

Dipl.- Ing. (FH) Thomas Neumann

a practical guide to

Time Alignment

in small PA systems

Preface

Due to falling prices for digital equipment digital speaker controllers are available for nearly everybody. This controllers enable the users to affect a lot of parameters like crossover slops, frequencies or delays for each output.

This adds a lot more possibilities and complexity to the setup of PA systems. This complexity enables you to optimize a PA system in a way that was not possible before.

Due to this complexity some settings, like delays of the single output need measurement to set optimal values.

In common PA systems the frequency range is divided into different ranges which are reproduced using different systems. Different systems mean different locations of the sound sources.

This leads to interference in the so called crossover range, causing notches and peaks in that area.

Time alignment tries to adjust the arrival time of sound so that in the crossover range the sound of both systems arrives at the same time, so adding in perfect manner.

Because the difference between the arrival times of two systems changes depending of listener's position it is impossible to get perfect alignment for all locations, but especial at lower frequencies time alignment will improve the performance of the system.

This paper shows time alignment for a very common small venue system consisting of a 12" / 1.5" mid/high speaker with internal passive crossover which is supported by a active separated 18" subwoofer.

The procedure of time alignment can be used for other system configuration as well.

The software **SATlive** is used for measurement.



Preparation for measurement

An external usb Audio interface was used for measurement. Because SATlive was operated with an other audio interface before, you have to select the proper interface prior to measurement.

The driver selection is located at **Setup -> I/O Devices**.

For this example the Direct Sound driver is used. After selection of the Kind of audiodriver from the list you click on the setup button to invoke detail setup.

At that setup the interface for Audioinput and Audiooutput is selected from the lists.

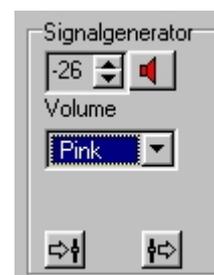
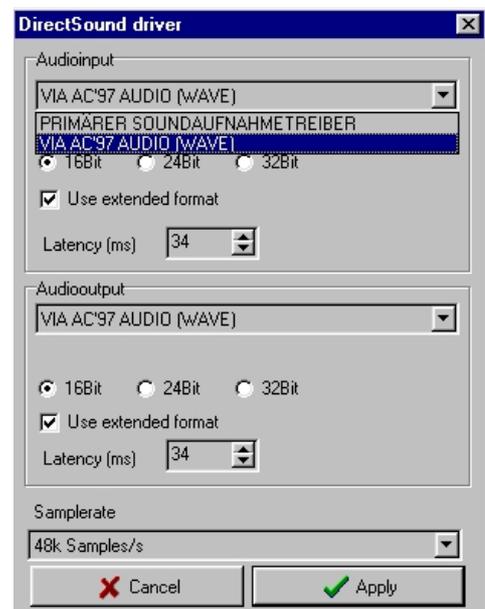
The selection is confirmed by clicking on the **Apply** button. This closes the detail setup and brings us back to the kind of audiodriver selection. To confirmed the changes in that section we use the **Save** button in the top menubar.

Pink noise is used as audio signal for measurement.

The type of signal can be selected from a list at the signalgenerator section at the right bottom of the program's window.

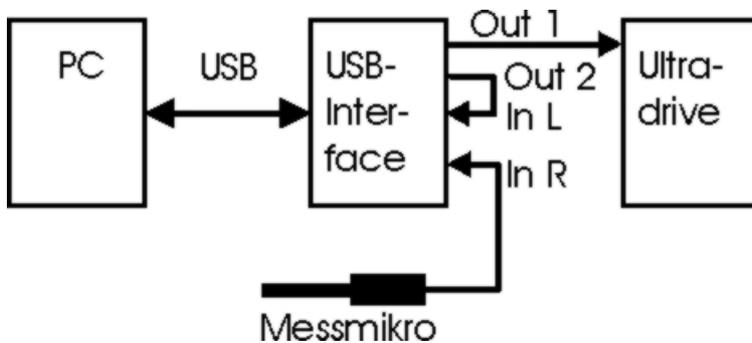
Use the button with the speaker symbol right of the level setting to start or stop the audio input.

Adjust the audio levels so that both bars of the VU meter show a level around -15dB.



Audio wiring

The USB audiointerface used contains a microphone preamp providing phantom power, which ease the wiring.



One output of the audio interface is connected to the input of the digital speaker controller used as crossover. The other output is used as reference and simply looped to the left input of the audiointerface.

The omnidirectional measurement microphone is connected to the right input of the audiointerface. If the audiointerface features no microphone preamp then an external microphone preamplifier must be used to supply gain to the microphone signal.

Use pink noise to verify correct wiring and gain adjustment.

Position of the measurement microphone

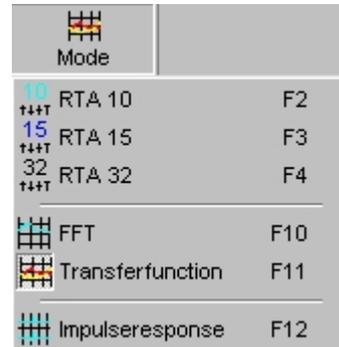
The measurement microphone stands approx 5 meters away on axis of the high/mid speaker at a height of approx 1.6 meters.



