MANUAL

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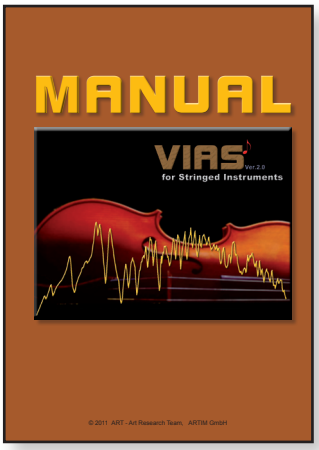
VIAS was originally a simple software for the measurement and graphic display of the Transfer-Function of stringed instruments according to the method of Heinrich Dünnwald.

In the late 90ies the VIAS software was improved and various simulation modules, special tools for data processing and a sound generation module for an acoustic data output were added. Thereafter VIAS was primary used by research institutes and advanced users as a valuable software extension for the BIAS software packages.

With the development of reasonably priced hardware components for admittance measurements, VIAS returned to it's originally application.

Therefore two VIAS manuals exist: a common one which describes both applications (impedance and admittance measurement) shortly and one which deals more detailed with the admittance measurement of stringed instruments.



What can VIAS be used for?

1. for extended and more accurate impedance measurement and analysis, including audio tests of the measured instrument based on a measured or calculated impedance curve

2. for admittance measurements and evaluation of bowed and stringed instruments such as violins, cellos, harps, guitars, pianos, and percussion instruments, with pulse hammer method based applications

3. for transfer function measurements

3. for the generation of a calibration matrix for the BIAS measurement head

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VIAS for Stringed Instruments supports the following admittance measurement methods:

- **Pulse hammer method**

If, for instance, the bridge of a violin gets excitet at its upper edge by a stroke with a pulse hammer and if an accelerometer is mounted at the opposite edge of the bridge, you can obtain an admittance curve, which contains nearly all relevant information about the acoustical properties of this violin

You need:

- a pulse hammer with integrated force sensor
- an accelerometer
- an amplifier.

We offer two hardware systems:

- the **PCB-system** consists of components produced for commercial use in laboratories and for scientific research
- the **LC-system** consists of components especially produced for musical instrument makers

- **Vibration measurement at arbitrary points of an instrument**

The above mentioned hardware can be used to perform vibration measurements at any location of the instrument body. Can be used as data acquisition method for Modal Analysis.

- **Admittance and Vibration measurements with a sinusoidal excitation by a shaker**

Both above mentioned methods can be performed by an excitation signal provided by a commercial shaker. An excitation signal consisting of a sinusoidal sweep provides you with a better resolution (better signal to noise ratio) in the high frequency range.

It should be taken into account, that the mass of the shaker is relatively large compared to the mass of e.g. the bridge of a violin (not to the mass of a double bass bridge) and therefore can adulterate the measurement result.

Components of the PCB System

PCB 086C03 Impulse hammer

- pulse hammer with integrated force sensor

ROGA Plug.n.DAQ
USB charge amplifier

- ROGA Plug.n.DAQ USB charge amplifier

Recommended configuration

- PCB352C23 Ceramic miniature accelerometer 0.2 g
  PCB030C10 Teflon cable

If you already have such or similar components, you can use them with VIAS in most cases without any problems. The only thing to keep in mind, is that the accelerometer must have the least mass possible, to avoid affecting the oscillating properties of the object to be measured.

ROGA charge amplifier

- Connect the accelerometer to “Input 1”
- Connect the pulse hammer to “Input 2”
- Connect the amplifier to your PC via a USB cable.
- Press these two buttons to activate the power supply for both channels.
- Press these two buttons to choose the amplifier level “**+20 dB**”. For measurements on violins. For violoncellos, and double basses choose “0 dB” or “-20 dB” respectively.
- USB connector “OUT”.

Connection points of the sensor and excitation point:

In most cases it is advisable to perform an admittance measurement directly at the bridge of the instrument, in particular in the case of traditional string instruments.

- To mount the accelerometer on the instrument:
  Use the delivered beeswax to mount the accelerometer, for instance, to the left upper border of the bridge of a violin (as seen by the player)

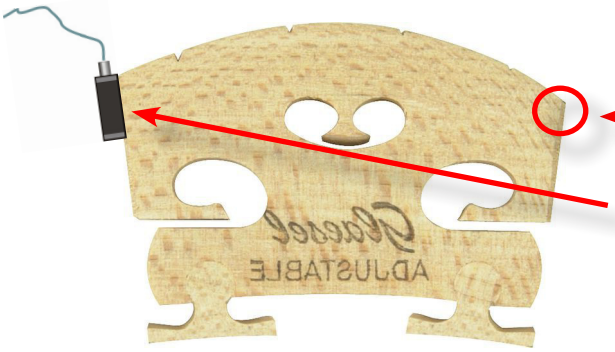
REMARK:

It is advisable to use beeswax because it does not leave marks on the instrument. Furthermore, it is commonly accepted by the owners or players even of very precious instruments. The less beeswax you put on the wide side of the accelerometer, the better the contact. Unfortunately, the adhesiveness of the beeswax is reduced with higher ambient temperatures.

As alternative a filmy(!) twin-sided adhesive tape or for instance photo stickers like "Fotoketts" from Avery-Zweckform (Article No. 3516) or Article No. 1070 from "Herma" can be used.

Sensor Mounting

- Point of excitation.

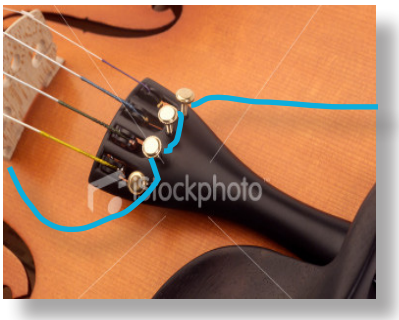


Point of excitation with the pulse hammer

Mounting the sensor on the bridge. Check that you stick the sensor to the bridge with that side where the letters “PCB” are visible. If the accelerometer is mounted with the opposite side on the instrument you will obtain the same curve, but the phase information will not be correct.

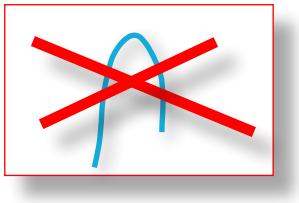
IMPORTANT:

From an electronic engineering point of view, the amplifier is a charge amplifier rather than a voltage amplifier. Since every cable has a capacitance, every movement of the accelerometer cable (during a measurement) leads to substantial measuring errors.



- To avoid possible measuring errors and to provide strain relief, we recommend to fix the accelerometer cable. In most cases, this can be done by clamping the cable in between the fine tuners or by fixing it with adhesive tape on the tail piece.

- Please make sure that the accelerometer cable is not flexed of bend in a radius of less than 4cm. A displacement of the core relative to the coating can change the capacitance of the cable.



Damping the Strings

IMPORTANT:

The strings of the instrument have to be damped with a piece of foam. If this is not done, energy is withdrawn from the system at the resonance frequencies of the strings. This results in minima in the admittance curve that distort the final result!

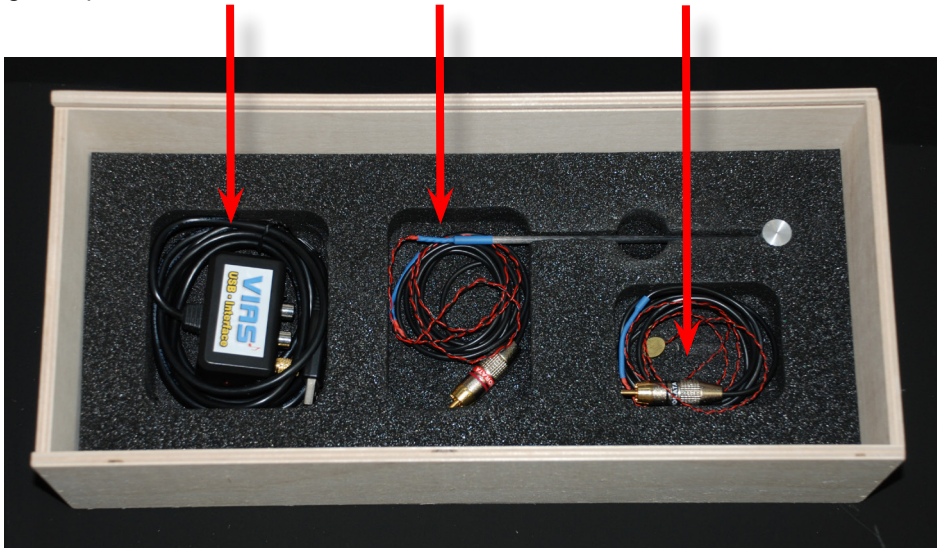
Hardware Components:

- PCB 086C03 Pulsehammer with integrated force sensor
- PCB 352C23 Ceramic miniature accelerometer 0.2 g
- PCB030C10 Teflon cable
- ROGA Plug.n.DAQ USB charge amplifier

Overview LC Hardware

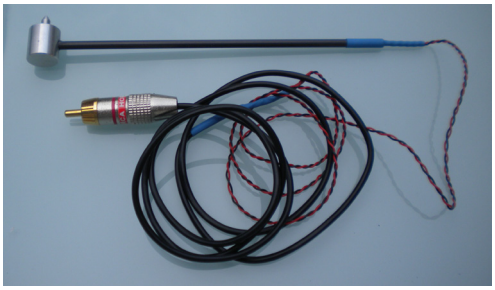
Hardware Components

Voltage Amplifier / Interface box Pulsehammer Accelerometer / Sensor



ALESIS Voltage Amplifier and USB-Interface

SMIA Low Mass pulsehammer with integrated force sensor



SMIA Accelerometer

Voltage Amplifier and Interface Box

- This jack is provided for the use as interface box with a turn table.

You do not need it in the case of a VIAS measurement!

- Connect here the accelerometer
- Connect here the pulse hammer ("red to red")
- This switch must **always** be at "**LINE**" !

This "Thumb Wheel" regulates the level of amplification. The advantage is, that you can optimize the signal to noise ratio by adjusting the signal level to the measurement object. A small disadvantage can appear, if you measure different instruments with a different calibration, because the measured curves will be displayed at a slightly different position along the Y-axis (the magnitude of the admittance has different values).

- If you want to compare curves measured with a different setting of the thumb wheel, you easily can do it by shifting the curves up or down at the display with the help of the arrow keys (see page 34 at the bottom)

  Recommended default of the thumb wheel position: ca. 3/4 of full scale (right position = 0, left position = 100%). It fits for the most instruments.

- Connect the VIAS-Interface Boxan to the USB-Port of your computer and wait some seconds till Windows has identified the device.

Sensor Mounting

Connection points of the sensor and excitation point:

In most cases it is advisable to perform an admittance measurement directly at the bridge of the instrument, in particular in the case of traditional string instruments.

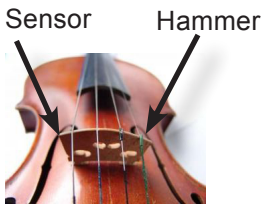
- To mount the accelerometer on the instrument:
  Use the beeswax or similar to mount the accelerometer, for instance, to the left upper border of the bridge of a violin (as seen by the player)

REMARK:

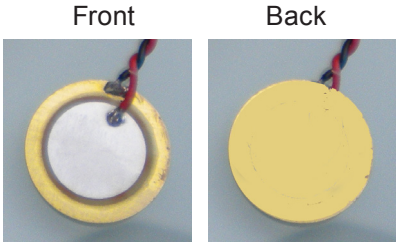
It is advisable to use beeswax or similar because it does not leave marks on the instrument. Furthermore, it is commonly accepted by the owners or players even of very precious instruments. The less beeswax you put on the wide side of the accelerometer, the better the contact. Unfortunately, the adhesiveness of the beeswax is reduced with high ambient temperatures.

As alternative a filmy(!) twin-sided adhesive tape or for instance photo stickers like "Fotoketts" from Avery-Zweckform (Article No. 3516) or Article No. 1070 from "Herma" can be used.

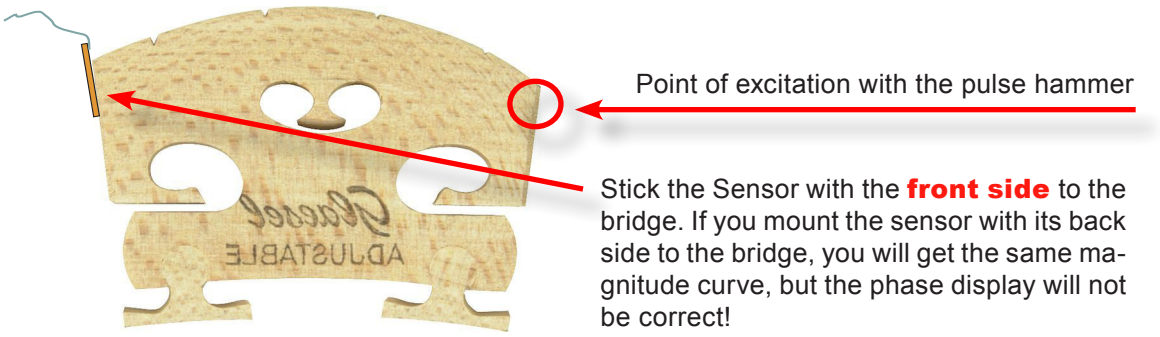
- Point of Excitation



- The Sensor



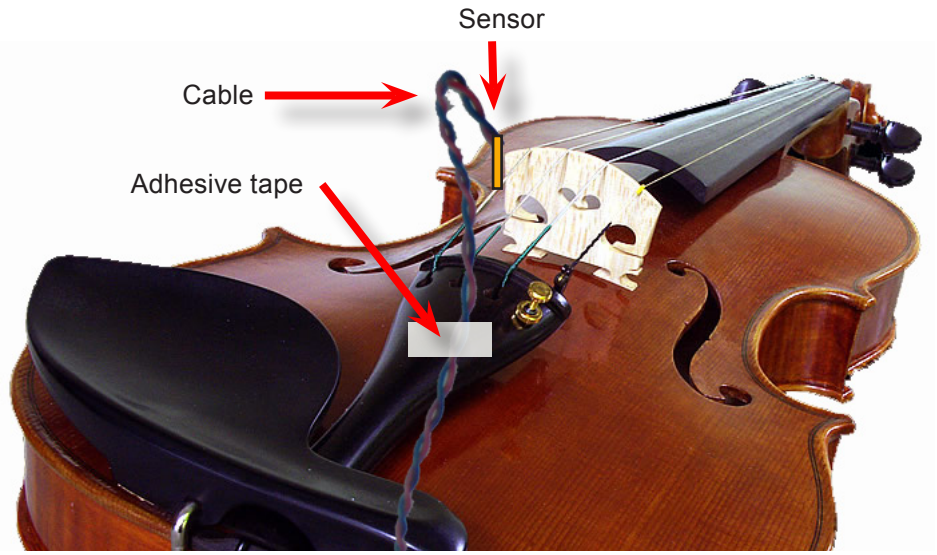
- Mounting the Sensor



Sensor Mounting - Damping the Strings

Hint:

The cable has much more "mass" than the sensor and its stiffness is relatively high. To avoid tensile forces on the sensor which could shift its position or peel it off the bridge, we recommend to fix the cable at the tail piece by an adhesive tape.

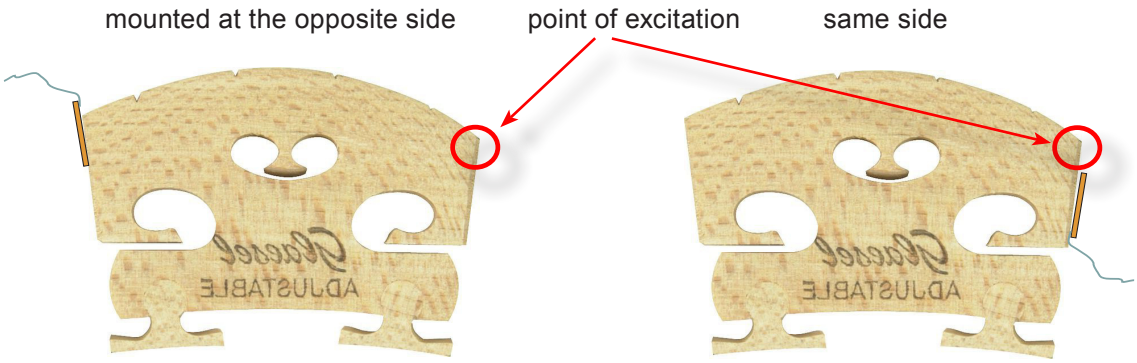


IMPORTANT:

The strings of the instrument have to be damped with a piece of foam. If this is not done, energy is withdrawn from the system at the resonance frequencies of the strings. This results in minima in the admittance curve that distort the final result!

