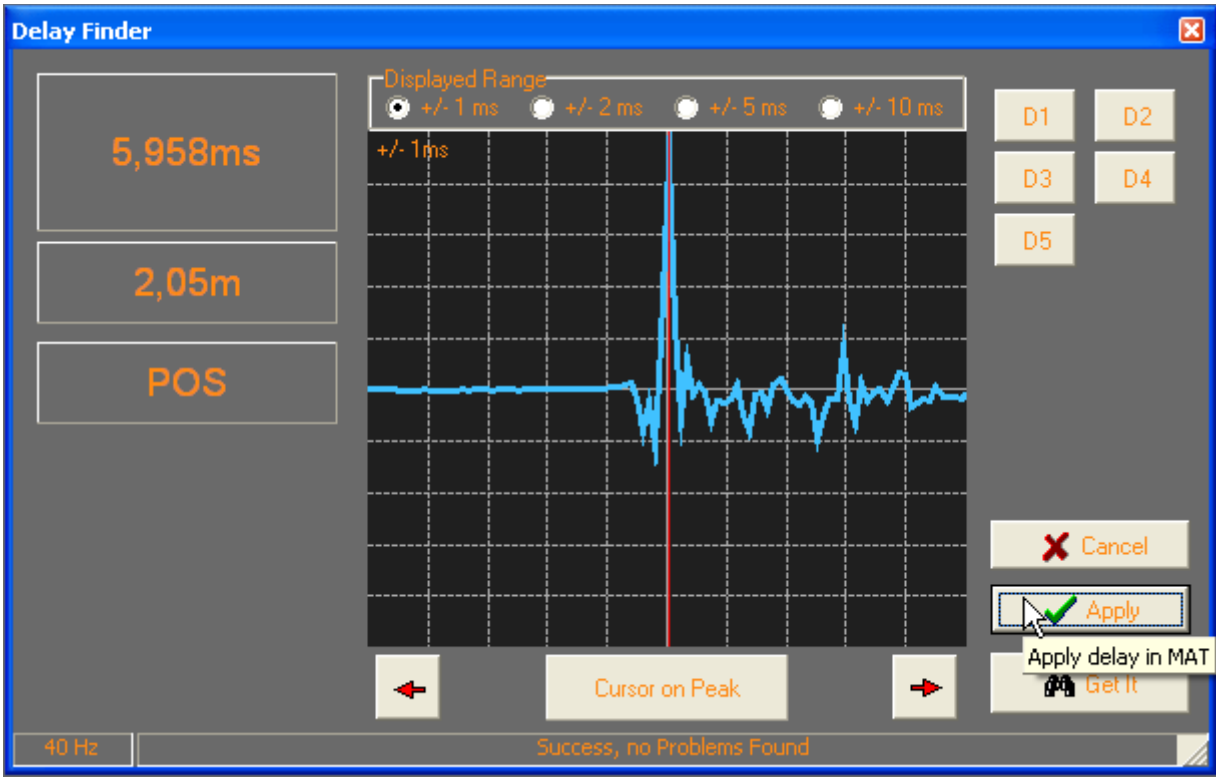
Alignment in SATlive Step by Step

Measure the frequency response of the mid/high cabinet

We start the measurement using the only the mid/high cabinet. The mid/high cabinet shows a clear peak in the impulse response, which makes the delay – adjustment for the measurement easier as it would be using the impulse response of the subwoofer.

Get the delay to compensate for the travelling time of the measurement signal.

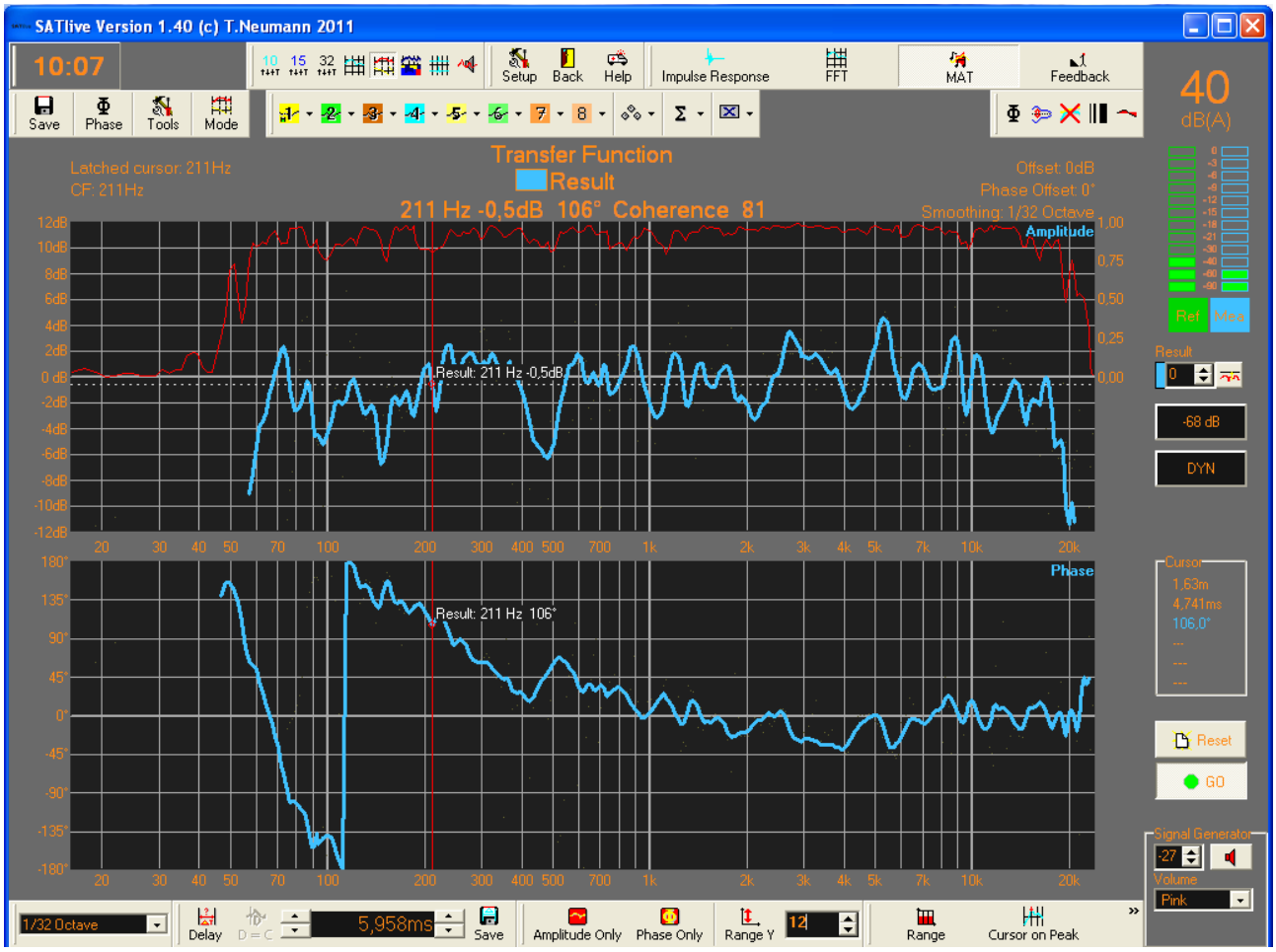
Since we compare two signals (hence the name Dual - FFT measurement), we need to be sure that both signals arrive at the same time. This is achieved using the delay – finder tool in SATlive. Invoke the delay – finder by pressing the *F7* key on your keyboard or by clicking on the delay – values display in the bottom menu bar.



Click on *Get It* to start the measurement. When the result shows up use the *Apply* function to apply the delay of the ensuing measurement. This will close the window and return to the main measurement area.