Measurement

The **MAT module** is selected for measurement from the top menu.

In MAT module select the mode **Transferfunction** from the **Mode menu**.



Before we start

Prior to measurement of amplitude and phase we need to compensate the delay between reference signal and the signal of the microphone.

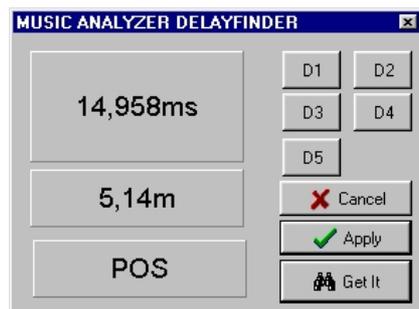
First start pink noise, then we invoke the delayfinder from the delay menu (bottom menu).

Click on **Get It** to start measurement. After a few seconds the upper value shows the distance in milliseconds. The second value is the distance calculated from the measured time¹.

Use **Apply** to activate the result as delay in MAT module.

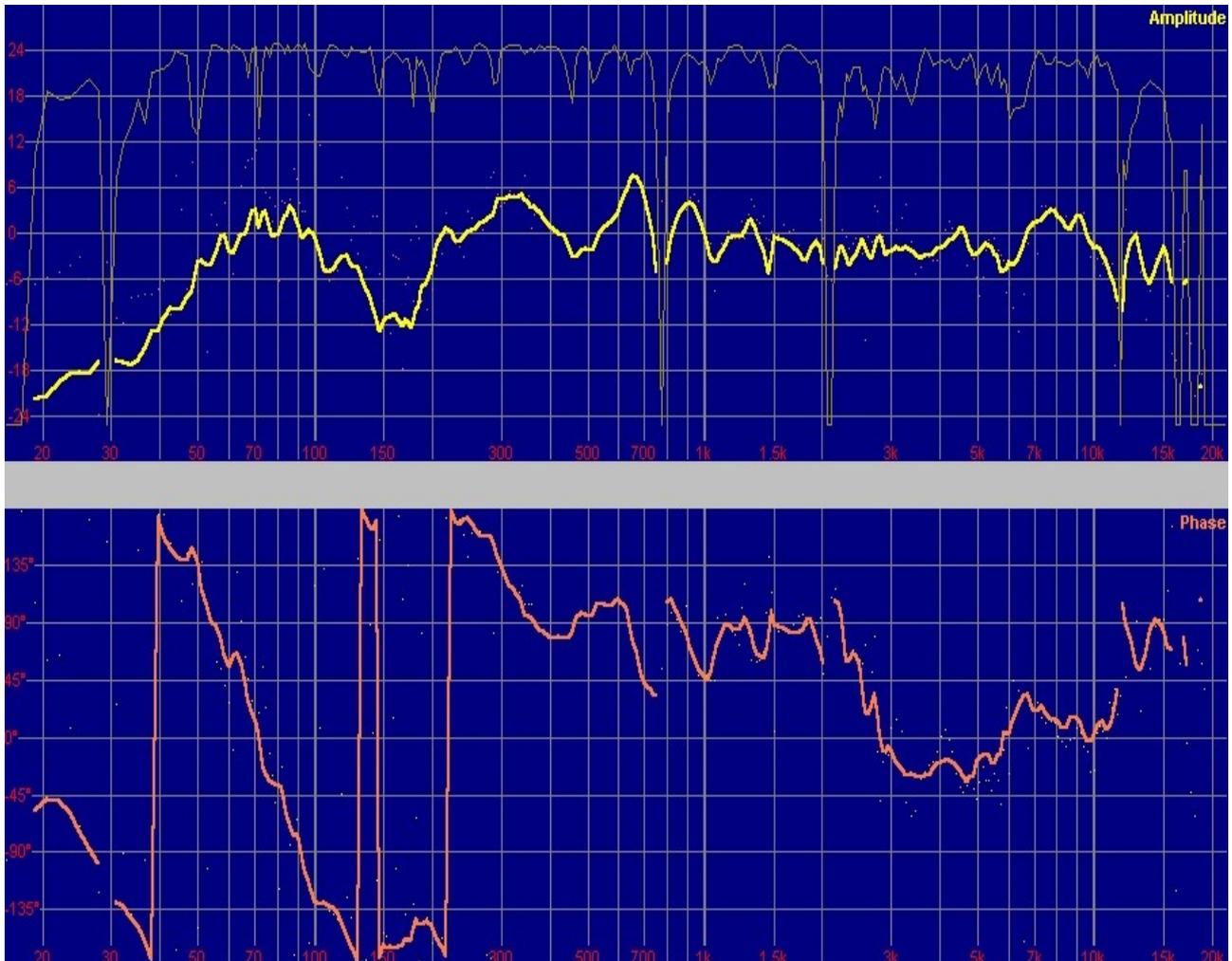
The delaytime latches (D1 to D5) can be used to save the delay to SATlive's delaytime memory.

You can invoke stored delaytimes from the Delay menu in the bottom menu.



¹ At setup -> features you can change the temperature used for calculation and the units used for distance and temperature.