16 Sensor Mounting for a correct PHASE display

To get correct phase data the sensor must be mounted with its correct side to the bridge. You can mount the sensor at the opposite side of the excitation (recommended) or at the same side of the bridge.



PCB System
Stick the sensor with the side where the "PCB" letters can be seen on the bridge.

PCB System
Use the side of the sensor where no letters are visible.

LC System
Use the front side to stick it to the bridge.

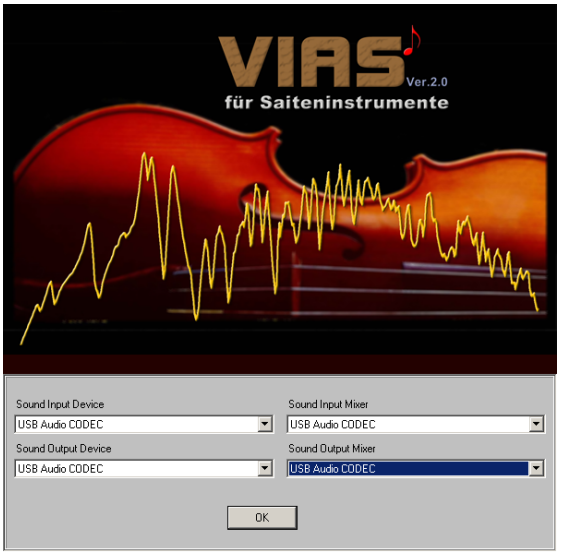
LC System
Use the back side to stick it to the bridge.

- **Start VIAS** as any other software by a click on the Windows Start button Start -> Program -> BIAS60 -> VIAS or use the shortcut at the desktop.

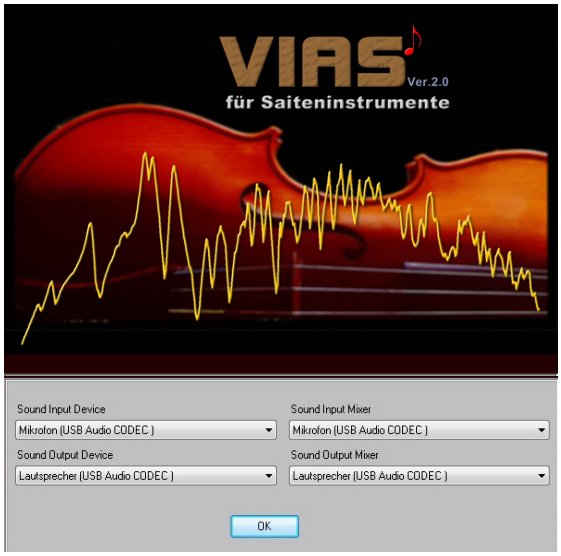
- If you want to measure, connect the interface box to your computer **before you start VIAS** (sensor and pulse hammer can be connected later).

- If you only want to analyze measurements or print out your curves it is not necessary to connect the interface box to the computer.

WINDOWS XP



WINDOWS 7



A "splash screen" appears and indicates which sound devices will be used for the data in- and outputs.

- If you connected the interface box already befor starting the VIAS software, Windows should have identified it as "**USB Audio CODEC**" (see figure above).

- If that was not the case, you have to choose it in the four drop down menus.
  Note that the name of the device associated with the interface box can depend on the Windows version you are using.

- Click on "OK" and the program starts.

WINDOWS 7:

Depending on your Microsoft Windows 7 version it can happen, that Windows 7 assigns wrong proprties to the interface box. Mostly "mono"= only one channel, and a lower bit rate. The correct properties are:
stereo, 2-channel, 16 Bit and 44.100 sampling rate.

See the separated manual "Windows 7 Guide".

ELEMENTS OF THE MAIN SCREEN

Oscilloscope window: Real time display of excitation and measured signal (time domain)

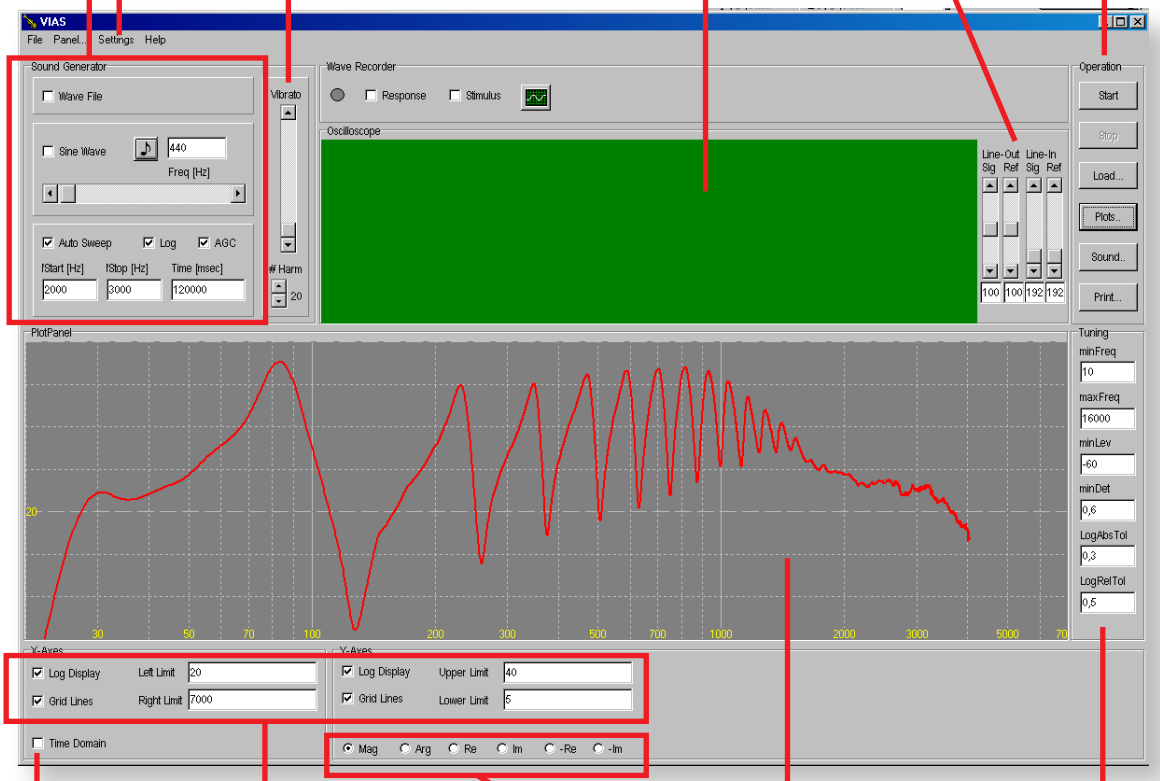
Selection of excitation signal

Menu bar

Settings for the virtual sound

Level selection for the excitation and measured signal

File management



Display area “Plot-Window”

Scaling and settings for X-axis and Y-axis

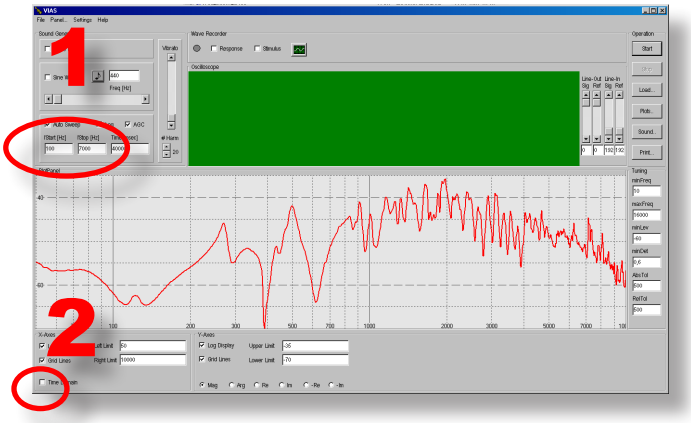
Selection of display between magnitude, phase, real and imaginary part

Check-box for starting the pulse hammer admittance measurement

Trigger and lock-in filter properties for the acquisition of the measured signal

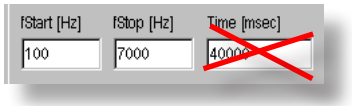
Note for first measurements:
For the time being, do not change any settings but use the defaults. In most cases the default settings are sufficient.

OVERVIEW ACQUISITION SCREEN



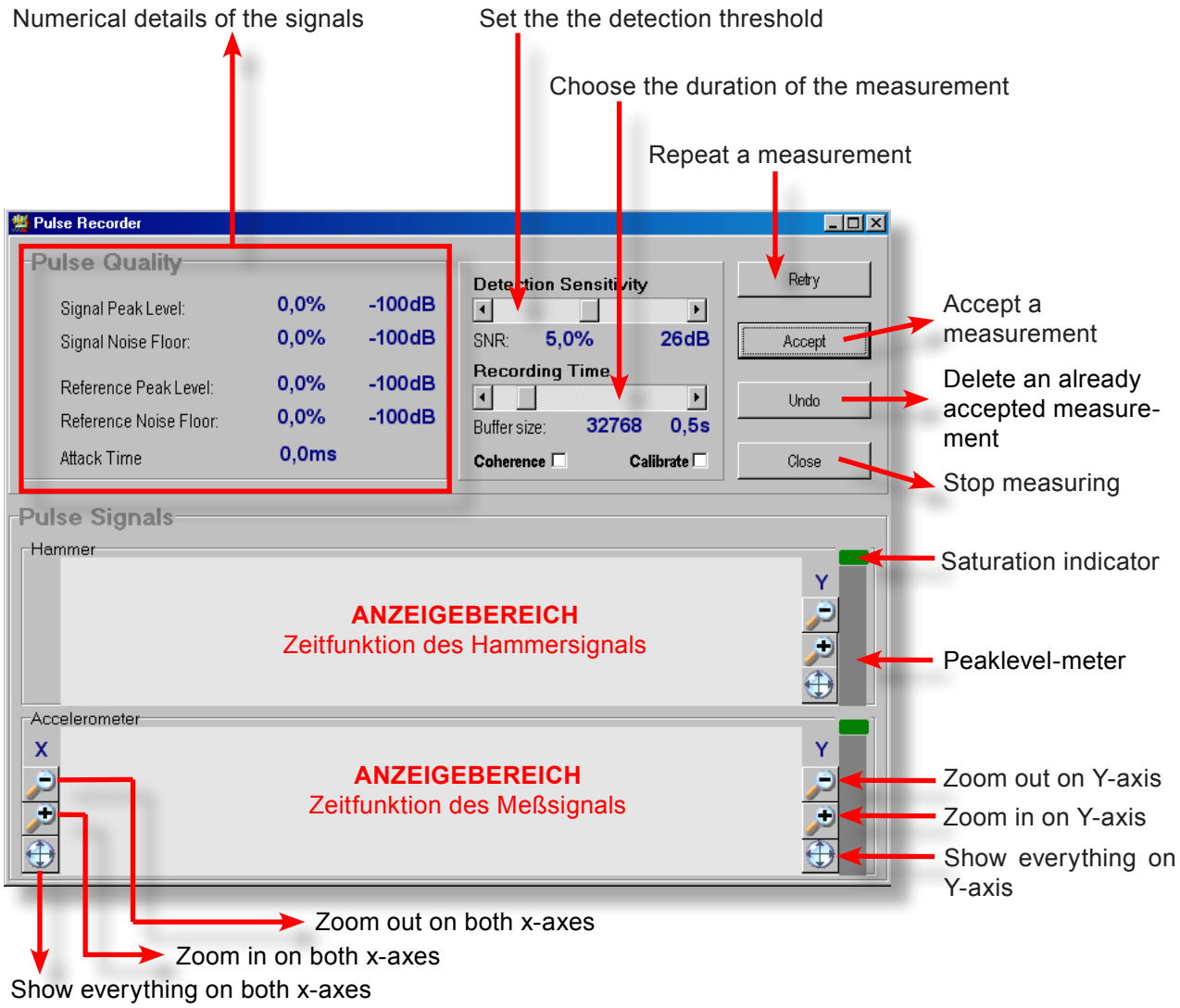
How to start a measurement:

1 Determine the frequency range for your measurement by choosing the start and end frequency.



2 Click at the checkbox " **Time Domain**" to open the measurement window. VIAS is now ready for an pulse hammer measurement in the time domain. Hit the excitation point with the hammer and you are **DONE!**

Elements of the Acquisition Screen



3 As soon as the measurement window is open, the **system is ready** for recording and expects a signal. Use the impulse hammer to knock lightly on the bridge. The trigger is released and the signals are recorded.

The measurement lasts about 1 second.

NOTE:
The force sensor on the impulse hammer is very sensitive. It is possible that a trigger impulse is already produced by merely picking up the hammer from a table.

If this happens, delete the measurement with the “Undo” button and click “Retry” to activate the system again.

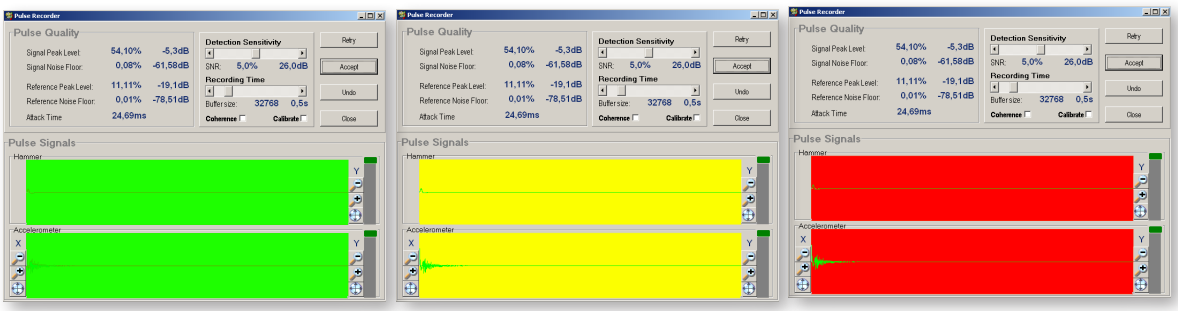
- **To check whether a measurement is useful:**

VIAS uses a colour coding to easily check the signals during a measurement. During a measurement the backgrounds of both display areas is:

GREEN if the signal strength is just about high enough to be useful. The impulse was too low and therefore the SNR is not optimal.

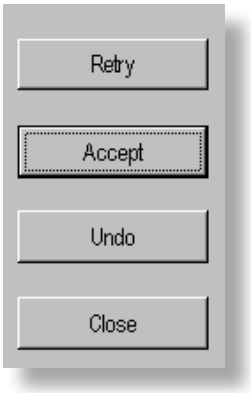
YELLOW f the signal strengths are optimal

RED if the measurement is saturated, as the signal strength was too high



4 If you are happy with your measurement you can click the "**Accept**" button or press the **Enter-key**. Consequently, the measurement is passed on to the VIAS main window. There you can edit or save the curve.

The **measuring window** will remain **open**, and you can continue measuring immediately



If you are not happy with a measurement you can either click on the "**Retry**" button or press the ESC-key to repeat the measurement.

The key "**Undo**" deletes a measurement that has already been passed on to VIAS with the "Accept" button. Thus, you do not have to close the measurement window to delete a measurement that has already been passed on.

The "**Close**" button closes the measurement window and brings you back to the VIAS main window

The buttons described above are useful for a one-person measurement. While you hold the violin in one hand, you can hold the impulse hammer in the other.

If a measurement is OK you can press the Enter-key with the hand that holds the impulse hammer, as the focus of the measurement window is set to the "Accept" button by default.

If a measurement is not OK, you can press the Arrow-Up-key to choose "Retry", and continue measuring.

We recommend to perform at least 5 measurements (better 10) at a time!

AVERAGING SEVERAL MEASUREMENTS

NOTE:

We recommend that you perform between 5-10 measurements. You can use these measurements to calculate an average curve with the “Average” command in the context menu of the VIAS main window.

EXPLANATION:

The measurement method is based on the assumption that a very short impulse contains all frequencies. However, the amplitude in the high frequency range is typically very small. Therefore, the measured curve is very noisy at higher frequencies and contains amplitude fluctuations.

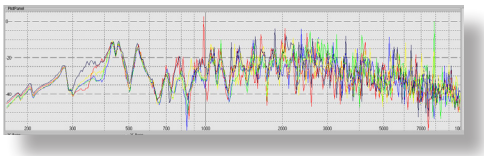
By computing the average from several measurements, these fluctuations are reduced and the reproducibility of the measurement is increased.

TIP:
Please note that the original curves are deleted by the “Average” command. **Only the new, average, curve is displayed.**

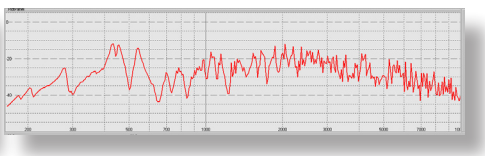
Therefore save the original curves before the calculating the average **if they are needed for later use**.