Get the frequency response

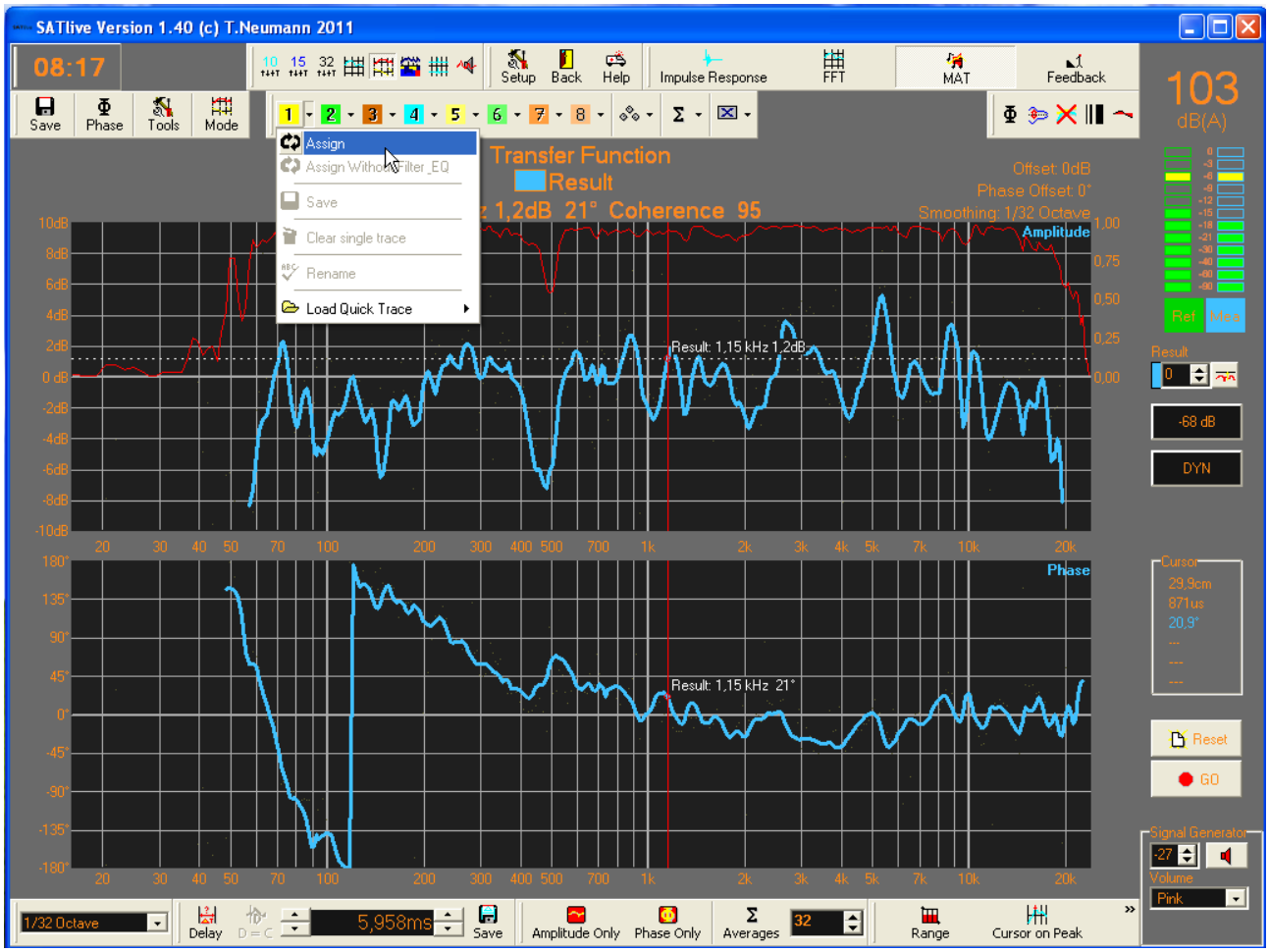
After you return from the delay – finder window, you'll see the frequency - response trace building up in the display area.



Store the frequency response to a Quick-Trace

Now we need to store the frequency response of the mid/high cabinet in one of the eight Quick-Traces available in the upper menu area.

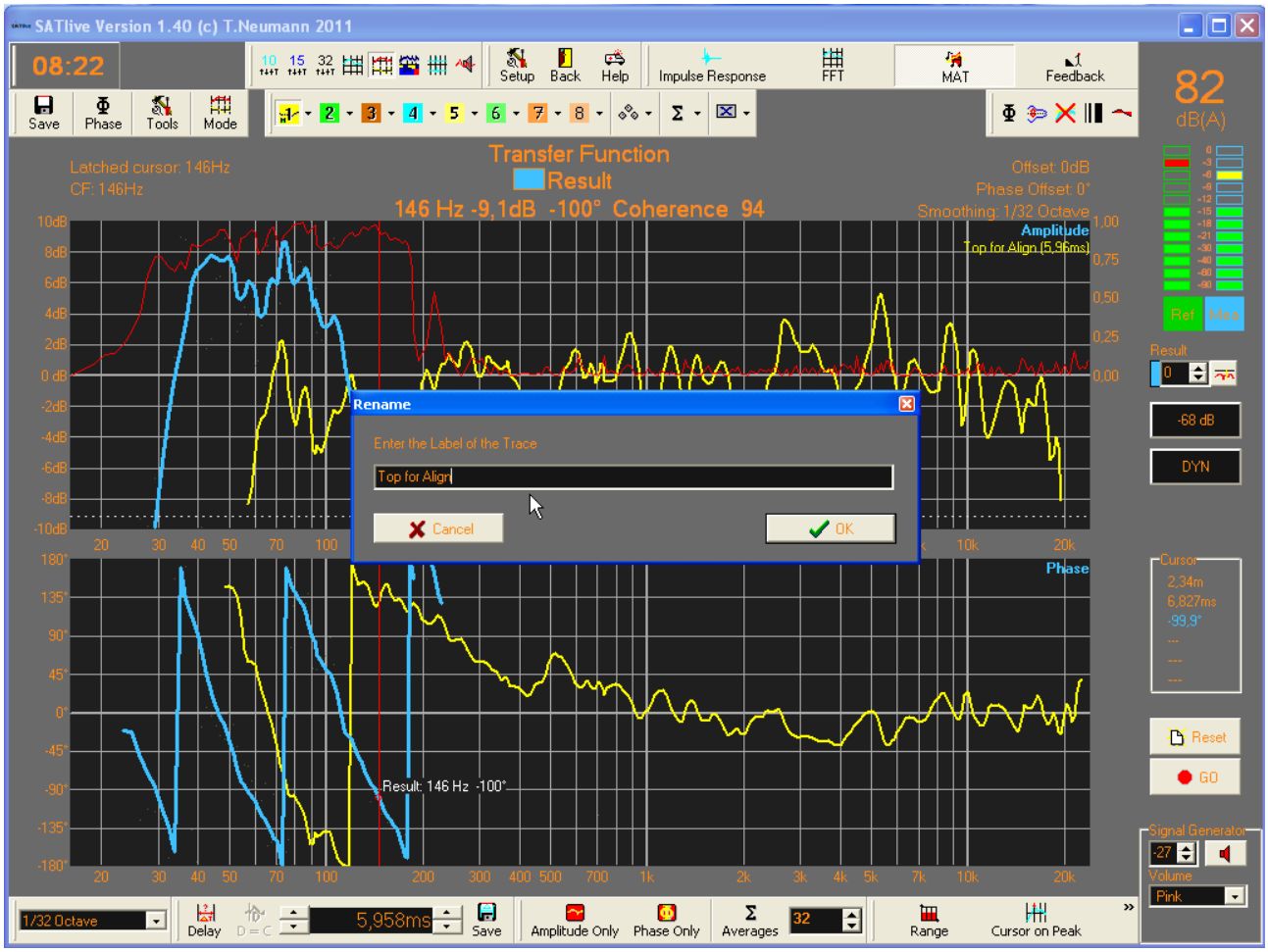
We can either use the shortcut s*hift + 1* (for Quick-Trace number 1) or the *Assign* entry in the pop-up menu of the Quick-Trace.



Label the Quick-Trace

This step is optional, but will help you to keep track of your Quick-Traces.