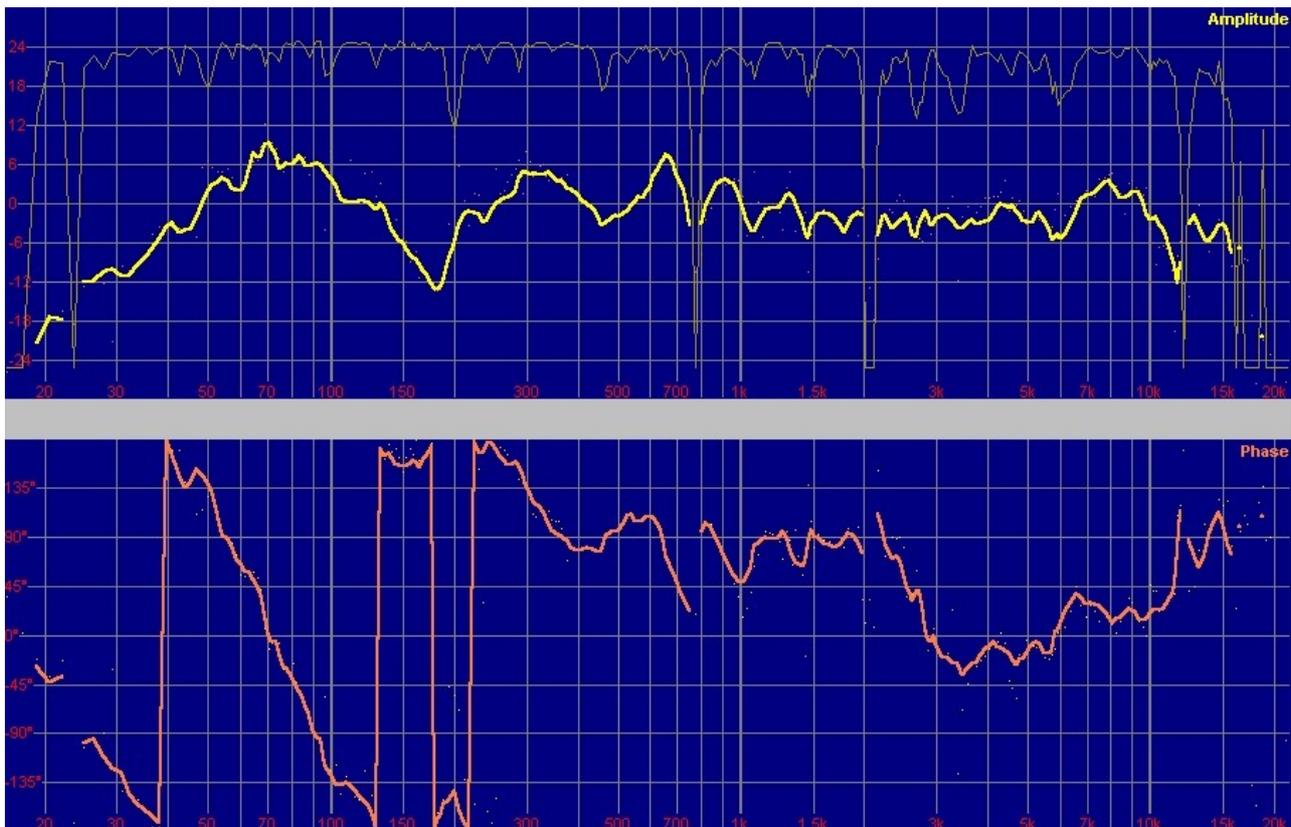
Full range without Time Alignment



The upper trace shows the amplitude and the lower one the phase over frequency for the whole system without delay.

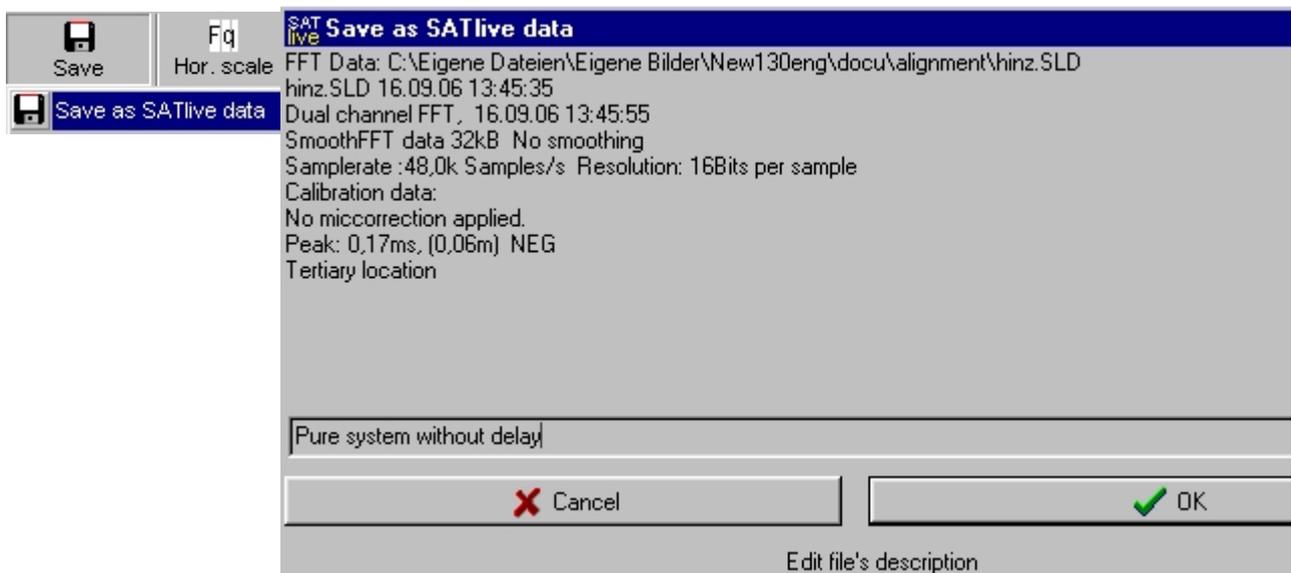
The thin trace in the upper area is the coherence, which is a measure for the quality of data.