- **To calculate the average of all curves shown in the display area:**

  Right click anywhere in the **display area** and select the command “**Average**”.



The 5 original curves

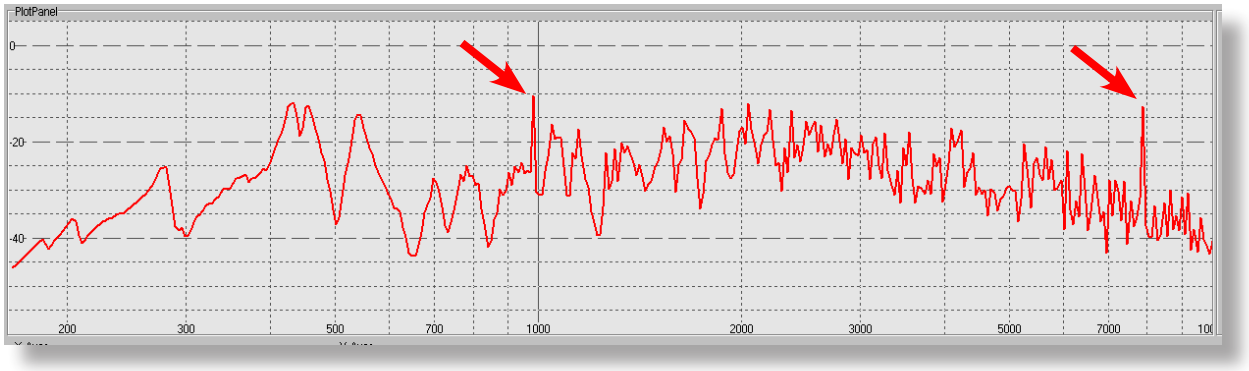


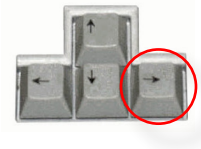
the average curve

SMOOTHING TO CORRECT ERRORS

Curve averaging and smoothing: An example

After calculating the average curve as described above, there are two measurement errors (peaks at 1 kHz and 8 kHz).

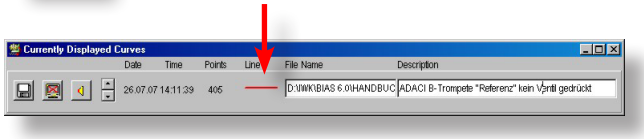


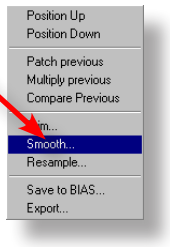


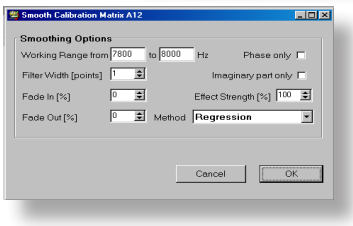
- Press the right arrow key several times to activate the cursor. Determine in which frequency range(s) smoothing has to be performed. In the above curve the first range is between 950 Hz and 1000 Hz, and the second range is between 7800 Hz and 8000 Hz.

- Click on the “Plots” button (in the upper right hand corner) to list the average curve.

- Right click on the coloured line to open the context menu, and select the command “Smooth”.

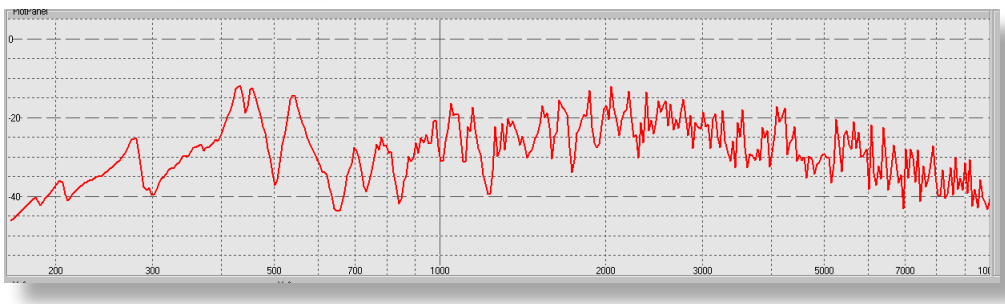






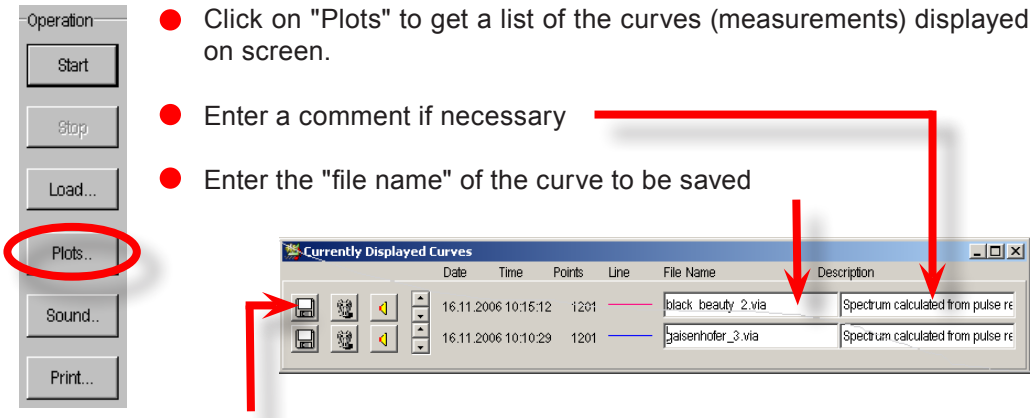
- Enter the frequency range and choose a filter width of **1** point. Then click on the “**OK**” button. Repeat the same procedure for the second frequency range

- Save the resulting curve by clicking on the disk icon



Result

Save measurement

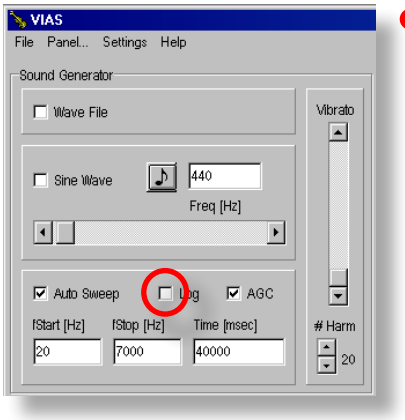


- Click on "Plots" to get a list of the curves (measurements) displayed on screen.
- Enter a comment if necessary
- Enter the "file name" of the curve to be saved
- Click on the diskette symbol to save the measurement

Axes scaling

The X-axis (frequency) scale is by default set to logarithmic. That is: In the low frequency range there are more measuring points (higher resolution), than in the high one (lower resolution).

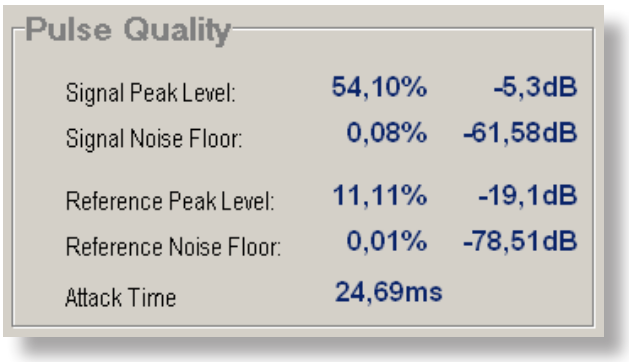
If for any reason you need to have the same resolution in the whole frequency range, you have to uncheck the box marked “Log” before opening the measuring window.



- **How to measure with a linear frequency resolution:**

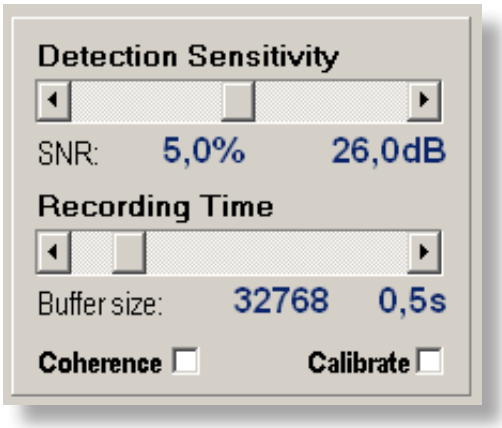
Disable the logarithmic scaling by unchecking the box “Log”.

A further click on this box will enable the logarithmic scaling and will be again the standard scaling for all following measurements.



The details are self explanatory (see picture).

Apart from the signal levels and the SNR of the reference and measured signals, the impulse duration is also measured and specified.



The trigger sensitivity (from which signal strength the measuring process will start) is specified with the scrolling bar marked "**Detection Sensitivity**". The standard setting is 5% of the maximum level.

The **Recording Time** (how long the measured signal will be recorded) is set with the scrolling bar marked "Recording Time".

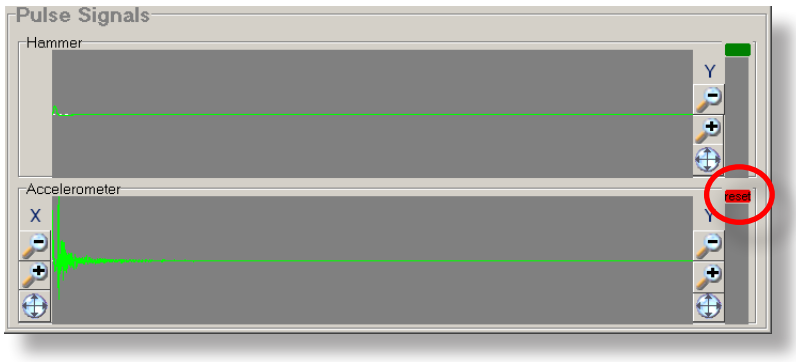
The standard setting of 0.5 seconds works fine for violins. For instruments whose decay time is longer (e.g. Guitars), zoom in the Y-axis to see if the signal is cut off at the end of the measurement, in which case you can just increase the recording time.

If the box marked "**Coherence**" is checked before a measurement takes place, the following curves will be generated and passed on to VIAS: two auto power spectra, a cross power spectrum, a coherence spectrum and the admittance curve (5 curves in total). This calculation takes place as soon as you press the "Accept" button.

WARNING:

This works only if you have checked the box "Response" (in the top middle of the VIAS screen, see page 31) before opening the measuring window. This will record the signals as .wav files

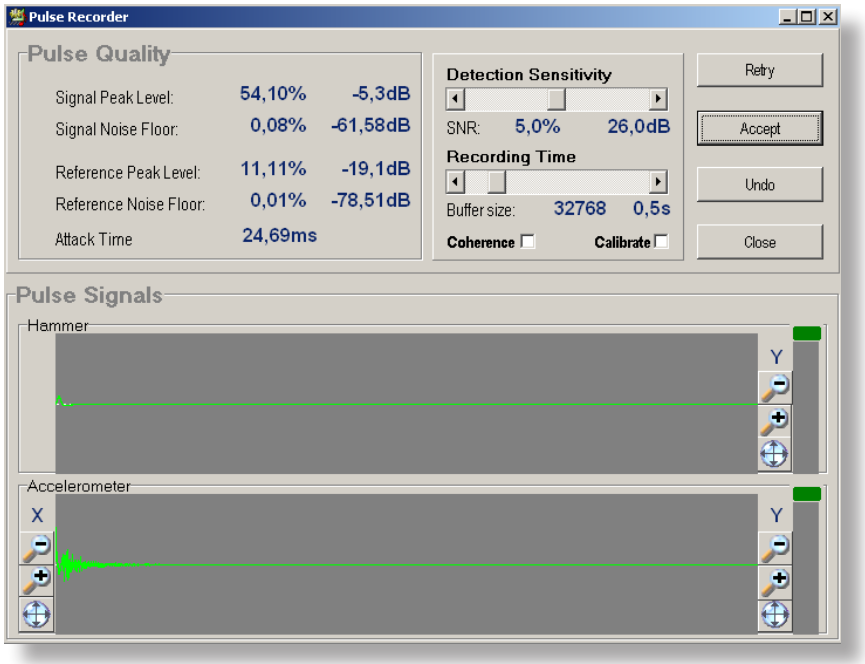
Calibrate: This command is explained in an separate document. Please do not use it for the time being!!!



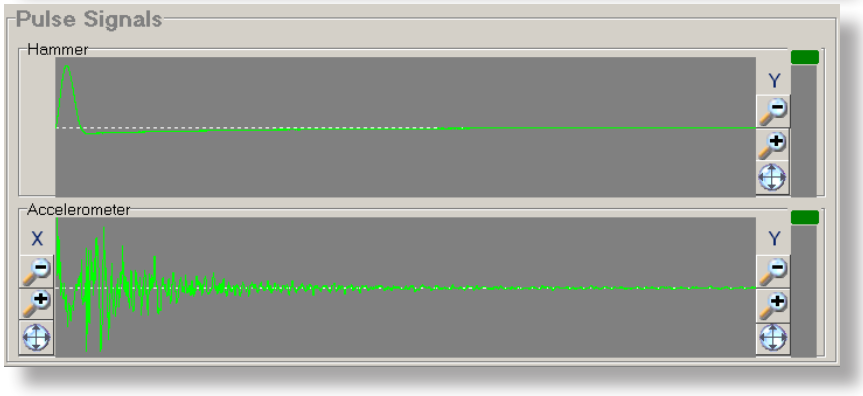
Display area

When one of the signals saturates, two things will happen: 1. the display area will be shortly coloured in red, and 2. the corresponding peak level meter will be marked red, and will stay red to show that there was saturation during the measurement (see picture).

The Zoom functions are self explanatory. While zooming in the Y-axes, the X-axis settings for both channels will remain unchanged.



Normal display



Y-axis zoomed in

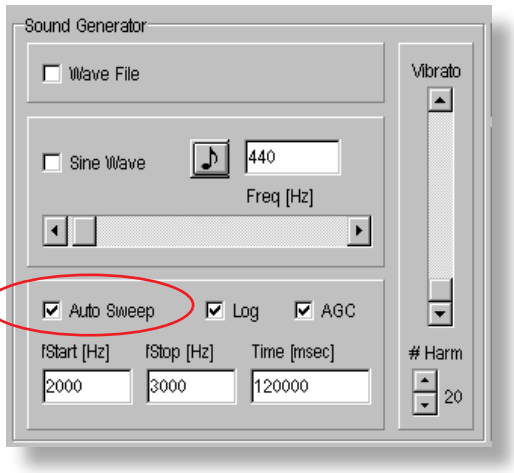
Apart from using an impulsive excitation, a sinusoidal excitation is also possible by using e.g. a shaker. In this case, the sinusoidal sweep generated by VIAS is used.

HARDWARE SETUP

The set up is similar to that of the impulse hammer setup. You need to have a shaker (any brand) instead of an impulse hammer. The shaker receives the excitation signal (e.g. a sinusoidal sweep) from VIAS via the output 1 or 2 of the ROGA amplifier. As the voltage delivered by the ROGA is very small, you need to add another amplifier in between the ROGA and the shaker.

To get a measurement as meaningful as possible, you should add a force sensor between the shaker and the object to be measured (see picture).

To select the excitation signal:



- Normally, a sinusoidal sweep will be used as excitation signal. In this case, the box “Auto Sweep” should be checked.
- Choose between a logarithmic or linear sweep.

  This selection depends on the desired result: A logarithmic sweep is usually recommended, as it gives enough time for the generation of standing waves in lower frequencies, and it is musically relevant, since it corresponds to the way pitch and musical intervals are perceived.

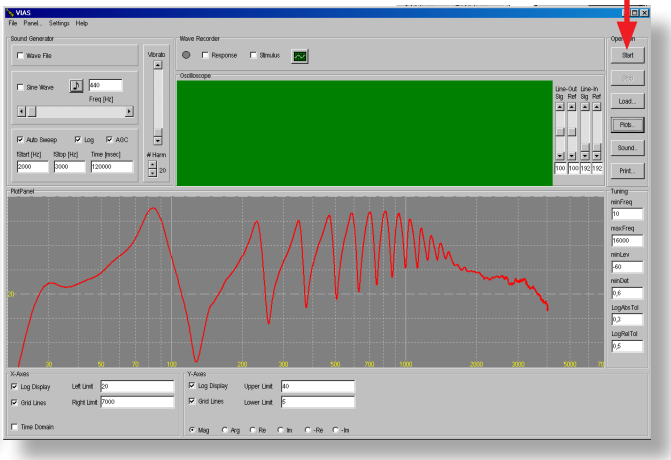
  If you need a specific accuracy in high frequencies, the linear sweep is recommended – In any case, you should allow enough time to achieve the desired resolution: e.g.: 5 minutes = 300,000 ms
- Type the start and stop frequencies in both fields **fStart** and **fStop**, in the range from 0 to 20,000 Hz. In the shown picture, the measurement will be done between 2 kHz and 3 kHz.
- Type the duration of the sweep (in milliseconds) in the field **Time**. In the shown picture, the duration of the measurement is 2 minutes (=120,000 ms) for a range of 1 kHz
- For short sweeps (less than 5 minutes for 0 – 20 kHz), the AGS sometimes does not work properly.
- Start the measurement by clicking the “Start” button.