Depending on the current setup of SATlive the rename window will pop up during the assignment of the Quick-Trace or you need to open it using the *Rename* entry of the Quick-Trace's pop-up menu.



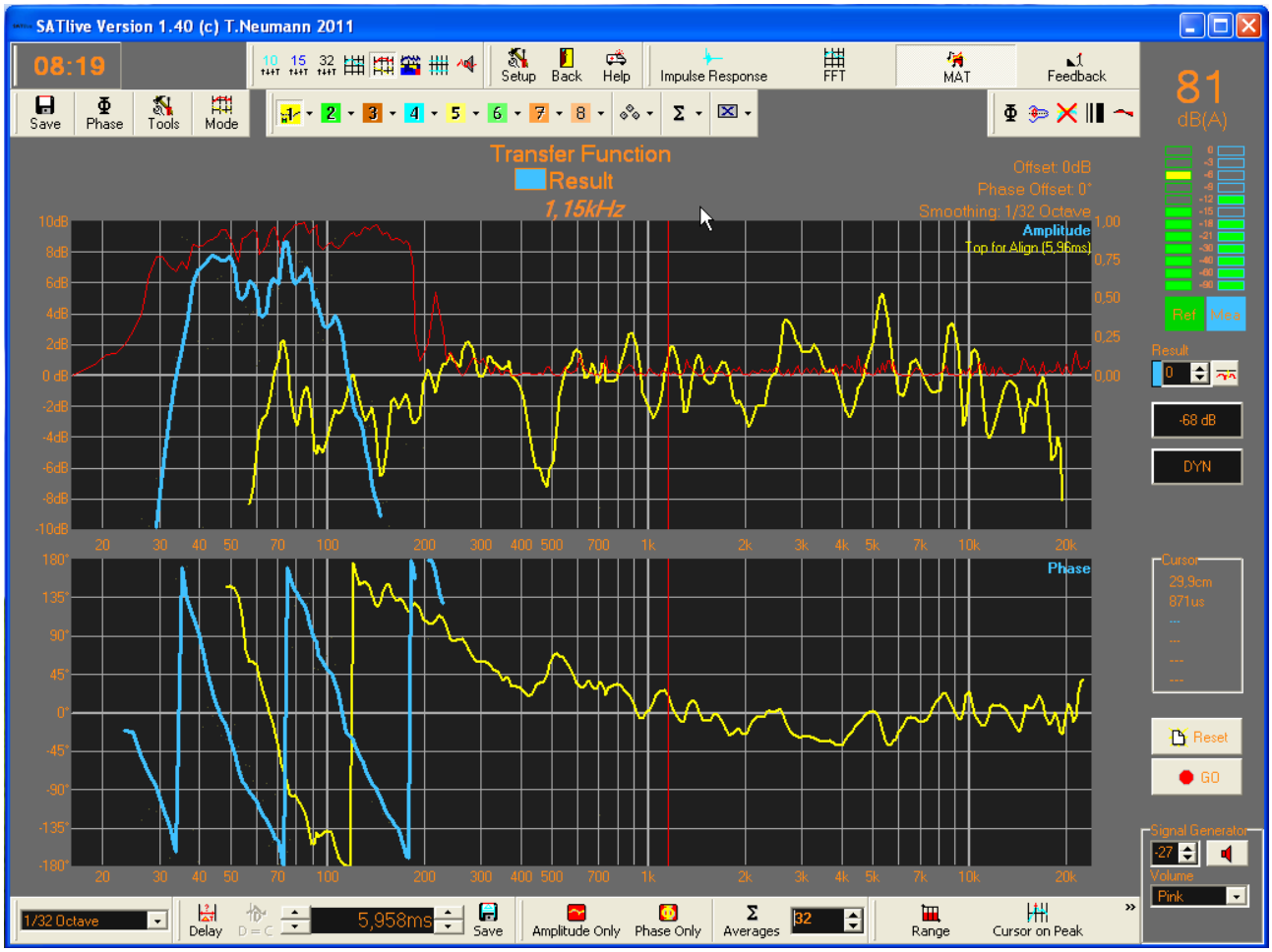
Edit the name of the Quick-Trace and click *OK* when you're done.

Measurement of the Subwoofer

Following that we begin to measure the frequency response of the subwoofer. It is important not to change the delay setting in SATlive here, because we need it as the reference in time for the adjustment intended.

So we just mute the mid/high cabinet and enable the subwoofer.

It will take a little bit longer for the trace to build up for the subwoofer. You can speed this up by cleaning the averaging latch using either the shortcut *R* or the Reset button in the right menu area. This is the time for level adjustments for the subwoofer.



Yellow: Quick-Trace 1 (the Mid/High cabinet's frequency response)
Light blue: Current measurement (the frequency response of the subwoofer)

Now we can stop the measurement by clicking on the *GO* button at the right menu area and after that we can stop the noise, because all steps to come are purely virtual.

Mark the frequency range of interest

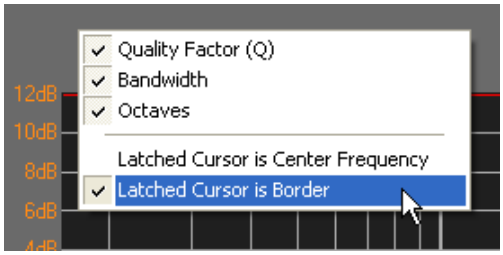
In order to perform the calculation only for the area around the acoustic cross-over frequency (and to speed up the calculation) we're going to mark the area which should be used for the delay – suggestion.

Select the desired mode for the cursor – range tool

We use the so called *Cursor - Range Tool* to select the area of interest.

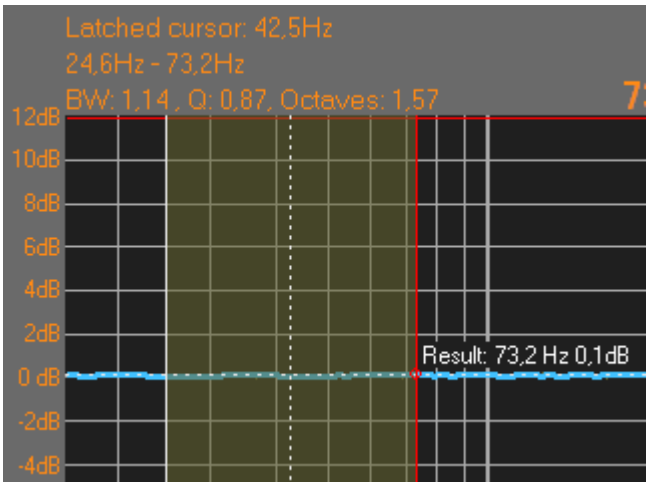
The cursor – range tool calculates information about the area selected.

You can set the desired calculations in the pop-up menu which pops up when you click at the left area in the information bar above the trace display.

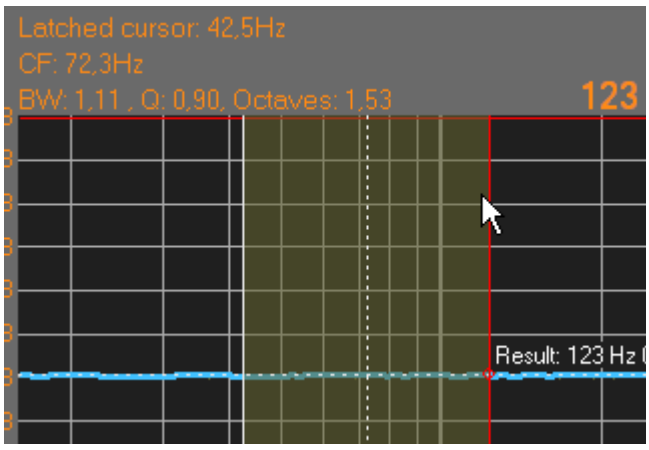


The cursor – range tool features two ways to select the area of interest.

- *Latched Cursor is Center Frequency:* the latched cursor is assumed to be the center of the frequency range to be marked. The area marked expands on both sides of the position of the latched cursor. This is helpful if you want to get information about a peak or dip in the frequency response.