It is important to adjust the levels of the single systems at this point, because changing the level relation will change the acoustic crossover frequency.



The level of the subwoofer was increased and the measurement was repeated.

Save the result



Now you can save the trace using the **Save as SATlive data** option from the top menu's **SAVE** button.

The **Infowindow**² enables you to change the trace's description.

² The Infowindow pops up after selection of the filename. This behavior can be changed using the **Show fileinfo when saving** option at Setup -> Features.

Measurement of the mid/high system.

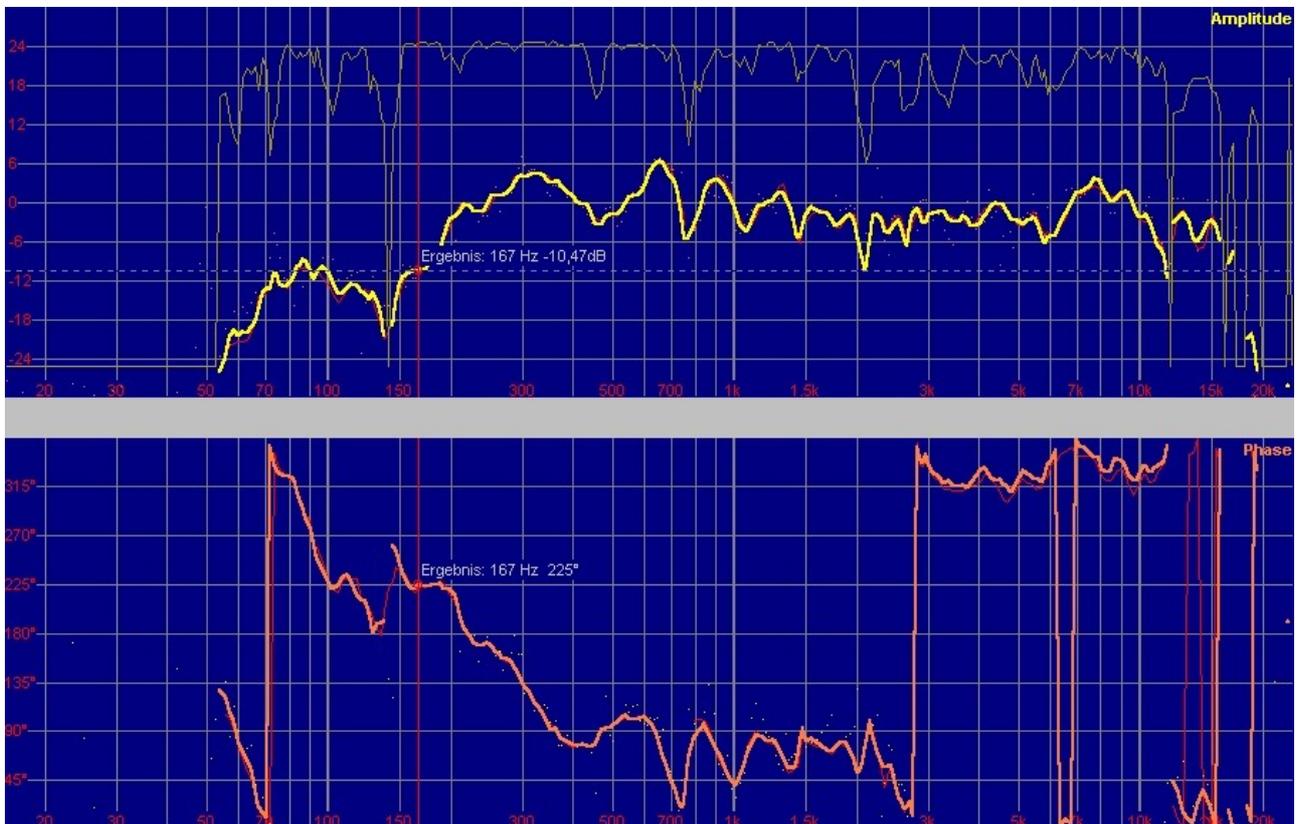
Delayfinder works better on higher frequencies as on lower ones. Therefore the mid/higher range is preferred as time reference for adjustment.

Because it's known for this combination that the lows are 'slower' than the mids and highs, a short delay of 10ms was added to the mid/high way of the speaker controller.