WARNING!

Whenever the shaker is used as exciter, the previously set calibration data will be deleted!

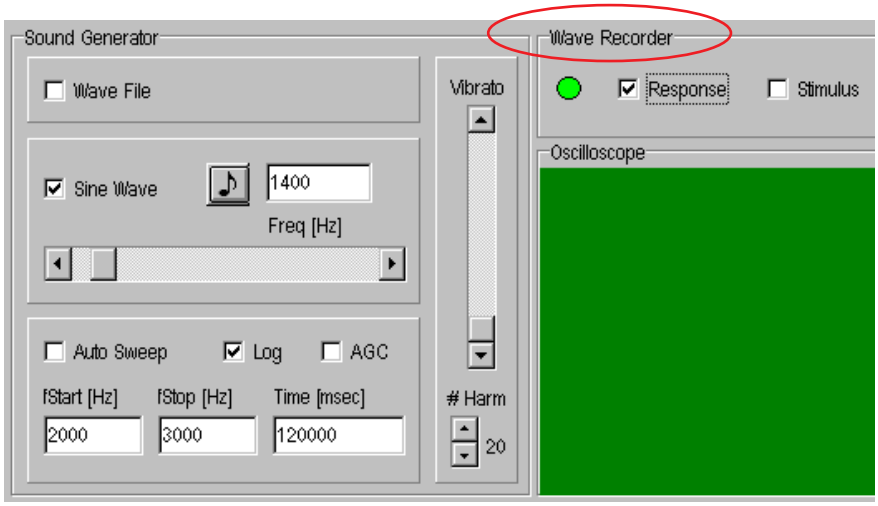
To perform BIAS measurements afterwards, the ***BIAS .cal file*** *must be imported first.*

If no force sensor is to be used, the shaker input signal should be set as reference signal.



Show measured signals in Microsoft .wav format:

Excitation and measured signals can be played and saved as .wav files. Therefore, they can be processed as sound files, used for the calculation of a coherence-, cross- or auto- spectrum, used for other purposes, or simply played back.



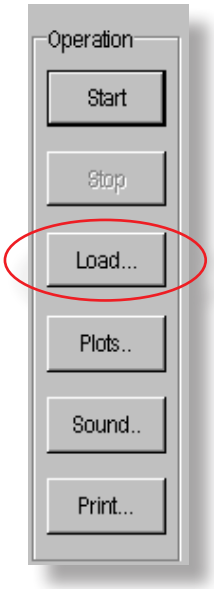
- By checking the box “Response”, the wave recorder is activated, and a new window opens where you can choose the name of the file and the directory where the displayed measured signal will be saved.

  This results in a stereo .wav file, one of the channels being the reference signal from the force sensor on the impulse hammer, and the other the measured signal from the accelerometer on the bridge.

- If you wish to choose the function “Coherence” in the measuring window, the Wave-Recorder must be activated.

- The box “Stimulus” is deactivated during measurements with the impulse hammer.

LOAD MEASUREMENT



Load...

Click on the “Load” button, and a new dialog window will open, where you can load a measurement that was saved previously. It will be displayed in the “Plot-Panel”, along with other current measurements.

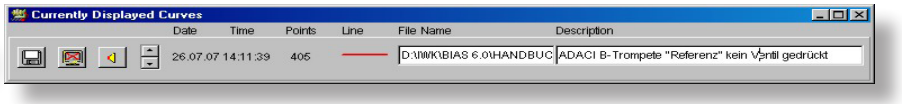
You can also load, show and work with BIAS or .wav files

NOTE: The buttons “Start” and “Stop” are only used for BIAS measurements, and have no effect for impulse hammer admittance measurements!

LIST CURVES

Plots...

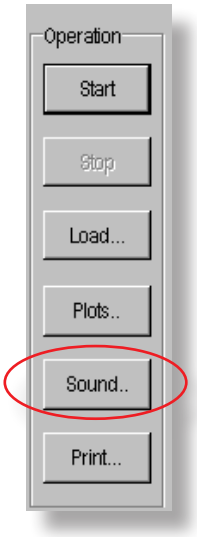
The “Currently Displayed Curves” window will open after clicking on the “Plots” button.



This window shows the currently displayed curves. Apart from being able to save or delete measurements, this window also:

- gives detailed information about each displayed measurement,
- allows you to manipulate the plots,
- is the starting point for multiple analysis, and
- allows you to manipulate and post process the data

SOUND ANALYSIS



Sound...

- To open the sound analysis window, click on the “Sound” button (see Sound Analysis, page XXX).

PRINTING

- Use this command to print the contents of the “Plot” window

Print...

List displayed / loaded curves

This window opens automatically after clicking on the “PLOTS” button

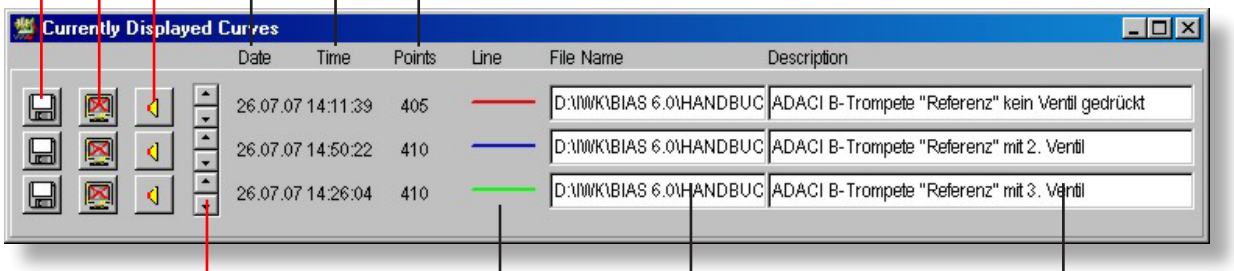
SAVE
- New measurements are saved
- If the curve has already been saved or loaded, all the changes will be saved after clicking “OK” in the confirmation dialogue.

DELETE
- New non-saved measurements will be deleted!
- Already saved or loaded curves will be removed from the Plot window

PLAY BACK SOUND
Generates a sound based on the measured curve, according to the properties set in the window where the excitation signal was chosen

Date and time when the measurement was done

Number of measured points in the curve



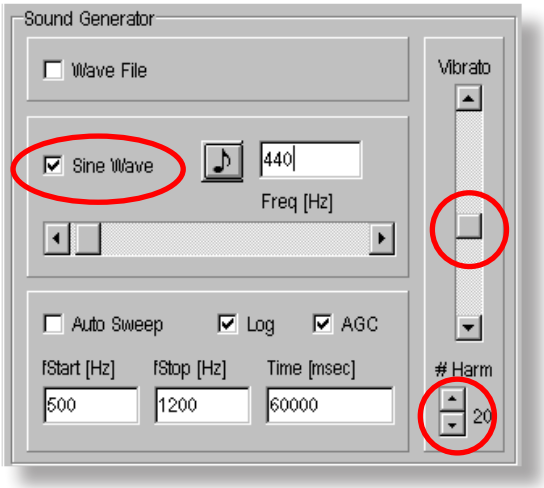
Line style, colour and thickness

File name, including path

Editable comments

SHIFTING
Shifts (without changing the data) the curve along the Y-axis in the Plot window, for ease of comparison

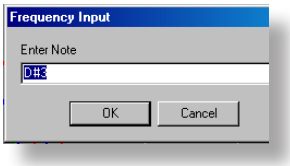
Playback simulated sounds



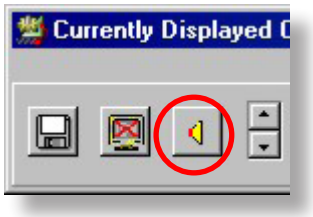
How to choose the sound parameters:

- Click on the box “Sine Wave” if you would like a tone, or in the box “Auto Sweep” if you would like a frequency sweep (the current Start- and Stop frequencies apply, as well as the time duration settings)

- If you click on the musical note icon, you can write the name of the note (CAUTION: American notation! **A4 = a^1**)



- The degree of vibrato can be set with the “Vibrato” scrolling bar.



- With the arrow boxes marked “**# Harm**” under the vibrato scrolling bar, you can choose the number of harmonics (1-99) that the sound will have

- Click on the speaker icon to hear the curve. Click again to stop the sound generator.

NOTE:
You can choose the number of harmonics the sound should have, but bear in mind that if you choose e.g. 60, only the first 22 will have an effect on the sound, if the admittance curve does not show any significant data above partial 22.

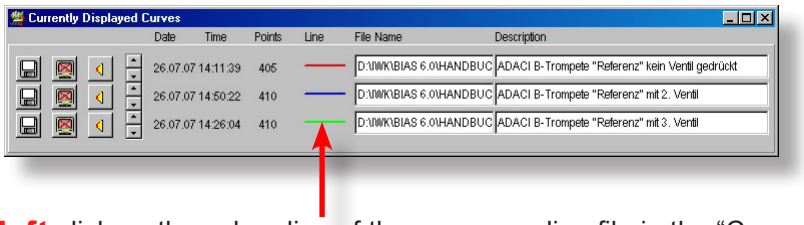
HINT FOR IMPULSE HAMMER MEASUREMENTS:
To be able to hear the “virtual sound”, you have to disconnect the “ROGA USB amplifier” from your computer first (simply pull out the USB cable!).

HINT FOR SHAKER MEASUREMENTS:
Usually, VIAS sends the excitation signal to the amplifier/shaker and the “virtual” sound to the sound card of your computer. Whether this works depends mainly on which sound card drivers are installed, and on which USB amplifier you are using.

In case the sound is mistakenly played through the shaker, choose the following command: Panel ... -> Options -> Properties. Here you can set the sound card as output device. If this does not help, disconnect the amplifier and shaker from the computer, so that the sound card is the only remaining output device in your computer

CHANGING THE PROPERTIES OF CURVES

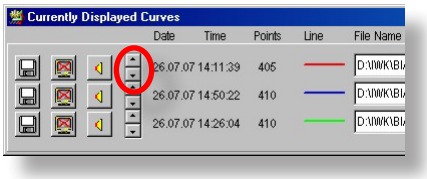
How to change the colour of a curve:



Simply **left** click on the colour line of the corresponding file in the “Currently Displayed Curves” window.

A window will appear where you can choose (or generate and add) any colour.

How to shift a curve without changing the data:



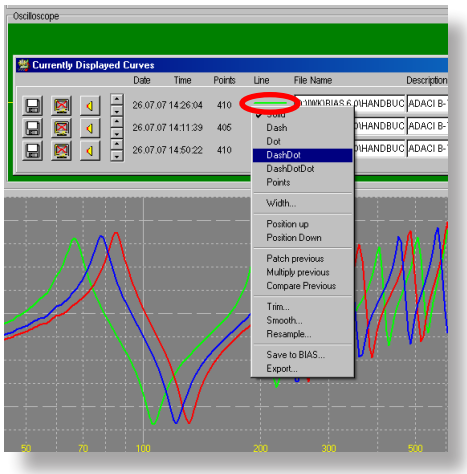
For ease of comparison, you can shift the curve up or down on the Y-axis by clicking on the arrows, without changing the data

HINT:

All changes apply only to the curve that corresponds to the colour line you clicked!

CONTEXT MENU

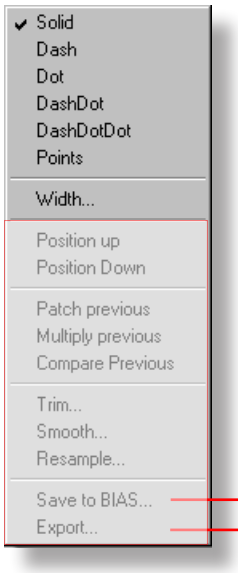
- **How to open the context menu:**



Right click on the colour line of a file in the “Currently displayed Curves” window

The context menu is divided in several areas:

The relevant commands needed to change the curve diagram are located on the top area of the Context Menu.



Curve representation:
Line style (solid, dotted, dashed, etc.). The line width is specified with numerical values.

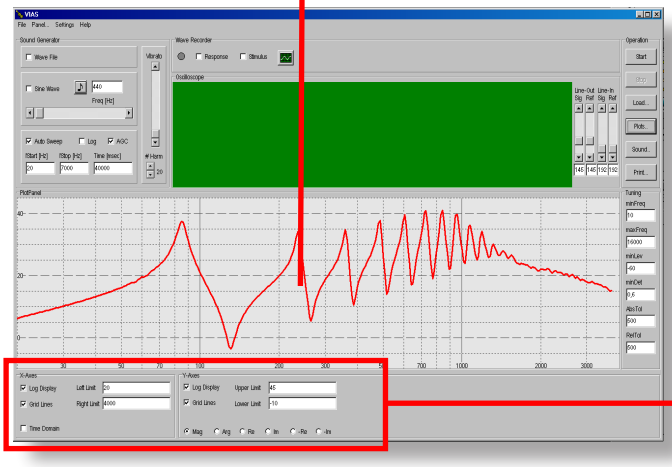
Data manipulation (Post Processing) **for further analyses (see page 52 - 65)**

Export the curve in the BIAS database
Export the curve in ASCII format

HINT:

All changes apply only to the curve that corresponds to the colour line you clicked!

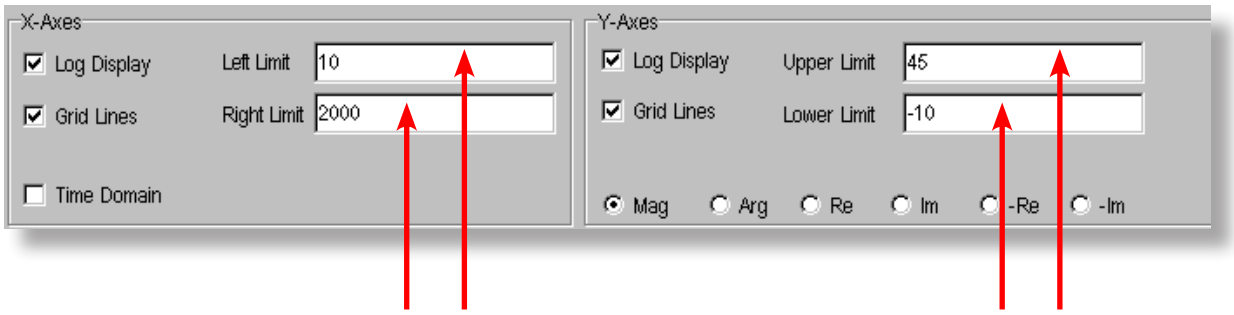
Display area (Plot window)



All parameters can be fast and easily changed by typing the appropriate values in the setting fields located below the display area

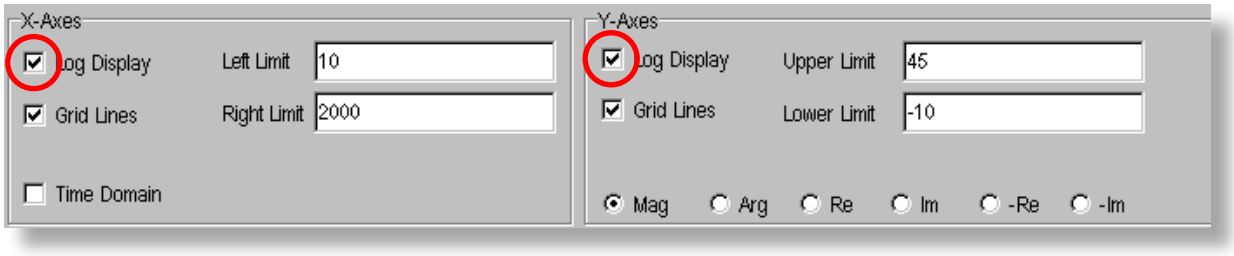
Area to set the display parameters

- Setting the frequency range (X-axis) and the impedance values (Y-axis)



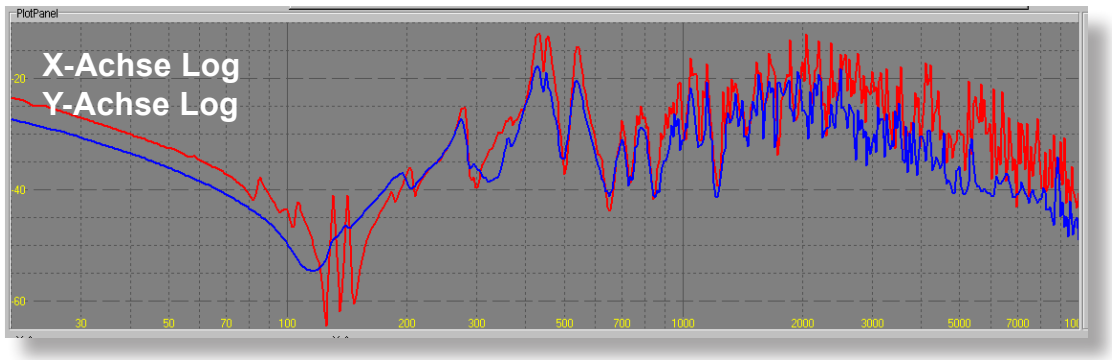
Simply double click in the field, and type the desired frequency and impedance range