- *Latched Cursor is Border:* the latched cursor marks one end of the desired frequency range. The area marked ranges from the latched cursor's position to the current position of the cursor. I prefer this setting for marking a certain range of frequency.

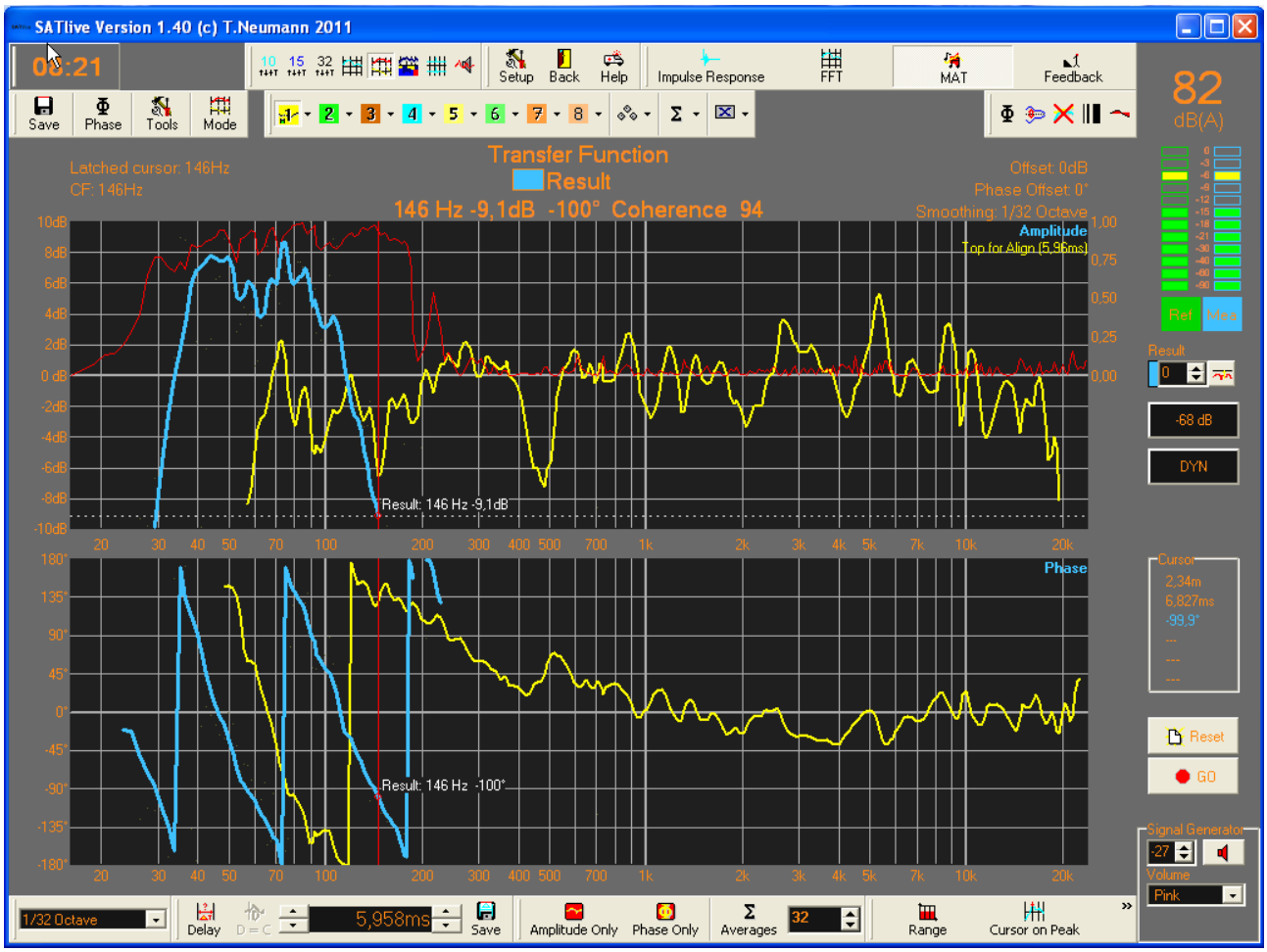


In this document, we are using the setting *Latched Cursor is Border*.

Latch the cursor at one end of the desired frequency range

Put the cursor to one end of the frequency range and press the key *D* on your keyboard.

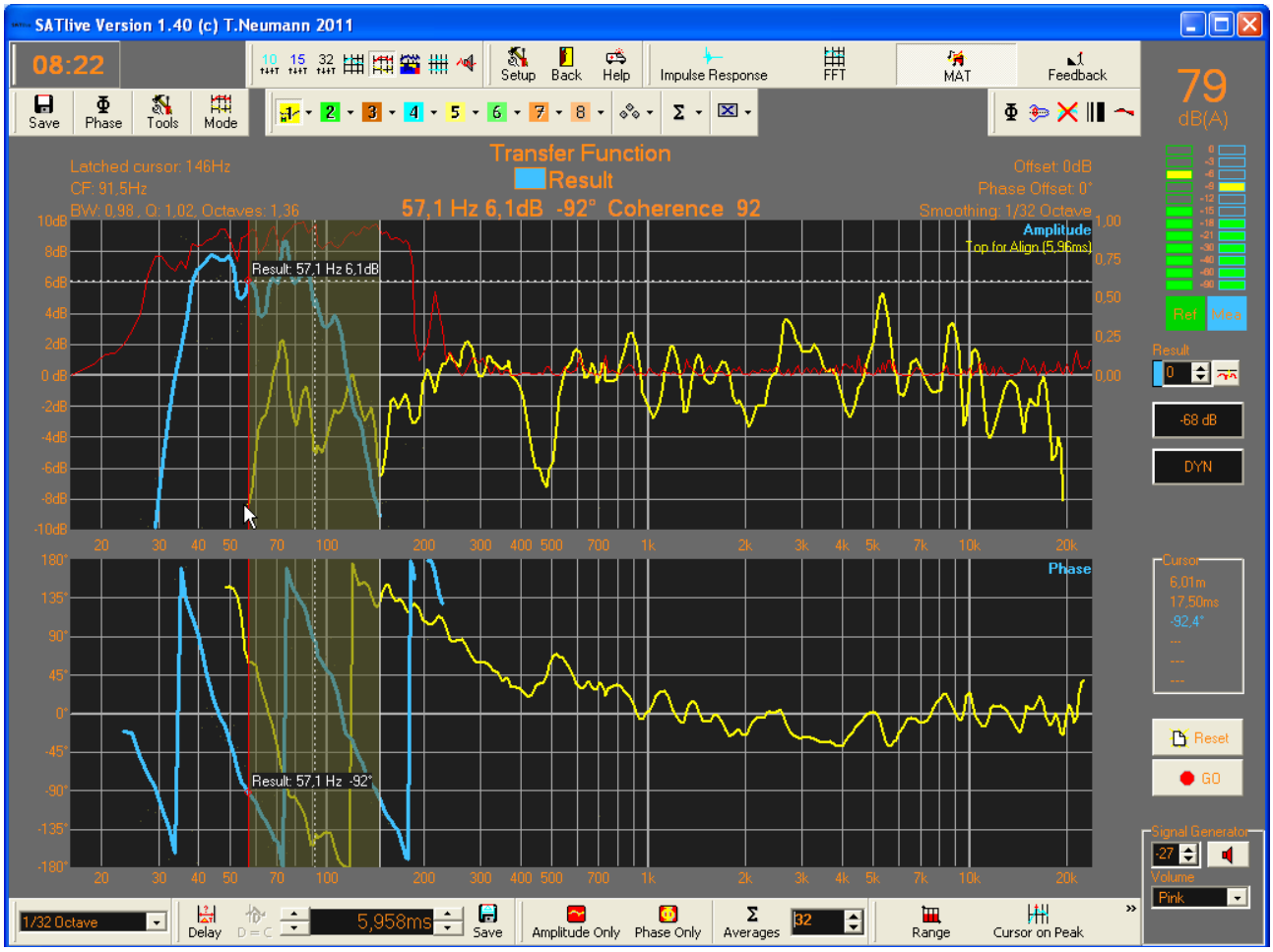
This will latch the cursor to this frequency. The position of the latched cursor is shown in the left area of the information area just above the trace display.