This makes it necessary to perform the delaytime measurement again.

Because the delaytime measurement is used as time reference, it is useful to **perform the delay measurement again** at this point after muting the subwoofer, even if no delays have changed since the first measurement of delay time.

Now the frequencies and phase response of the mid/high unit is measured.



Save mid/high response to short time memory

The **mid/high** system's response is needed as **reference** for further alignment. Therefore it is **saved** into the short time memory by just clicking on the short time memory's button.

If there was a trace assigned to this memory, you need to use the **Assign** option of its popumenu to overwrite the prior trace.

If a trace is assigned to the memory its visibility is toggled using the memory's button.

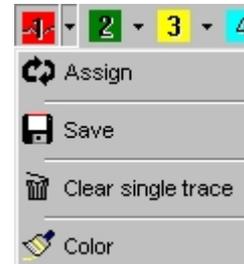
All short time memories are lost if you leave SATlive. You can use the **Save** function to save it to disk.

If you want to empty the short time memory, use the **Clear single trace** function.

The **Color** function enables you to change the color of the short time memory's trace.

The current state of the short time memory is indicated by the appearance of its label.

- Red trace is assigned and visible
- Green trace is assigned and not shown
- Yellow trace is assigned, saved and not shown
- Lime trace is not assigned

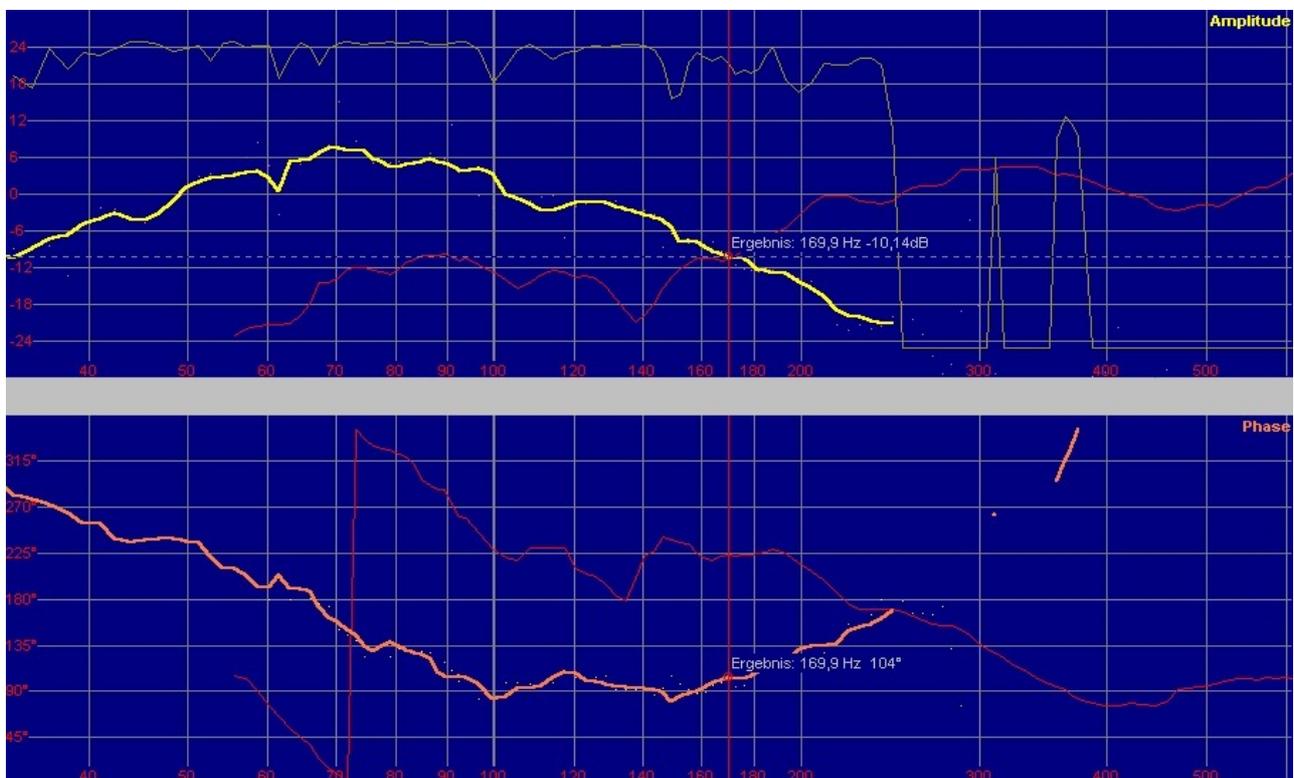


Time Alignment by adding delay to the subwoofer

As mentioned above the Time Alignment is done in the crossover area between bass and mid system. To get a better view on that area you can use the mouse to select the range of interest or use one of the **predefined ranges**³ from the Range menu.

The same pop-up menu features the **Linear scaling** option which changes the scaling of the x-axis to the unusual linear spacing, which might be helpful for phase slope comparison.

The delay time set prior to mid/high measurement is used as reference. Therefore **do not run the delay finder** again at this point.



The measurement⁴ shows a relatively high acoustic crossover frequency (intersection of amplitude traces) which is a lot higher than the values selected at the speaker controller.