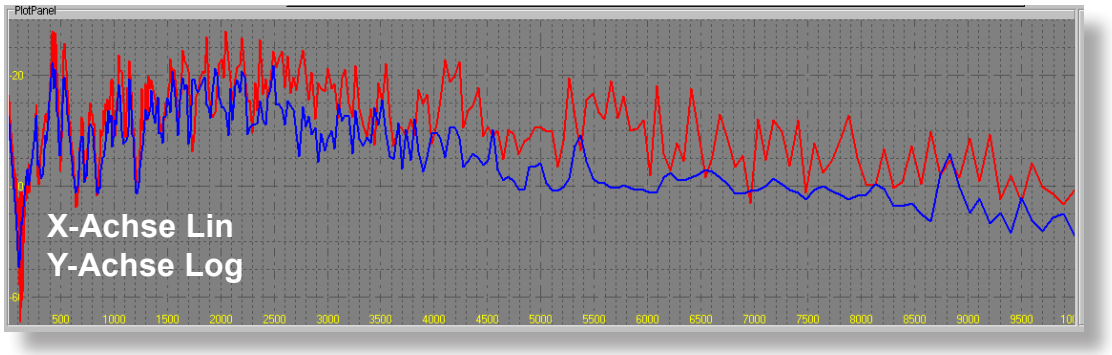
- Alternative between logarithmic and linear scale for both axes

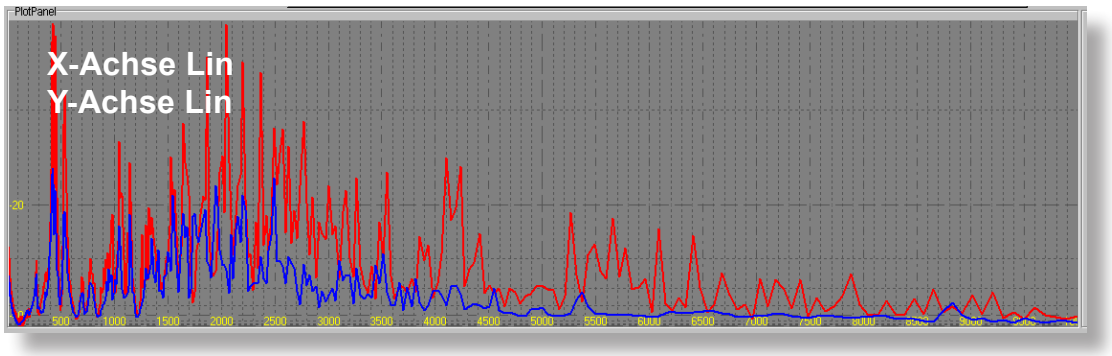


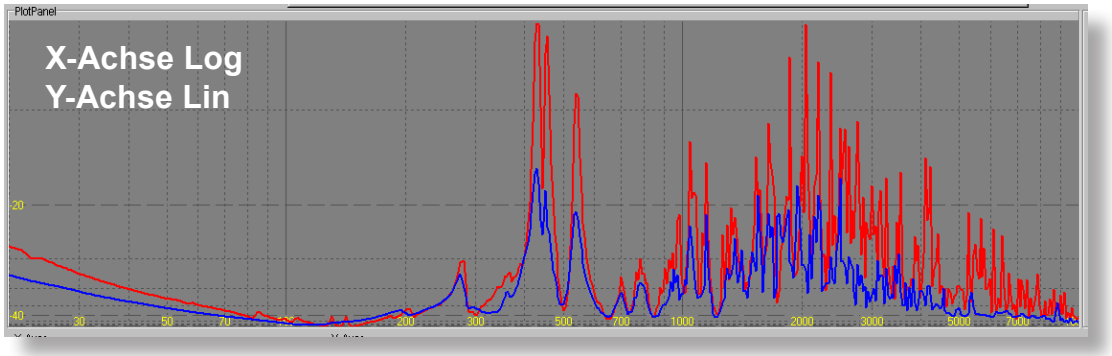
Click on the box to turn the logarithmic scale on/off

Scaling alternatives: Logarithmic – Linear



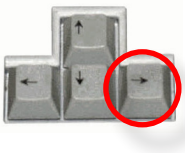




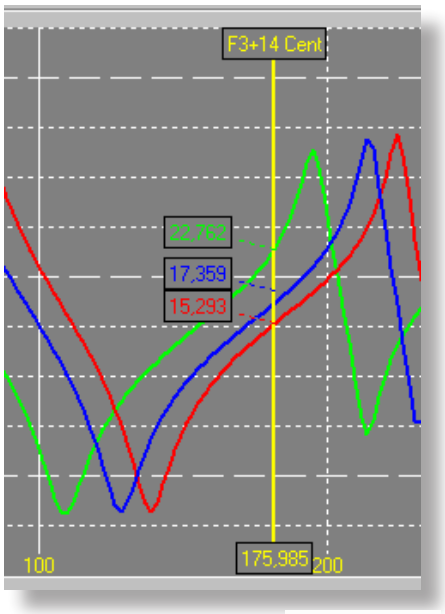


Retrieve the cursor:

Alternative 1: Move the mouse pointer to the left border of the display area, until it becomes a double arrow. Then left click and drag to the right: The cursor will appear.



Alternative 2: Strike the right arrow key (on the keyboard) several times. The cursor will appear in the left border of the display area



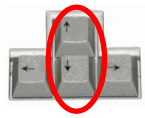
- The cursor reads all the impedance values of the displayed curves at the same time, and shows them in the colour of the curve to which each value corresponds

- The bottom field gives the current frequency value, the top field the corresponding musical note (in american notation $a^4 = a^1$) and the deviation in cents from an equally tempered scale, tuned at 440 Hz.

The reference frequency of 440 Hz (standard pitch) can be adjusted with the scrolling bar (below the input field). Clicking on the corresponding arrows will change the frequency in 1/10 Hz steps.

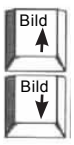
- The cursor can also be moved using the arrow keys from the keyboard

Move the cursor to the right or left with these two keys



Press the **"up arrow"** key to move the cursor to the next impedance **maximum** (peak)

Press the **"down arrow"** key to move the cursor to the next impedance **minimum** (valley). The movement of the cursor is always from left to right! If you would like to detect the maxima or minima, you should start with the cursor on the far left.



Press the **"Page up"** and **"Page down"** buttons to move the cursor to 2, 3, 4, etc. times the initial frequency. This is useful to detect harmonicity of the impedance peaks

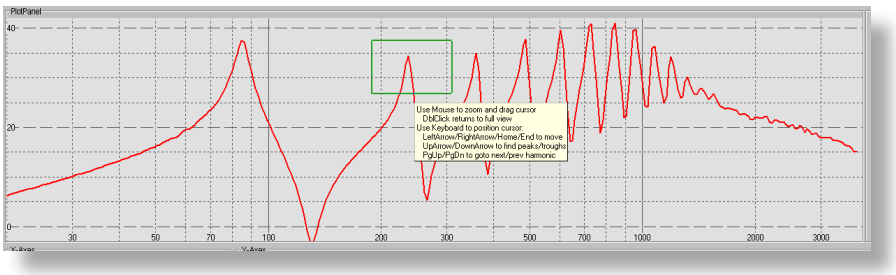
Admittance curves from bowed string instruments have pronounced maxima and minima.

If you would like to detect only the most important peaks, you should smooth the curve with the command “Smooth” in the context menu (see page 60).

All values read by the cursor will be loaded automatically in the windows Clipboard. You can simply paste all maxima, minima or other values on arbitrary points of the curve in a text editor or spread sheet for further work.

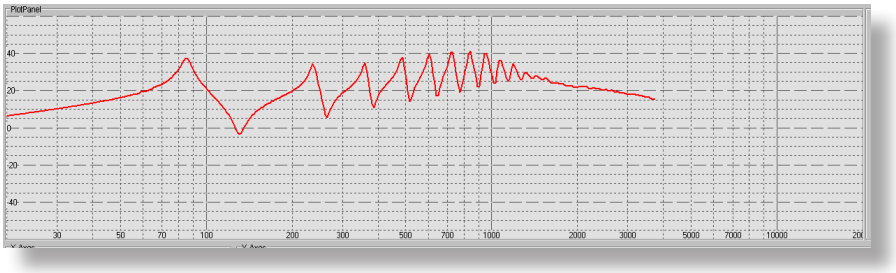
Zoom in

Use the mouse pointer to drag a rectangle around the region into which you want to zoom.



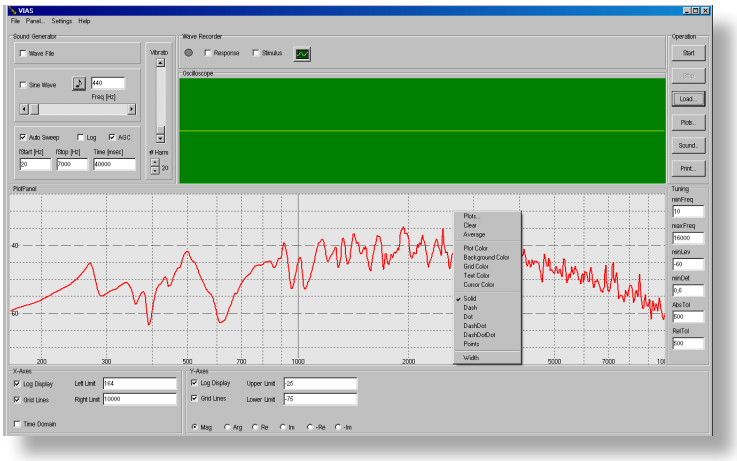
Zoom out

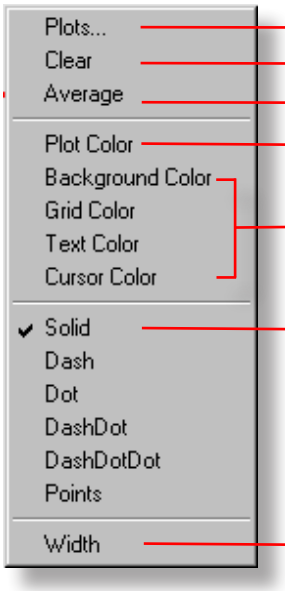
Double click on the display area, to restore the display back to the standard setting.



Right click anywhere in the display area to open the context menu.

The first three commands in the context menu refer to the curves currently displayed in the display area. All other commands refer to the curves of future measurements.





Choose a colour for the next measurement.

Background colour, grid colour, text colour, cursor colour.

Choose a line type for the next measurement.

Choose a line width for the next measurement.

Action: Opens the "currently displayed curves" window which lists the currently loaded files.

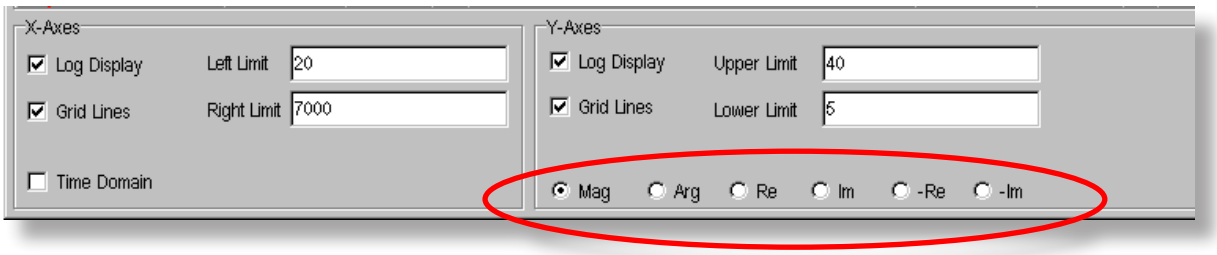
Action: Deletes all curves from the display area.

Action: Calculates the mean value of all displayed curves and display it as a new curve.

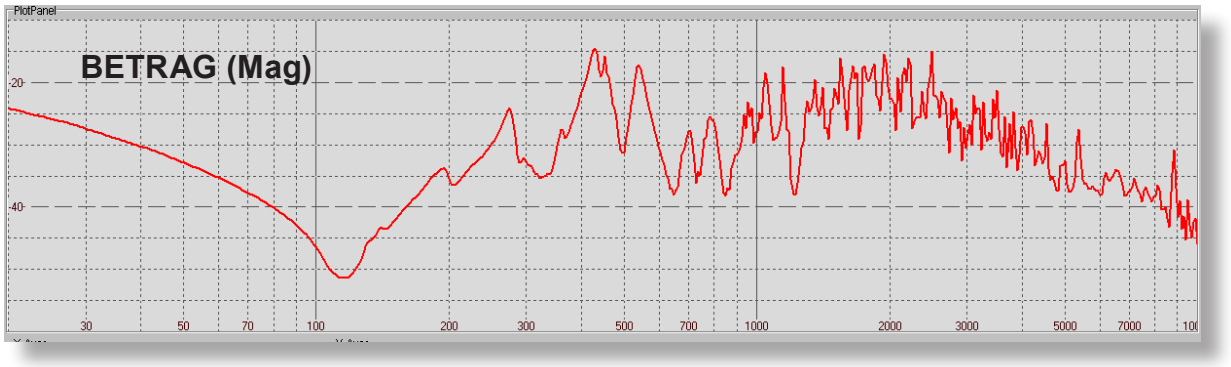
TIP:

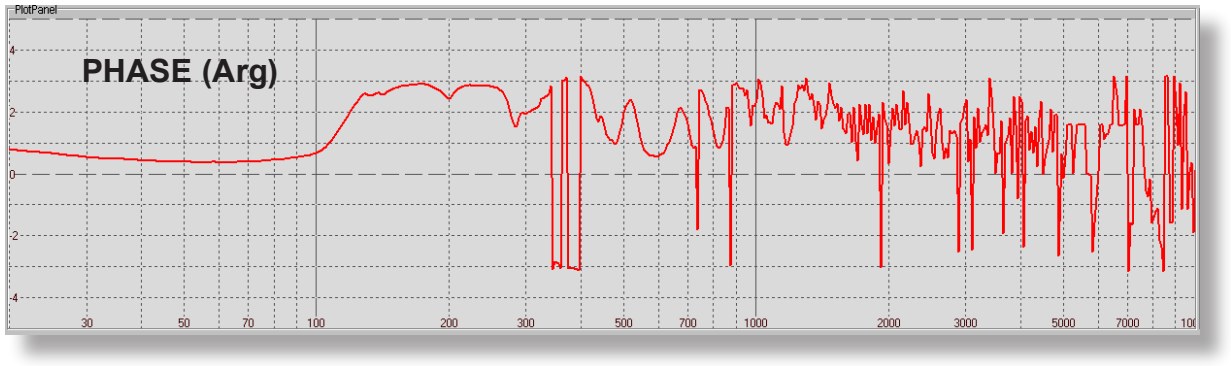
Bear in mind that when the mean value is calculated, the original signals are deleted from memory, and only the **new averaged curve will be displayed.**

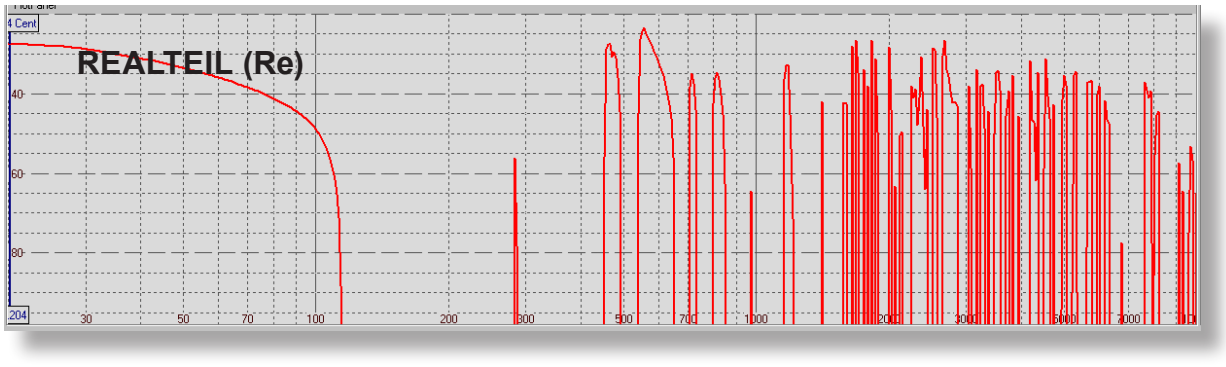
If you have not saved the original curves yet, you should do it before performing this command!