Move the cursor to the other end of the desired frequency range

Select the frequency range for the delay suggestion by moving the cursor to the other end of the frequency range.

The selected range is marked in the display.



You can see the data of the selected area on the left of the info area above the trace display.

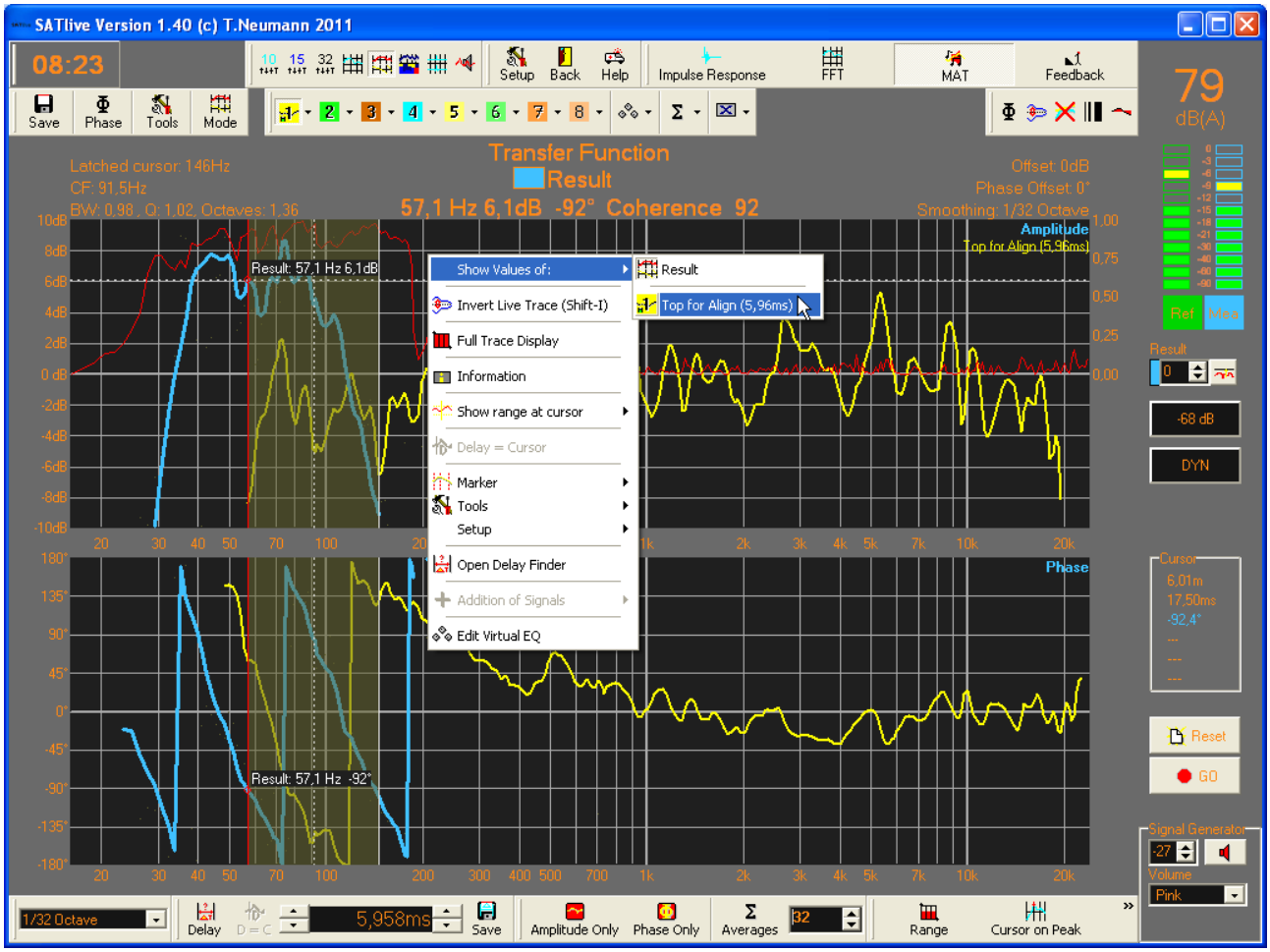
Select the Quick-Trace to be used for the delay suggestion

SATlive supports up to eight Quick-Traces at the same time. Therefore you need to define which Quick-Trace should be used for the delay suggestion.

You can select visible Quick-Traces only.

To select the Quick-Trace desired use the *Show Values of* sub - menu in the pop-up menu of the display area.

For this example we select the mid/high frequency response.

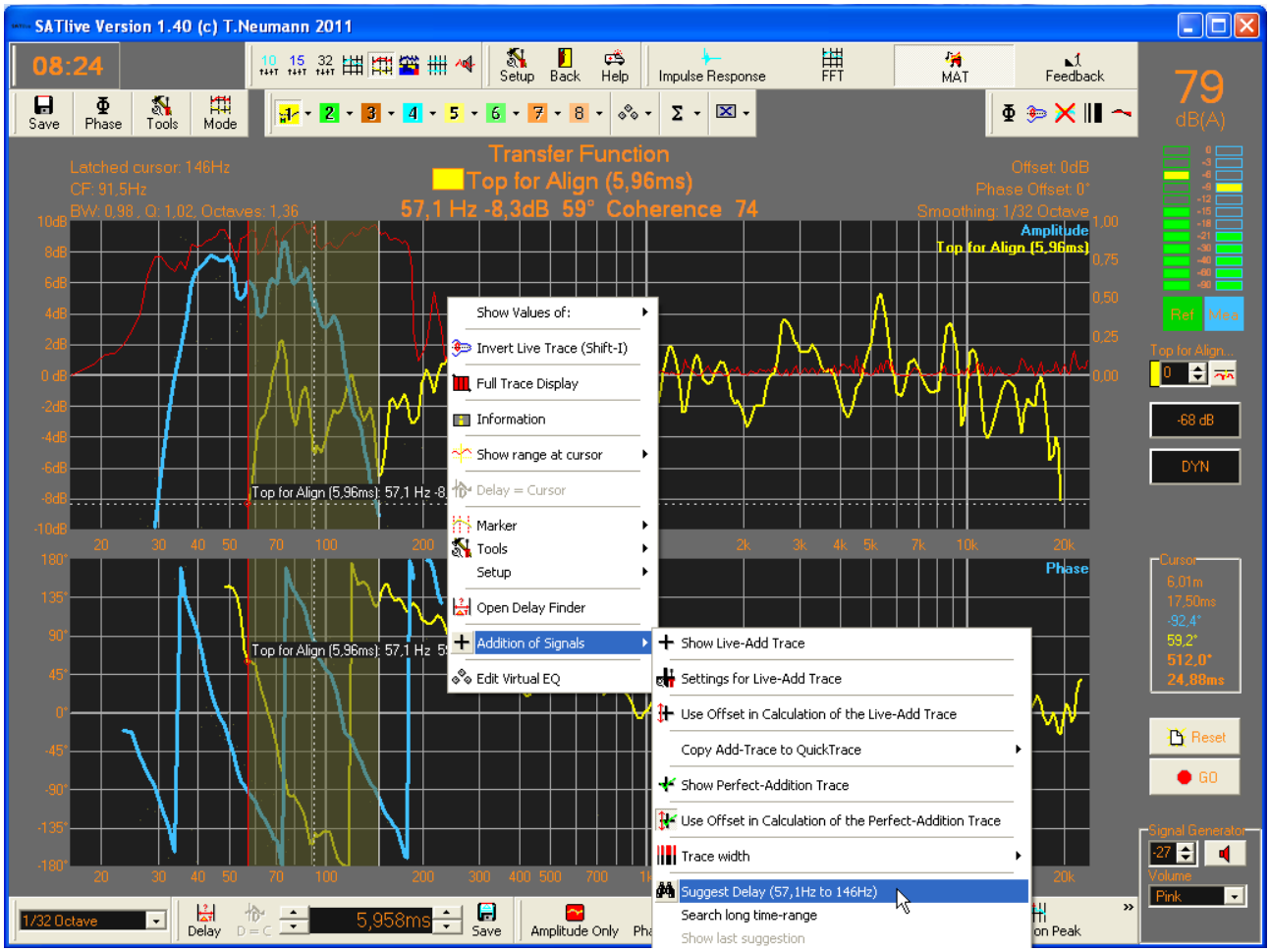


The name of the selected trace is shown at the top – center of the info area above the trace display.