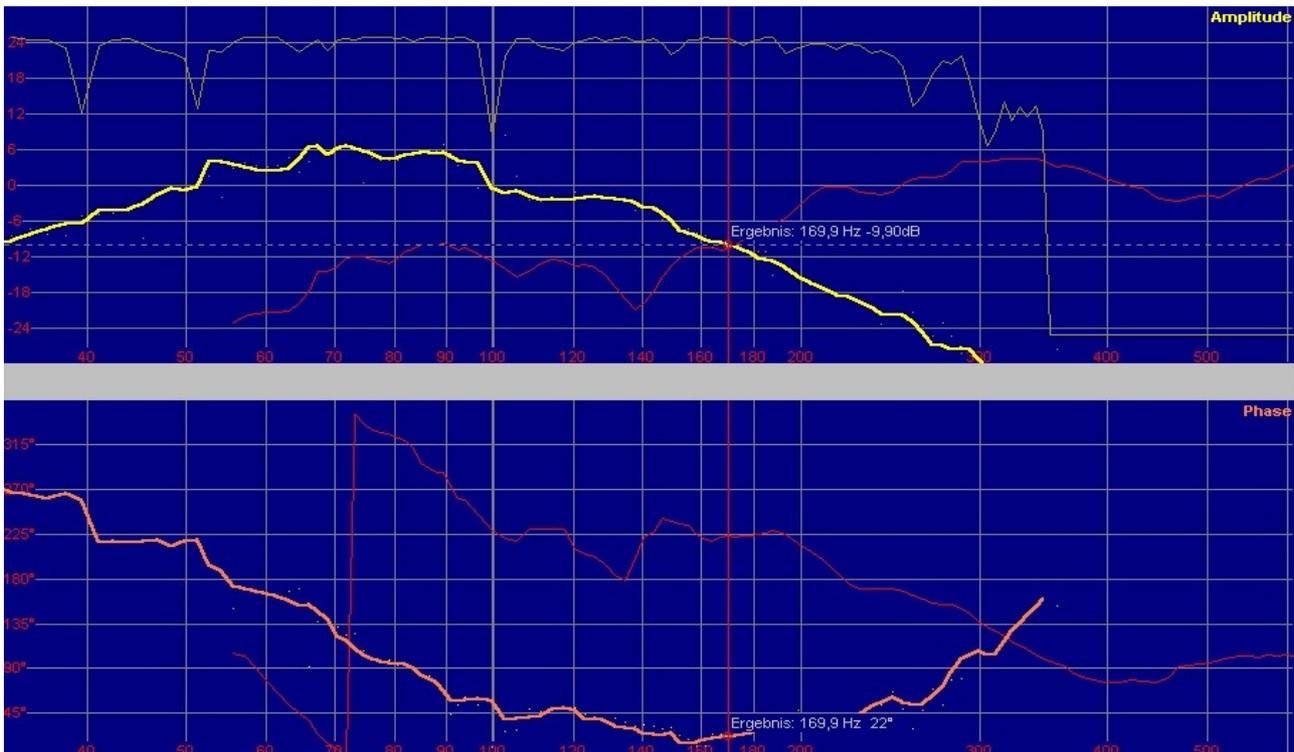
For the time alignment we take a look at the **slope of the phasetraces** around the **acoustic crossover frequency**.

In this area the phase trace of the subwoofer's has a slope which is not as steep (in fact, it is not falling but raising in this example) as the slope of the mid/high's trace.

This means that the **subwoofer** needs **more delay**, to 'bend' the slope of its phasetrace downwards.

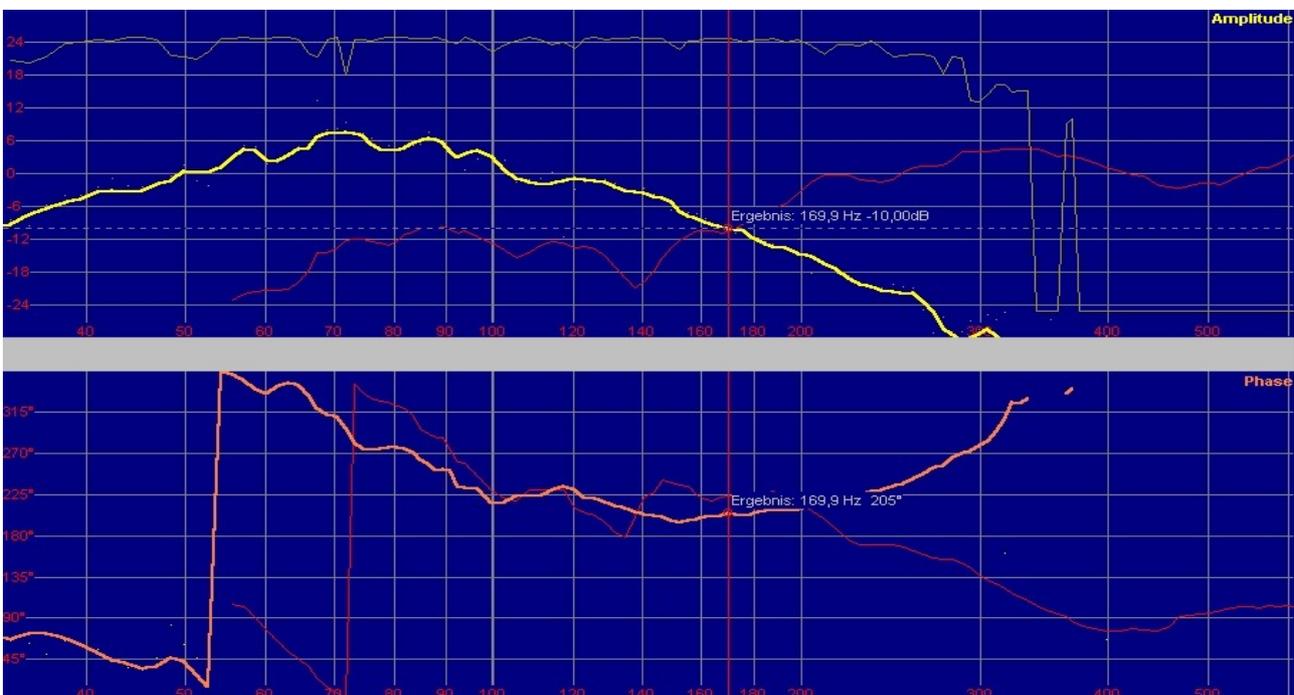
³ The borders of the ranges can be set at Setup -> Postprocess.