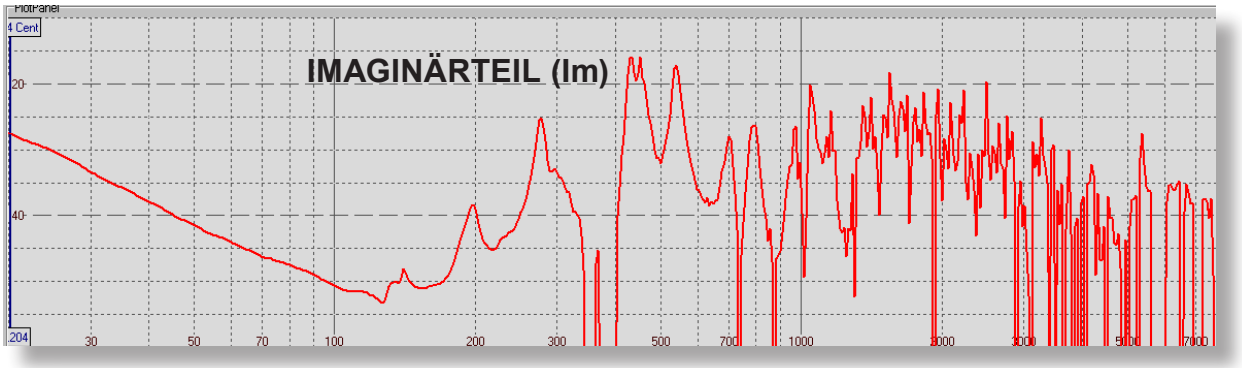


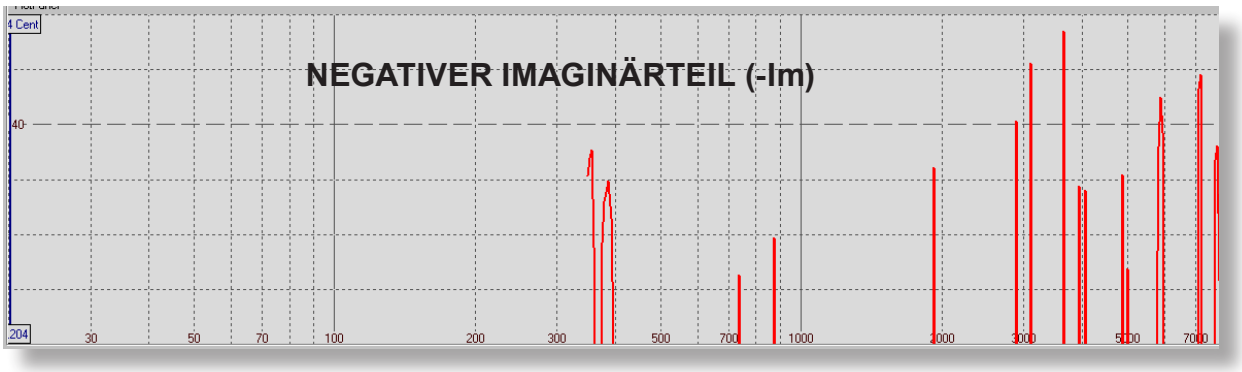
Click on the appropriate radio button to choose the desired display mode.

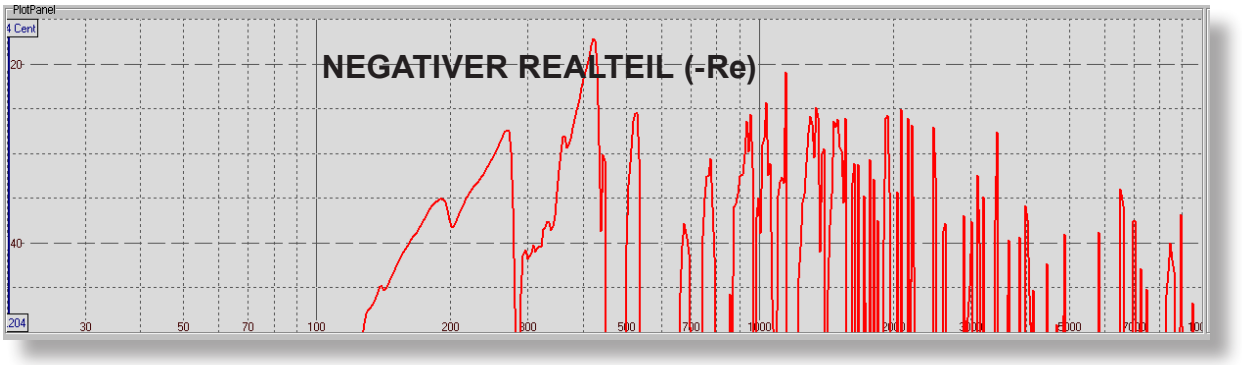












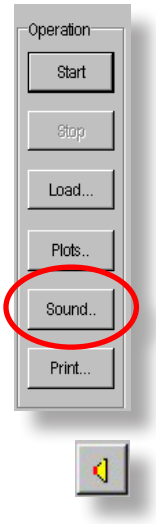
NOTE:

Normally an input impedance curve does not show a negative real part. If this ever occurs, effective power flows from the measured system back into the exciter. However, the reason for this is usually that there is some problem with the measurement conditions.

Possible error sources: The sweep moves too fast across sharp resonances, the polarity of a signal is inverted, there are phase shifts in an external signal amplifier or in the sound card.

Of course, arbitrary curves, such as the difference of two curves, can show a negative real part!

START SOUND ANALYSIS



- **To start the sound analysis**
  click on the button "Sound"

- The sound analysis will only be shown **for one curve**, no matter how many curves you are currently displaying.

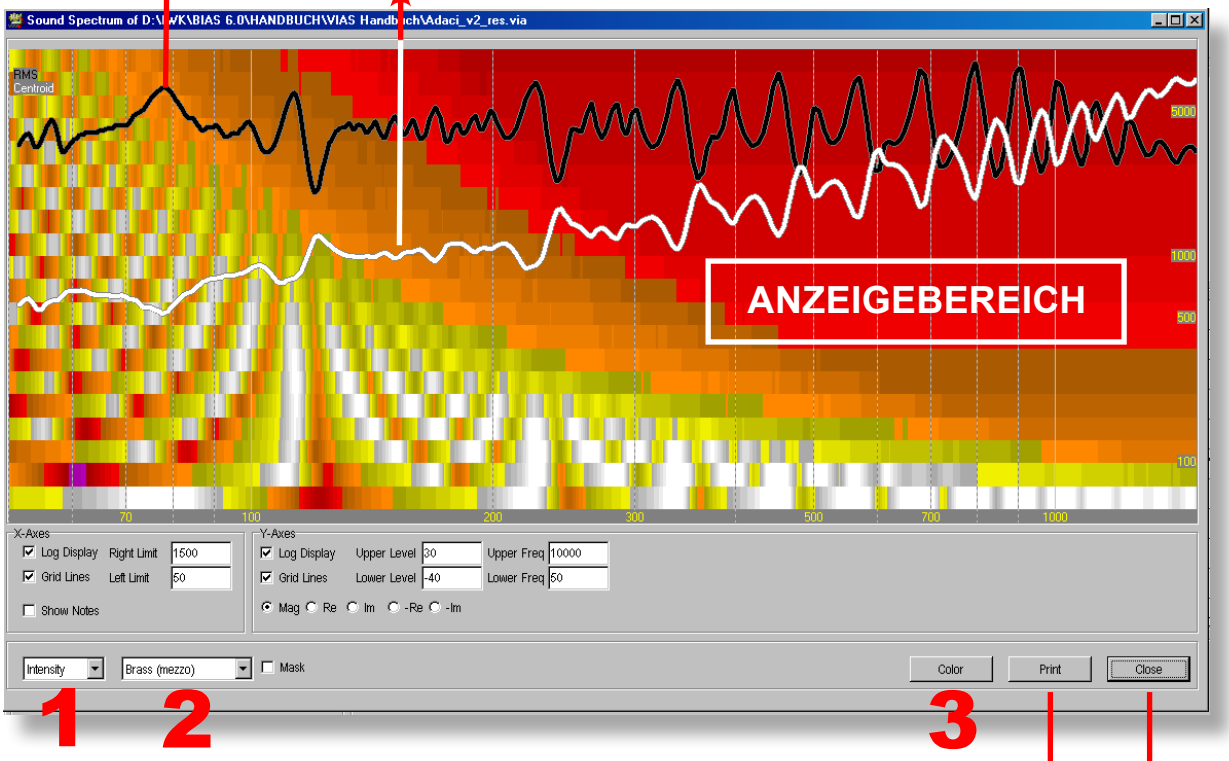
- The sound analysis for the **last active** curve will be displayed.

- **To choose a particular measurement for sound analysis:**

In the “Currently displayed Curves” window click on the speaker icon which belongs to the measurement you wish to analyse. A subsequent single click on the “Sound” button opens the sound analysis window.

RMS: relative dB values of the emitted sound level vs. frequency or note.

Harmonic Centroid (sound balance point) for every note (right Y-axis)



prints the contents of a display area

closes the sound analysis window

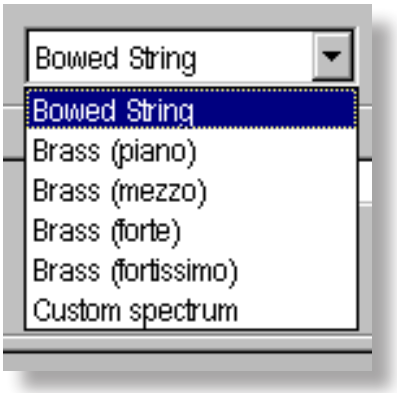
SOUND ANALYSIS - Modes of Display

1

Display Style

You can choose between a line spectrum (“Lines”), an area spectrum (“Areas”) or a spectrogram (“Intensity”).

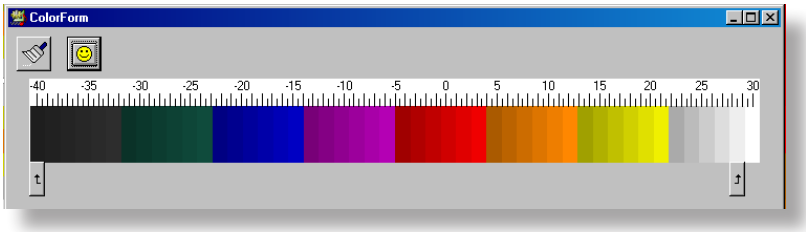
2



Sound Formation

With this drop down menu you can choose the number and weight of the harmonics in the produced sound.

3



Colour Coding

Using the two arrows, you can assign colours to the different intensity degrees (in dB).

Axes scaling for the Display Area:

Y Axis: Left: Partials from bottom to top (the shown picture depicts 20 partials)
Right: Frequency in Hz, logarithmic

X-Axis: Frequency in Hz or musical note
Linear or logarithmic

NOTE:
All available setting fields, e.g. Mag, Re, Im, etc., always work, but it does not always make sense to use them.

"**Mag**“ displays the magnitude spectrum,
"**Re**“ displays the real active component (= radiated or dissipated part),
"**Im**“ displays the imaginary reactive component (= part that is not radiated or dissipated)

SOUND ANALYSIS - Modes of Display

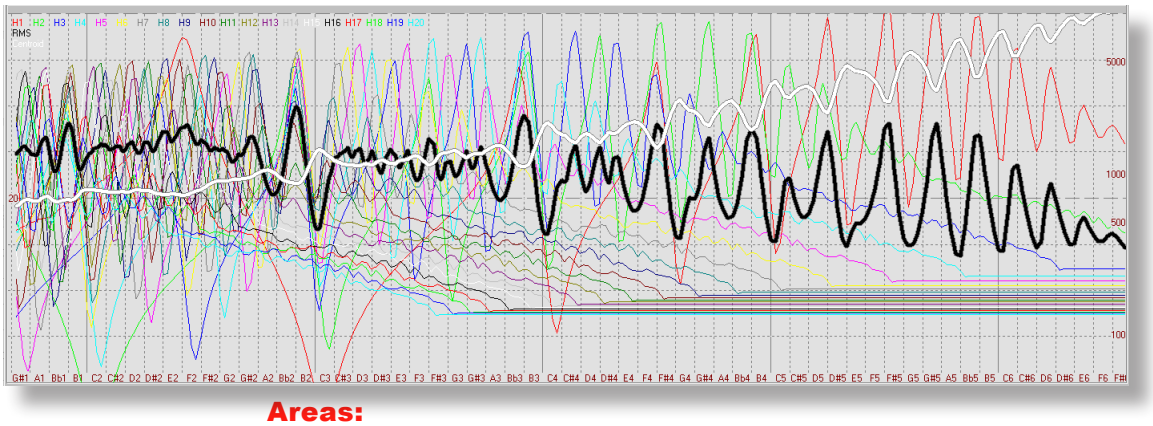
1

Here you can choose between three **different display options** for the analysed virtual sound of the instrument.

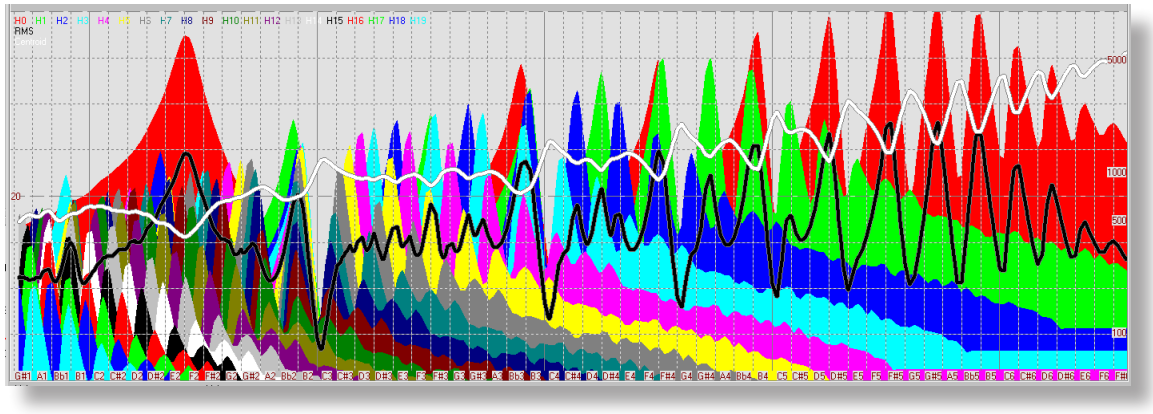
Lines:
X-axis: Frequency in Hz (linear or logarithmic) or musical note
Y-axis (left): Strength of the partial in dB (relative unit)
Y-axis (right): Frequency in Hz (logarithmic) of the harmonic centroid

The lines represent the contribution of each partial in the total spectrum for each frequency point or musical note.

The legends can be found on the top left corner of the display area. H1 specifies the colour of the first partial (=fundamental), H2 of the second partial, etc.



Areas:
Same as with “Lines”, but a colour area is displayed for each partial, instead of just a line. Higher partials are displayed on top of lower ones.



SOUND ANALYSIS - Modes of Display

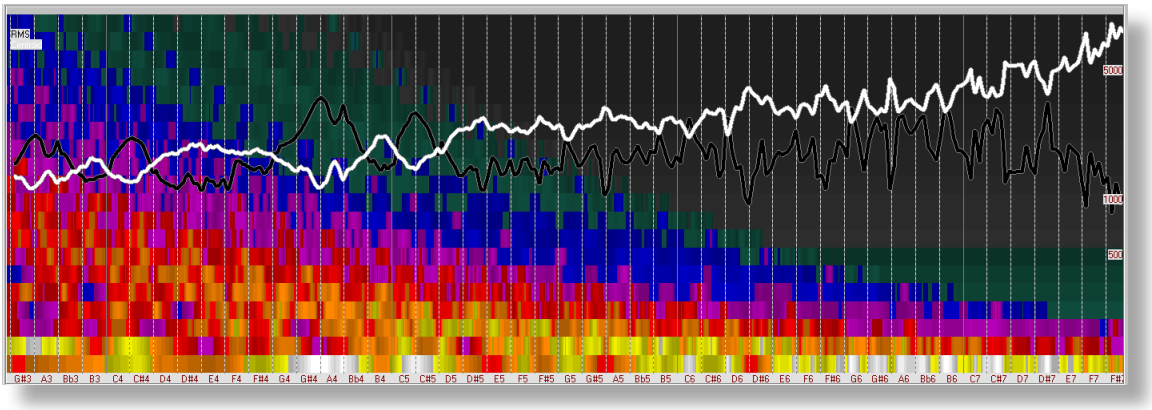
Intensity:

X-axis: Frequency in Hz (linear or logarithmic) or musical note

Y-axis (left): Partials (from bottom to top). First band = First partial, second band = second partial, etc.