Start the Delay – Suggestion Tool

Now we're ready to start the delay – suggestion tool. This tool is located in the *Addition of Signals* sub – menu in the pop-up menu assigned to the trace – display area.

Please note that the frequency range used for the calculation is shown right of the label, so we can check it here again.



Just click on the *Suggest Delay* entry to start the calculation.

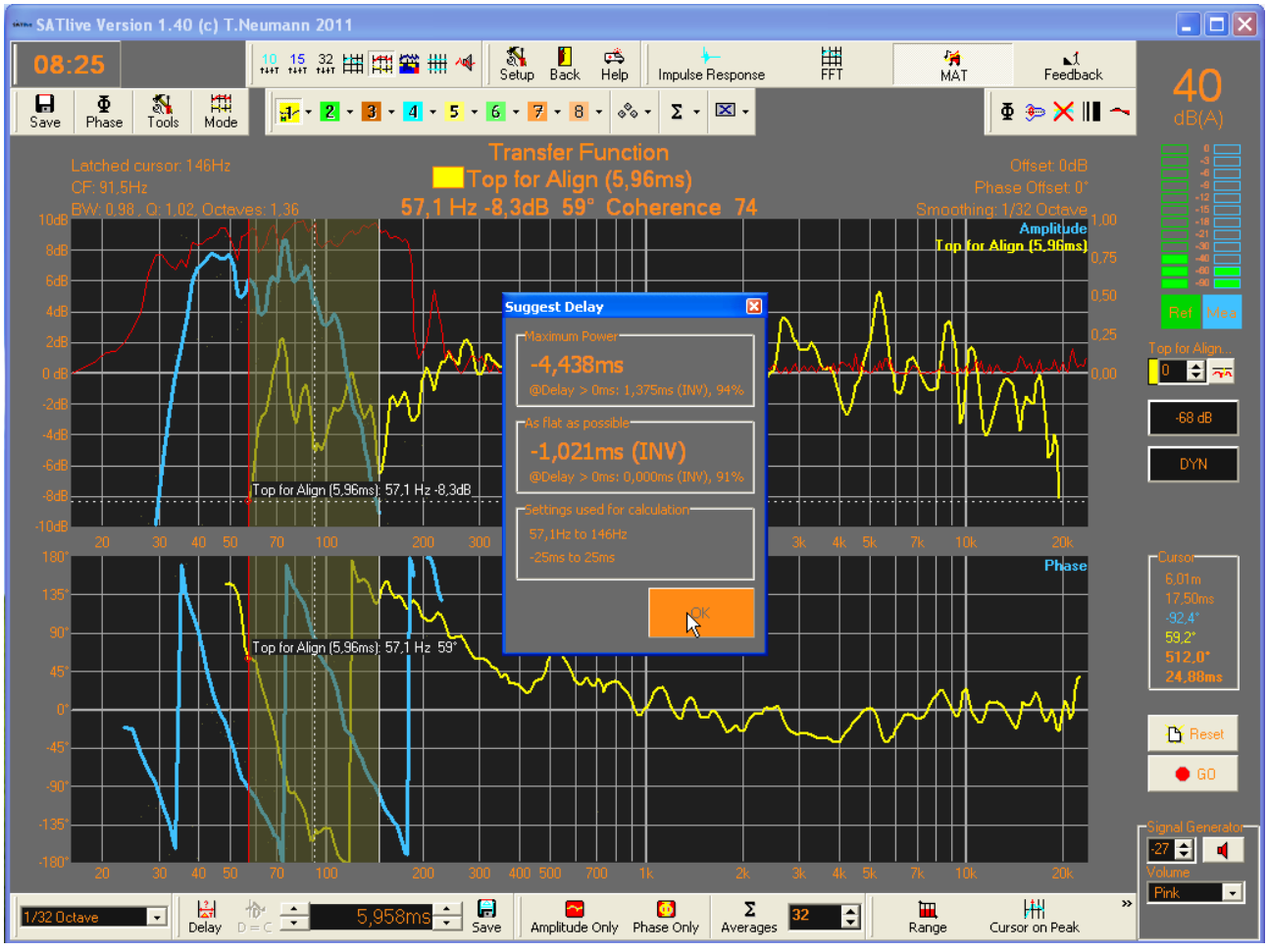
See (and use) the results

The software displays the results of the calculation in a window on the screen.

The window contains the results and lists the parameters used for the calculation.

The upper section contains the delay values, both for the whole range of delay time and for the positive range of the delay time. If both values differ the percentage value indicates the quality of the result achieved using the positive delay value in relation to the result achieved using the negative delay value.

The middle section shows the results for maximum flatness. The string (INV) indicates, that a polarity inversion is needed when you use this value.



Now we're done, and you can set the delay values of your controller according to the results and verify the result using your ears and SATlive. Add a positive delay time to the speaker currently measured (in our example the subwoofer). If a negative delay time is needed, you must add the absolute value of the delay time to the speaker measured when you create the selected Quick-Trace.

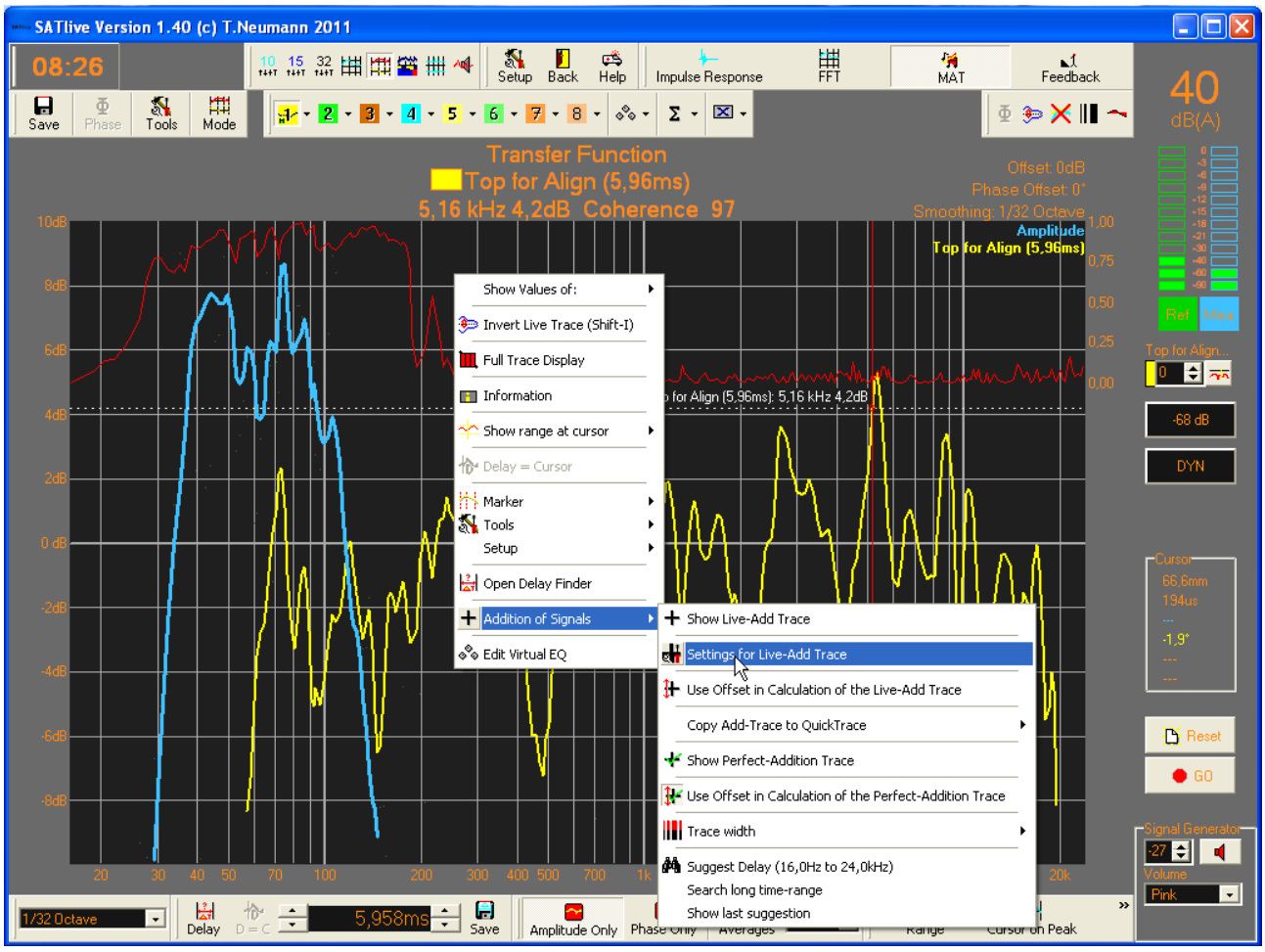
Virtual Verification of the Results in SATlive