⁴ Yellow trace shows amplitude and orange trace shows phase of the subwoofer. The red trace in background is the short time memory trace of mid/high's response.

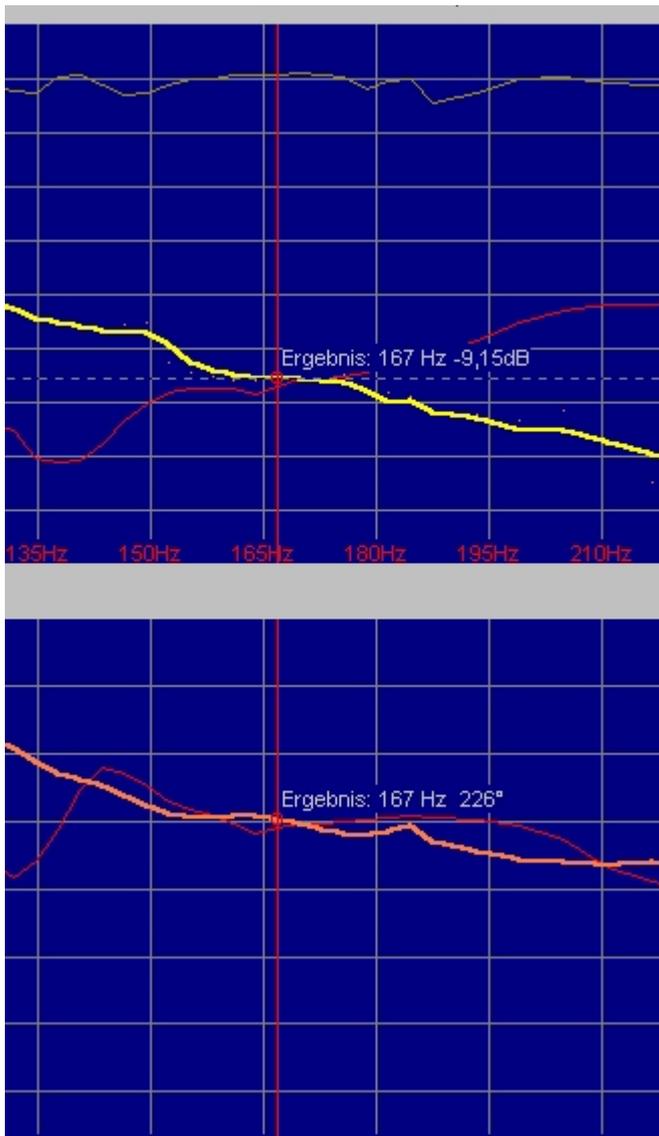


After adding a short delay to the subwoofer, the **slopes** of both phase traces get similar around the acoustic crossover frequency.

Because there is a large distance between both phase traces around the acoustic crossover frequency we add **polarity inversion** to the subwoofer's channel.



This polarity inversion brings both phase traces close around the acoustic crossover frequency. Their slopes also run nearly parallel at this area.



After some **fine tuning** using the **delay** of the subwoofer channel both phase traces match nearly perfect in the crossover area.