Y-axis (right): Frequency in Hz (logarithmic)

The amplitude is colour coded.
Colour grade step= 1 dB, dark means low amplitude, bright means high amplitude.



- The graphs show the amplitude of each harmonic at **every** frequency point, in other words, the contribution of each harmonic to the sound of a playable tone.

  Example: e^2 (E5 in American notation). The fundamental is considerably weaker than the 1st harmonic (2nd partial) and the 2nd and 3rd harmonics (partials 3 and 4) are even stronger.

  Example: a^1 (A4 in American notation). Conversely, the fundamental is very strong, and the first harmonic is very weak, which is also small relative to the amplitudes of the three following partials.

- **Sound level (RMS):** The black line shows the total sound level that the instrument produces at each note

- **Harmonic Centroid:** The white line shows the sound balance point of each note. Reference scale: Frequency scale on the right Y axis of the diagram.

-

The function "Mask" is intended for wind instruments, and has **no relevance** for string instruments!

INTERPRETATION

Examples:

Sound level (black curve): The instrument plays very loudly between the notes G4 and C5, but the sound level falls down when the note Bb4 is played.

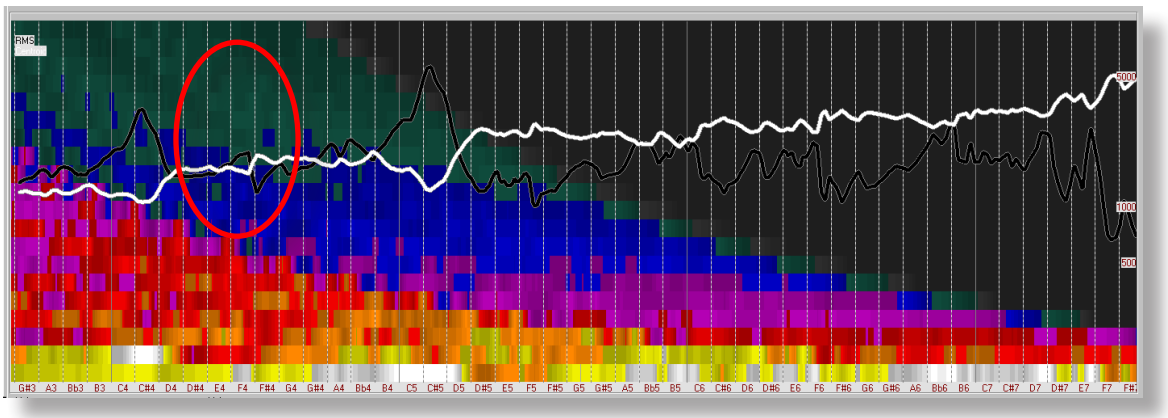
A closer look at the diagram reveals that the strong fundamental is responsible for the high RMS levels in these notes. Note that the second harmonic is weaker than the third!

Sound balance point (white curve): The strong influence of the fundamental in the mentioned range (between the notes G4 and C5) can also be seen in the white curve: The sound balance point is around 1 kHz in this range, while for lower notes it was around 2 kHz!

Except of course in the case of Bb4, where the harmonic centroid is 2.6 kHz, which means it sounds very bright

Wolf note candidates:

- The combination of sound level (black) and harmonic centroid (white) curves can reveal in certain notes a tendency to produce wolf notes.

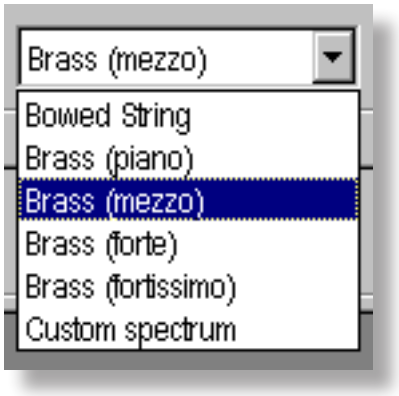


The instrument shown in this example (Schwartz 1841, Strassburg) has a wolf note at C#5

Wherever the black curve has an extreme peak, and at the same time the white curve shows a minimum, it indicates a wolfe note.

SOUND ANALYSIS - selecting sound color

2

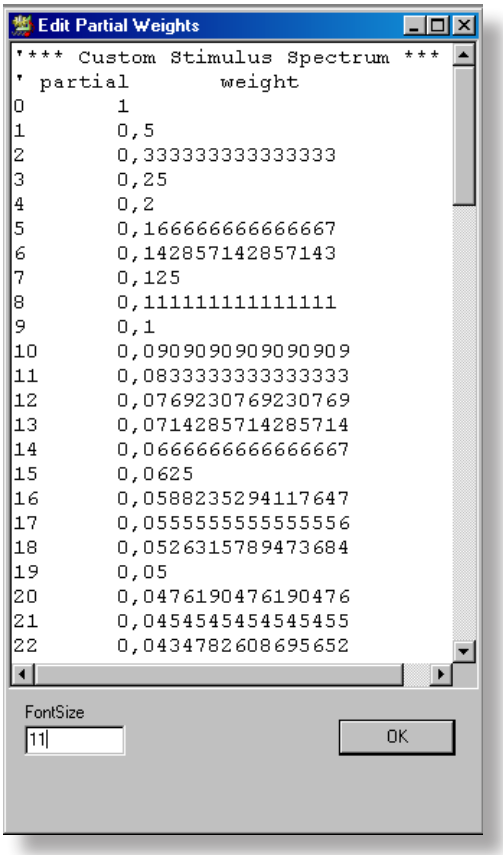


With this box a suitable excitation spectrum can be chosen.

The radiated sound of an instrument can be calculated using its “Transfer function” and the excitation spectrum: The radiated sound is the result of the excitation spectrum filtered through the Transfer function of the instrument.

The radiated sound of a **bowed string** is calculated using an excitation spectrum that corresponds to the well known **saw tooth** tooth waveform.

The “Custom spectrum” function is available, whereby an **individual excitation spectrum** can be modeled.



The left column corresponds to the harmonic number, and the right column is the weight of that harmonic in the sound spectrum.

- You only need to edit the given text guide.

1. The strongest harmonic has a weight of 1 (NOTE: The strongest partial does not have to be the fundamental, as it is shown in the example)

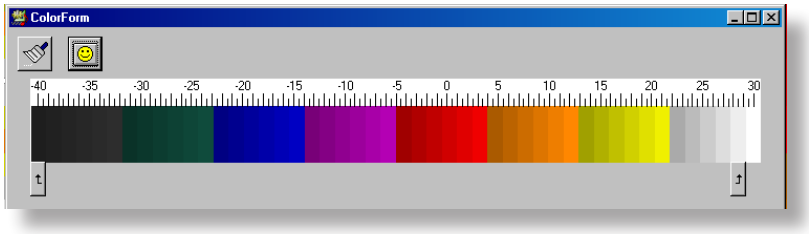
2. The amplitudes of all other harmonics are given as a percentage of the harmonic partial

Example in the left picture: The amplitude of the 3rd harmonic constitutes a fourth of that of the strongest harmonic (in this case, the fundamental). Therefore, its weight is 0.25. The amplitude of the 19th harmonic constitutes 5% of that of the strongest harmonic. Therefore, its weight is 0.05.

If for instance, the desired excitation spectrum consists of only 20 harmonics, the weight of the harmonics higher than 20 must be 0.

SOUND ANALYSIS - CHANGE COLOR SCHEME

3



Click on the brush icon to generate a colour gradient between the two colour fields marked with the arrows. The colour of all the fields that lie in between these two marked fields will be overwritten.

- The arrows can be dragged and dropped with the mouse
- Each field can be colourised individually. Click on the desired field to open a colour dialog window
- The typical procedure is as follows:

1. Place the arrows on the start and end of the colour gradient
2. Colorise the fields marked by the arrows
3. Click on the brush to generate the colour gradient in the marked interval

The “Smiley” restores the standard colour gradient

Remarks on making the data “audible”

The audible sounds generated by VIAS have only the stationary part of the sound, which lacks the characteristic attack and decay parts of the sound of a real instrument. That is the reason why they still sound synthetic and unnatural. The attack and decay can certainly be modeled as well, however, these tasks are highly complex, and the program would be much more complicated to use.

Furthermore, a real musical instrument sound has characteristic noise components produced by the excitation mechanism (bowing noise in bowed instruments, blowing noise in flutes, etc). The program does not simulate these noise components.

The goal of this analysis is not to produce an exact reproduction of how the sound develops in time, in the same way as when the player plays the instrument, but to make the **characteristic sound colour** of the instrument audible. Such data is for instance suitable to compare the sounds generated by different curves.

Of course, the composed "Sound" (i.e. musician + instrument) is strongly influenced by the musician. The bowing and playing technique used by the musician can weaken or change the characteristic sound colour of the instrument.

The influence that the strings have on the sound of the instrument does not have any effect on the simulated sound, as they are damped during the measurement!

Only the sound characteristic of the instrument body is made audible.

However, The tension of the strings affects the loudness indirectly, by exerting pressure on the top plate of the instrument. A high string pressure increases the sound level curve, and makes the sound louder.

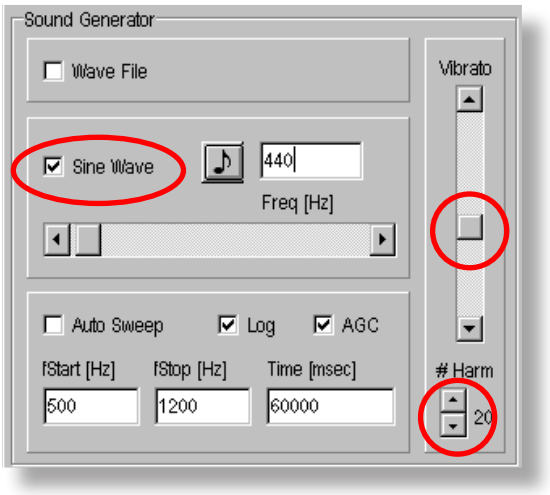
● The presettings for calculating the sound spectrum (described on page 48) have also influence on the sound produced by the loudspeaker.

Making data "audible"

1 Disconnect the interface box

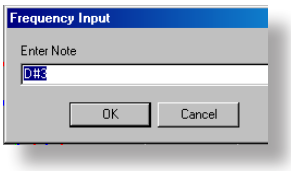
If you want to make the measured data audible with the help of loudspeakers, you must **disconnect the interface box before** in order that the output is done by the internal sound-card of the computer.
Otherwise VIAS uses the interface box as output device...

2 How to select specific sound parameters:



- Mark the check box "Sine Wave" if you want to hear a note or mark "Auto Sweep" if you want to play a sweep (in the case of a sweep select the start- and stop-frequencies and enter a propriate the time!)

- If you click on the "note" symbol you can enter the name of the note. American names! (**American A4 = European a[1]**)

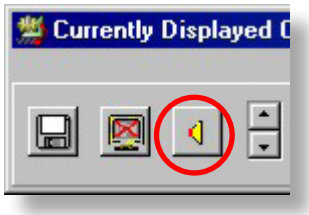


- Select the intensity of an added "Vibrato" with the scroll bar.

- Use the arrow buttons "**# Harm**" below the Vibrato scroll bar to select the number of harmonics (1-99) the sound should contain.

Remark:
You are free to choose up to 99 harmonics, but perhaps only 22 are effectively if the admittance curve has no significant peaks in the higher frequency range.

3



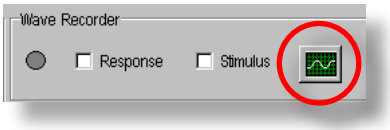
- Click on the loudspeaker symbol to start the sound. A click again stops the sound output.

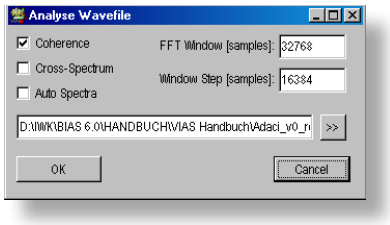
COHERENCE FUNCTION

The coherence function is a measure of the degree of linear dependence between two time signals, x(t) and y(t), in the frequency domain. Mathematically, it is nothing more than the square of the magnitude of the average cross-power spectrum and is calculated as follows:

$$\gamma^2_{XY}(f) = \frac{|\langle G_{XY}(f)\rangle|^2}{\langle G_{XX}(f)\rangle \cdot \langle G_{YY}(f)\rangle}$$

If the coherence between an input signal x(t) and an output signal y(t) of a oscillating system in a frequency range is not 1, it is an indication that linear signal analysis theory is not applicable.





- With the coherence button you can check the validity of a VIAS measurement.

- Record the “Response” with the wave-recorder (see page XXX)
- Click on the shown icon to start the coherence function
- Load the recorded response-signal and click on the “OK” button

Set the window length (in samples) in the field marked **FFT Window**.
Set the step size (also in samples) in the field marked **Window Step**.

For more information about Coherence see Wikipedia!

CROSS SPECTRUM

To be able to calculate the coherence spectrum, it it necessary to calculate as intermediate results the **cross power spectrum** as well as the **auto power spectrum**. These results can also be plotted by clicking the corresponding boxes.

The cross-power spectrum is calculated by using the following equation:

$$S_{XY}(f) = X^*(f) \cdot Y(f)$$

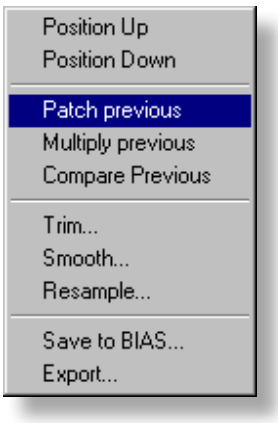
The equation to calculate the auto-power spectrum is as follows:

$$S_{XX}(f) = X^*(f) \cdot X(f) = |X(f)|^2$$

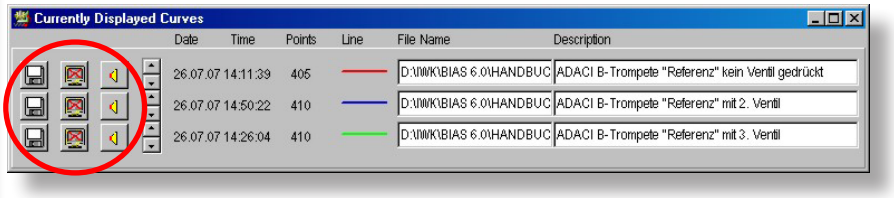
In both equations, the star sign (*) denotes complex conjugate

ERROR CORRECTION

To correct errors:



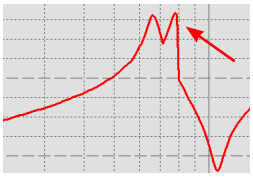
Right click on any icon corresponding to the curve that you would like to paste into the previously listed curve. The context menu will open. Click on the command “Patch previous” (the current curve will be inserted in the previous curve).



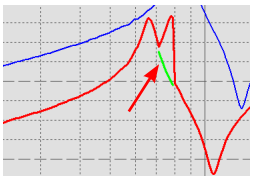
NOTE:

With the “Patch previous” command, the data in the previously listed curve is replaced with the data from the current curve. Any curve which needs to be improved, must **always** be listed **just before** the curve which will be used to improve it.

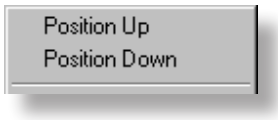
Example:



The red curve (see picture) has an error between 70 and 80 Hz (second peak). You have repeated the measurement only in this frequency range, which is correct (green curve).



You would like to improve the red curve with the green curve. For this purpose, the **red curve** must be listed **just before the green curve**. As this is not the case (see picture), you will need to either shift the green curve upwards or the red curve downwards.