We now use the Live – Add feature of SATlive to verify the results of the delay – suggestion tool.

Open the Setup Window for the Live – Add Trace

The Live – Add Trace shows the frequency response of the complex addition of both the current measurement (called the *Live Trace*) and the selected Quick-Trace (called the *Selected Trace*[2]).

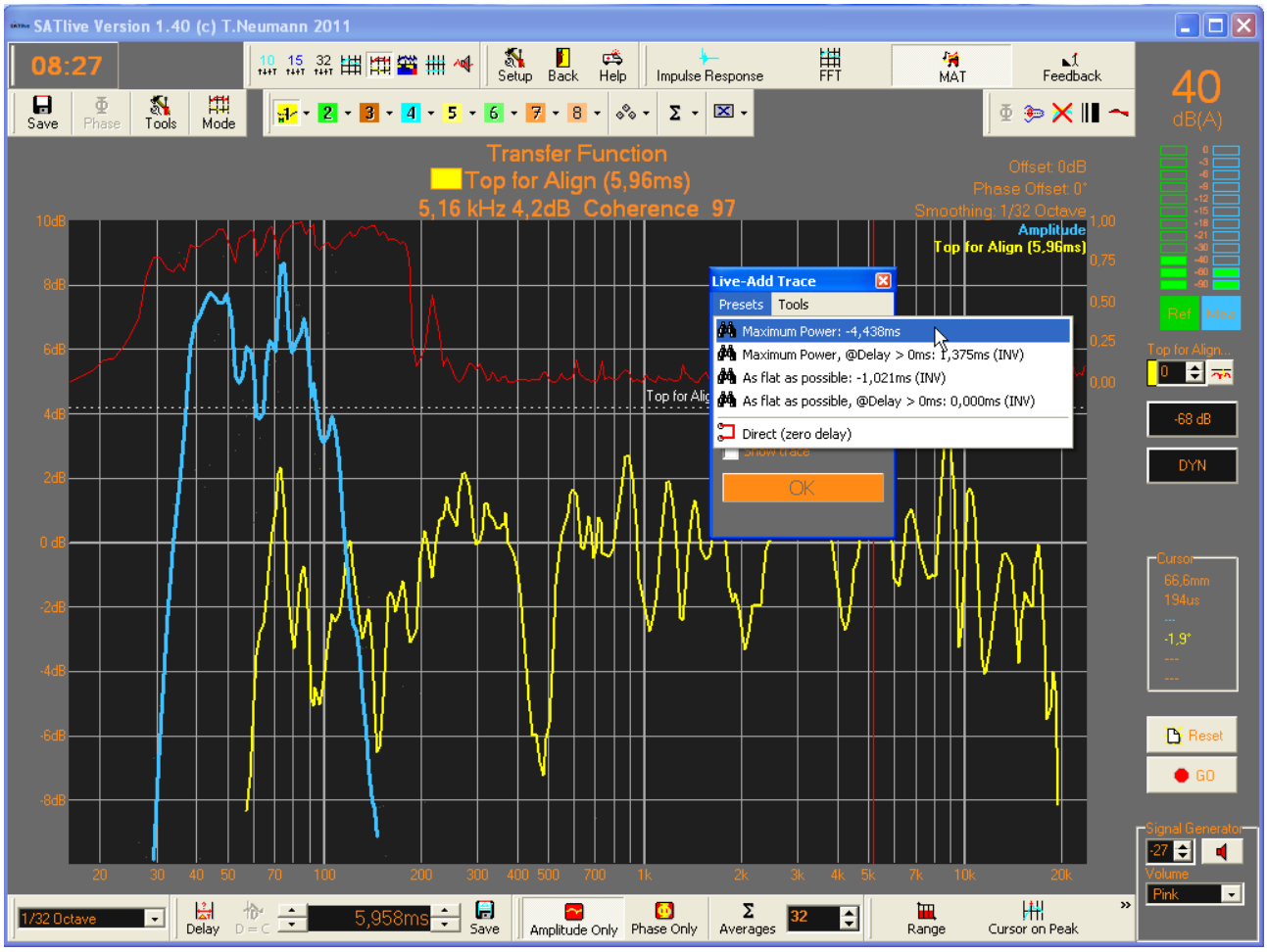
You can invoke the setup of the Live – Add Trace either using the shortcut *shift* + *L* on your keyboard or by selecting the entry *Settings for Live – Add Trace* in the sub – menu *Addition of Signals* in the pop-up menu of the display area.



2 The concept of the *Selected Trace* contains even more settings and features, which are not in the focus of this document. Please consult the SATlive documentation for details about the *Selected Trace*.

Load the Delay Suggestions for the Live – Add Trace

The presets menu in the setup window contains the results of the last delay suggestion. Just click on an entry to apply the values to the Live – Add Trace.



Both settings, delay time and inversion are now applied to the live – trace prior to the calculation of the Live – Add Trace.