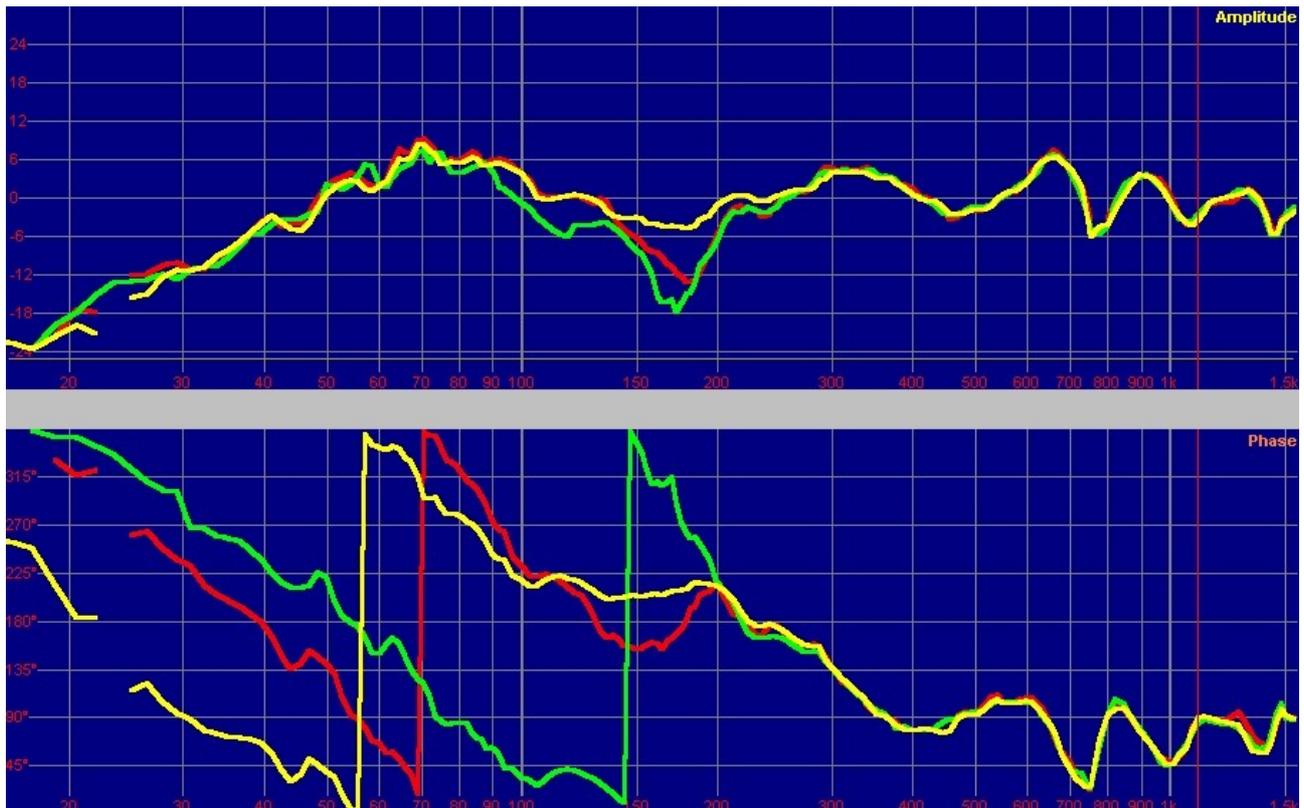
Opposite to the prior measurements the linear scaling of the X-axis is used here.

Result and verification of time alignment

To check the time alignment a **measurement of the whole system** is performed.

In order to verify the quality of alignment a **measurement with inverted polarity** of one way is performed for comparison.

With proper time alignment there should be a large difference in the amplitude traces around the acoustic crossover frequency.



Yellow trace shows the whole system using the **Time Alignment**.

Green trace is the comparison trace created with **inverted polarity**⁵ of the subwoofer.

Red trace shows the trace **prior** to time alignment.

Even if the frequency is still not perfect in this area the positive effect of time alignment is evident.

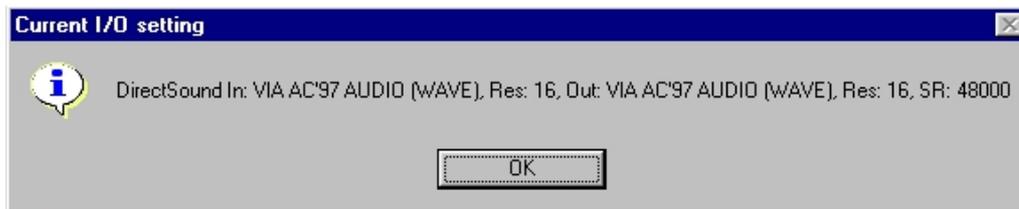
The time alignment enables us to apply an **EQ** in this area.

Eqing in the crossover area should be done before the crossover section of the speaker controller, because applying equing after the crossover can affect the time alignment.

⁵ Because the polarity of the subwoofer was inverted during time alignment, it was reseted to unaffected polarity for verification.

Hints and remarks

- If one or both phasetrace wrap in the area around the acoustic crossover frequency, you can use the **Phase shifted** setting in the Phase menu to move the phasetrace to the middle of display.
- **Any change of filter parameters** at the crossover frequency like slope, type of filter used affects the phase trace. Therefore you need to check time alignment every time a setting of the speaker controller is changed.
- If you want to know **details about the current audio I/O configuration**, then you can use the key combination **ALT-GR** and **D**.



- **SATlive Homepage** can be found at <http://www.take-sat.de>
- Questions, suggestions or reports of your experiences are welcome. You can mail them to SATinfo@take-sat.de oder post at the **SATlive** Forum http://www.s4.forumfactory.com/cgi-bin/s4/foren/F_1827/cutecast.pl



Any publishing in full or part only with author's permission.

© 2006 Dipl. Ing. (FH) Thomas G. Neumann