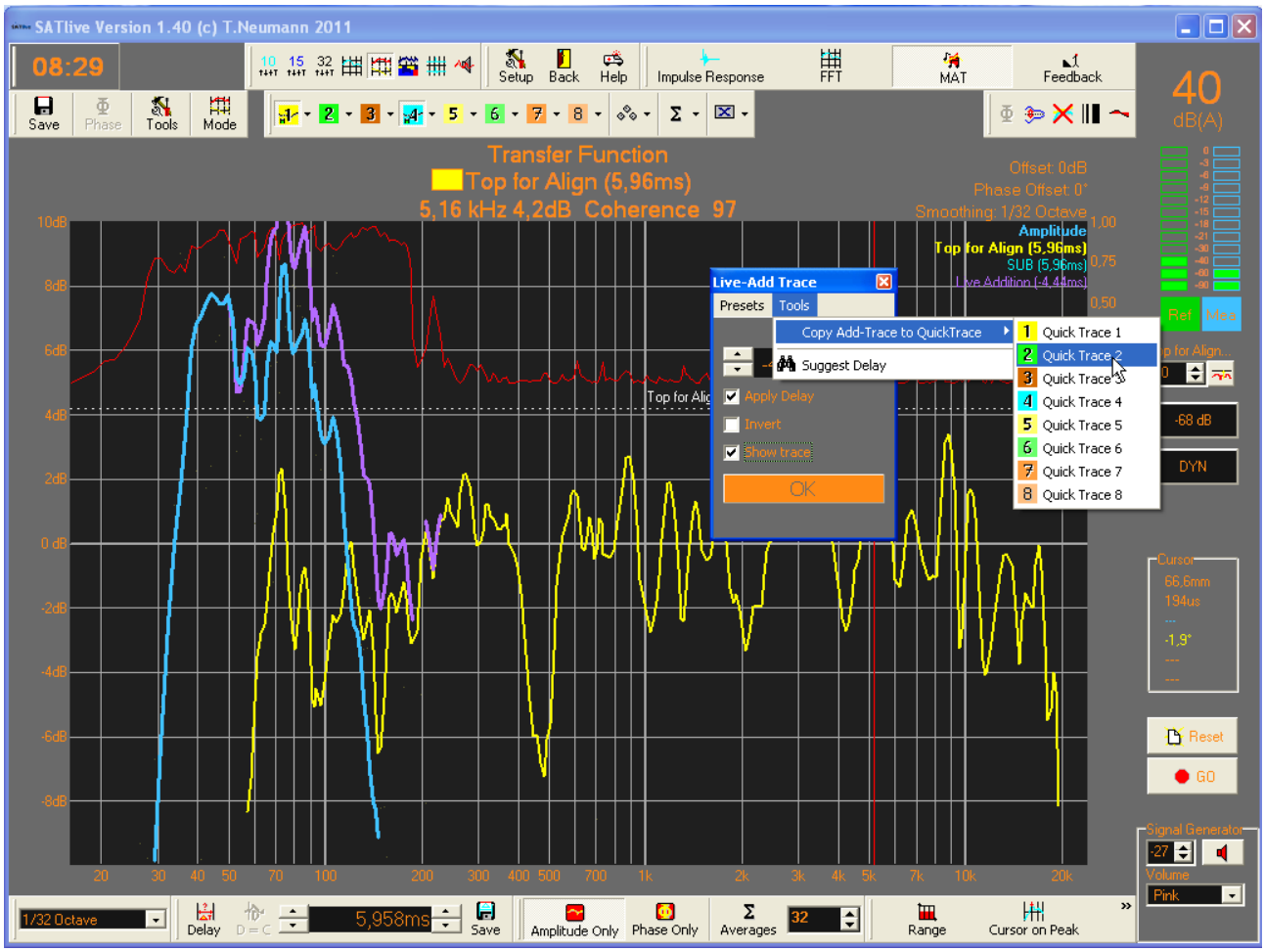
Enable the display of the Live – Add Trace by selecting the *Show Trace* option in the setup window.

Store the Live – Add Trace in a Quick-Trace

In order to compare the results of the different settings, we must save the results of all four presets to different Quick-Traces.

To be able to save the current Live – Add Trace to a Quick-Trace, the Live – Trace must be visible.

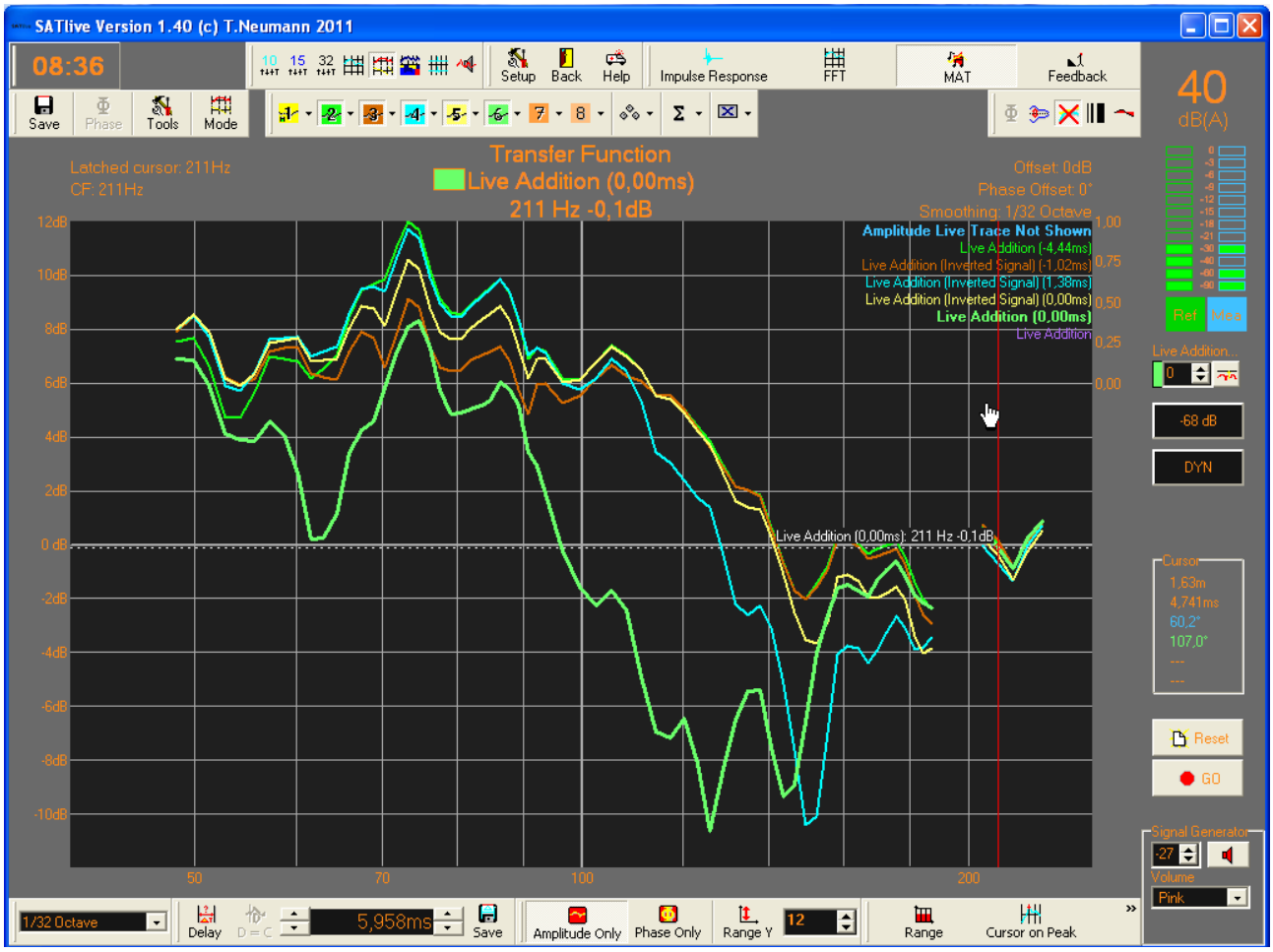
In the *Tools* menu of the setup window select the desired target from the entries of the *Copy Add – Trace to Quick-Trace* sub – menu.



Display and compare the Results

After all the different settings have been applied to the Live – Add Trace and all results have been saved to different Quick-Traces, we'll finally take a look at the results.

For this view I have switched to the amplitude - only mode and zoomed into a smaller frequency range.



Thick green trace: Overlay without any delay.

Small green trace: Alignment max Power

Brown trace: Alignment max flat

Light blue: Alignment max Power, positive delay – time

Yellow: Alignment max flat, positive delay - time

Results

The concept of Energy - Optimization has proved to work for the task of the time – alignment between high/mid cabinet and the subwoofer.

It also succeeded in the delay adjustment for a cardioid subwoofer setup, which was not part of this document.

The goal of maximum flatness is not suitable for most of the alignment situations between high/mid and sub-woofers, because in the real world the output level of the subwoofer is significantly higher than the output level of the mid/high cabinet. The maximum - flatness approach adjusts both levels in order to reach a flat response trace. In this case, cancellation of energy will occur.

The maximum flatness approach can be used to align a delay line or to optimize the overlap in an area covered by two speakers at nearly the same level.

Other optimization goals, like maximum flatness of the phase – response need to be tested for their practical relevance in the future.

Further Informations

- The SATlive software is available at http://www.take-sat.de/english/main.php
- For discussion and comment, you are welcome at the SATlive forum. Http://www.take-sat.de/forum.
- Feel free to contact us via e-mail SATinfo@take-sat.de or visit us on facebook.

History:

7.9.2011: Improved spelling and grammar (thanks to F. Neumann).

5.9.2011: Added cursor – range tool information.