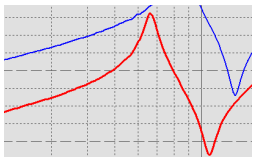


This is done with the command “Position Up” or “Position Down” in the context menu. Let us shift the green curve upwards:

- **Right** click on e.g. the speaker icon that corresponds to the green curve
- Click on “Position up”

Now the curves are in the required order

ERROR CORRECTION

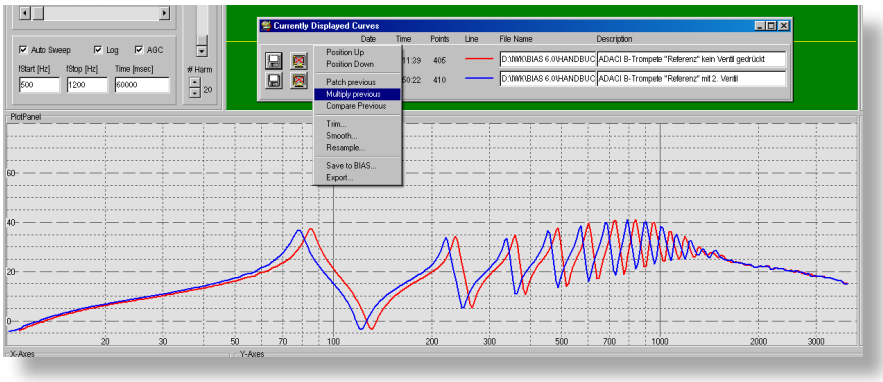


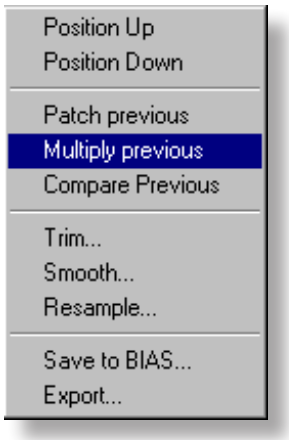
Now we can perform the error correction:

- Right click on any icon that corresponds to the green curve
- Click on “Patch previous”

Done!

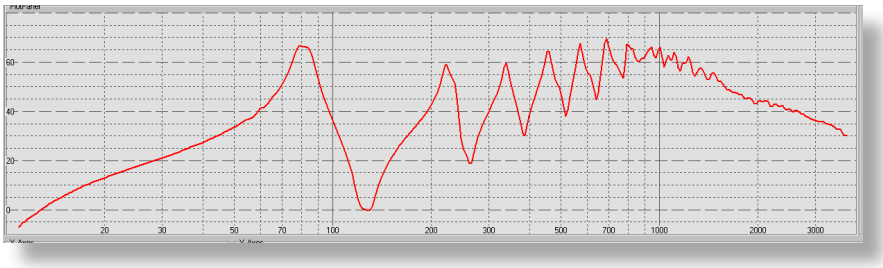
CURVE MULTIPLICATION = ADDITION





To multiply the red curve times the blue curve:

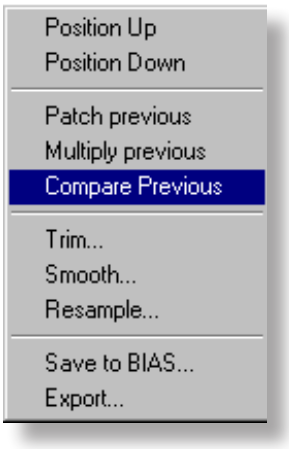
- Right click on any icon that corresponds to the blue curve
- Click on the command “Multiply previous”



RESULT

For the commands “Multiply” and “compare”, the two curves do not have to have the same length, or frequency range, or sampling frequency.

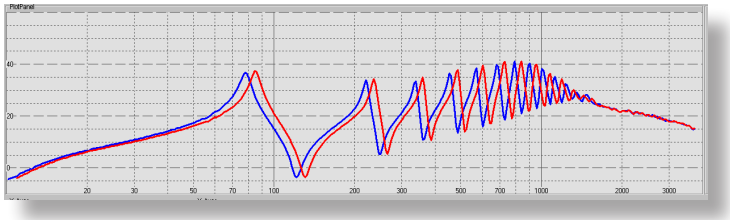
CURVE COMPARISON - DIFFERENCE



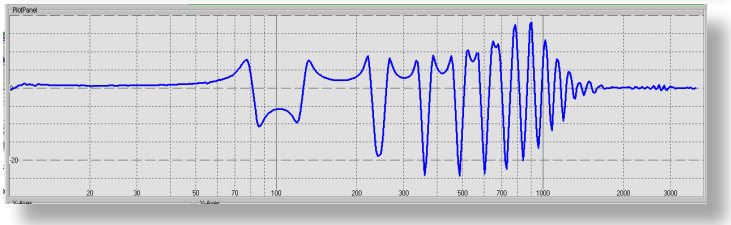
To compare the red curve with the blue curve:

- Right click on any icon that corresponds to the blue curve
- Click on “compare previous”

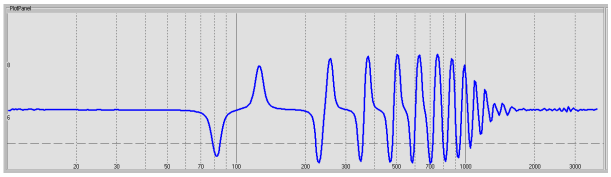
Curves to be compared



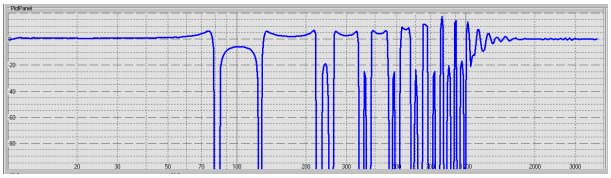
Result



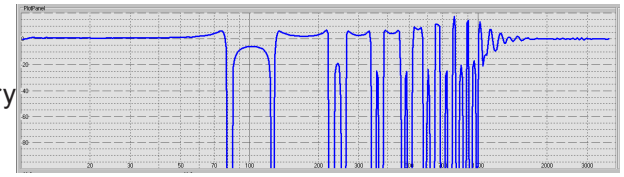
Result – phase



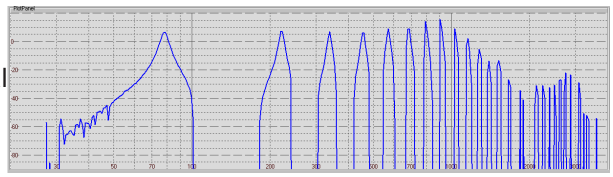
Result – Real part



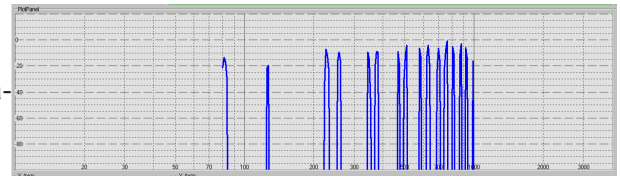
Result – imaginary part



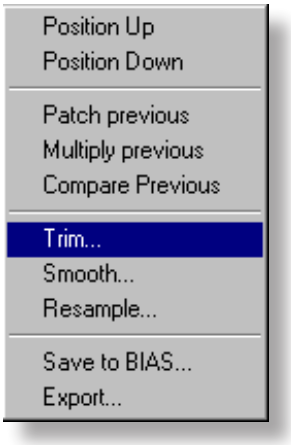
Result – negative real part



Result – negative imaginary part



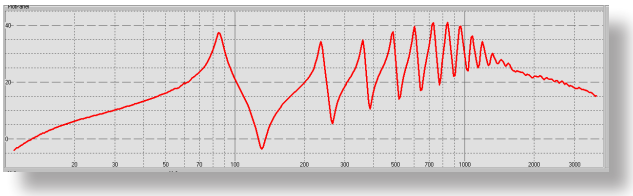
CURVE TRIMMING



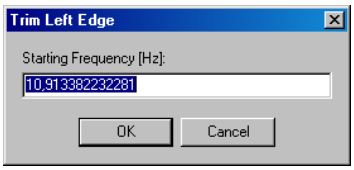
- To crop a curve, use the command “Trim” on the context menu

All data under the start frequency and over the stop frequency will be cut off

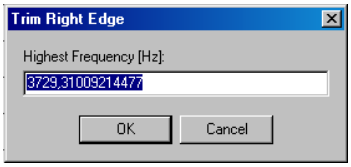
Curve to be cropped



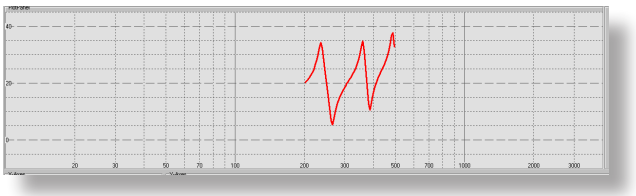
- Type in the lower frequency (e.g. 200 Hz)



- Type in the upper frequency (e.g. 500 Hz)

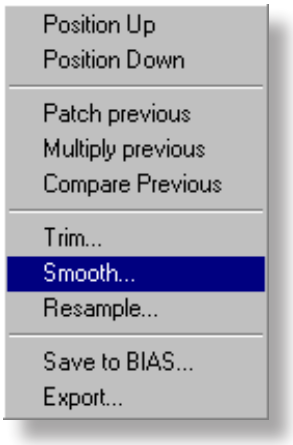


Result

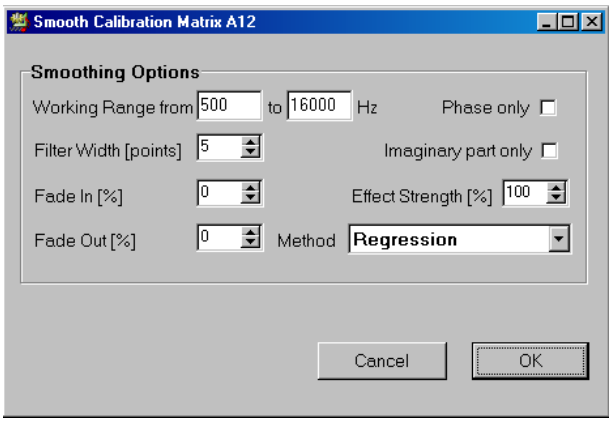


CURVE SMOOTHING

There are many reasons to smooth a curve: For instance, when detecting maxima / minima points by pressing the arrow keys does not work properly, or when the curve has got ripples, etc.



- **To define the smoothing parameters:**
  In the context menu, Right click on the command “Smooth”



Parameters:

Working Range:
Here you can specify the frequency range where the smoothing will take place.

Filter with [points]: Filter (smoothing window) width.

Fade in [%] and **Fade out [%]:** f you would like to avoid having an abrupt transition between the unsmoothed and the smoothed parts of the curve, you can specify a transition range. The value 10 means e.g. that the transition range amounts to be 10% of the working range. In the picture above, it would be a width of 1,550 Hz.

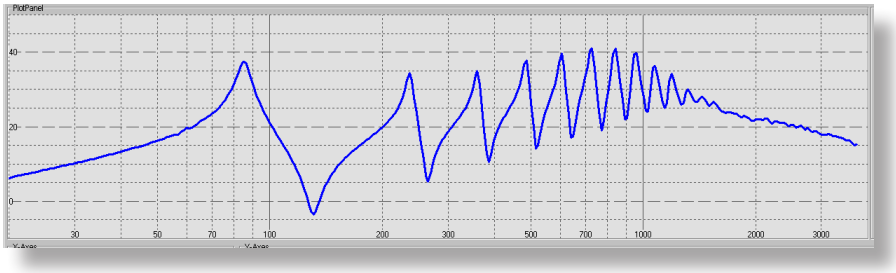
Phase only and **Imaginary Part only:** The smoothing parameters will only be used for smoothing the phase or the imaginary part.

Effect Strength [%]: E.g. 50% means that the curve in the working range consists of a 1:1 mixture of filtered and unfiltered values

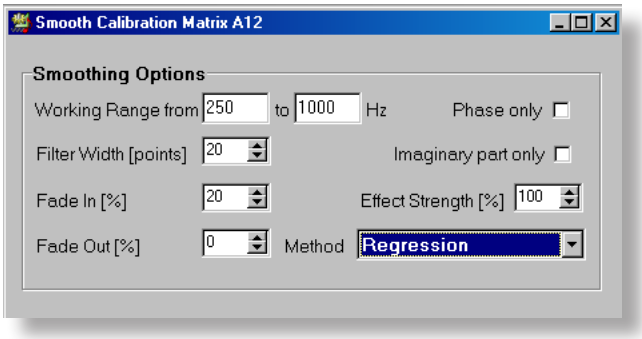
Method: Here you can choose the smoothing method: “Running average”, “Gauss-filter” and “linear regression” methods are available.

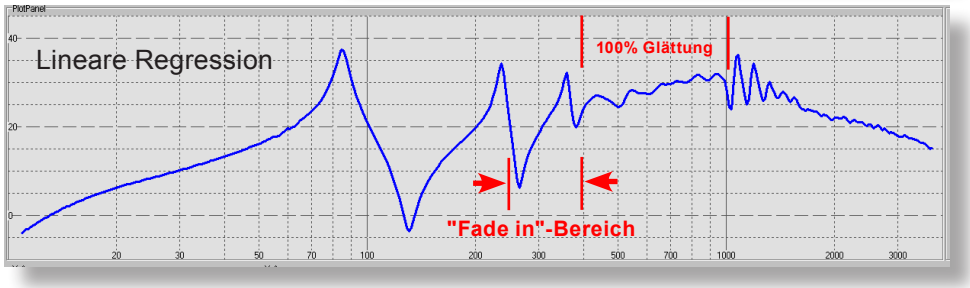
CURVE SMOOTHING

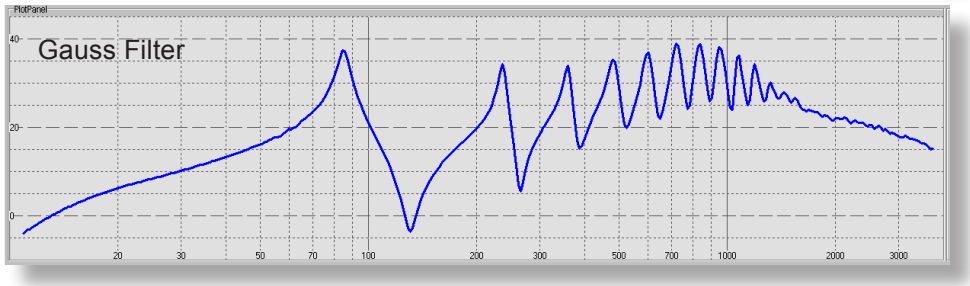
Here is a radical example:
Curve to be smoothed

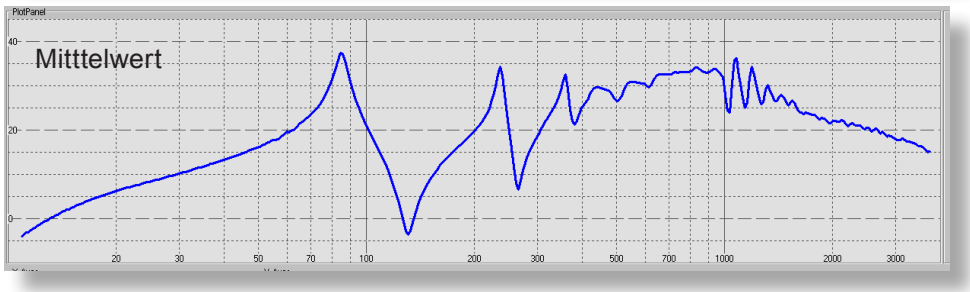


Working range: 250-1000 Hz
Filter width: 20 points
Fade in range: 150 Hz
No Fade out
Method: Linear regression

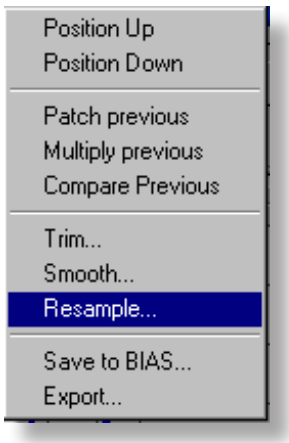




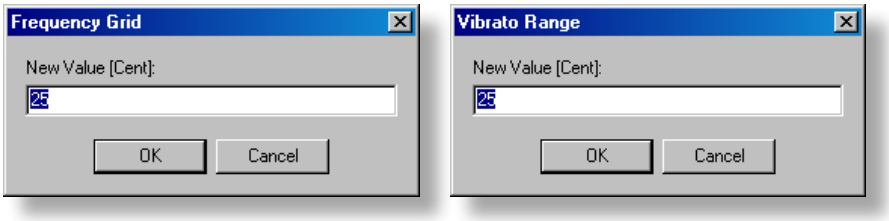




CURVE RESAMPLING



In some cases, having a higher or lower resolution than what was actually measured is required. This can be changed with the command “resample” in the context menu. Two parameters are required: GRID and VIBRATO RANGE.



GRID: With this parameter, the total number of points in the curve (hence the resolution), as well as the distance between the points in the frequency axis can be changed

Example: We have a measurement from 100 Hz to 7 kHz with 600 points.

- This measurement encompasses approximately 6 octaves:
  1st octave: 100-200 2nd octave: 200-400 3rd octave: 400-800
  4th octave: 800-1600 5th octave: 1600-3200 6th octave: 3200-6400
- One octave has 1200 cents, and has 100 points in this measurement
- Therefore, 1 point corresponds to 12 cents
- A new grid of 25 cents per point would have half the resolution, and the curve would have 300 points
- If in this case, a value of 6 cents per point were selected, the curve would have 1200 points.

VIBRATO RANGE: Any new non-existent point must be interpolated. In this case, 25 cents means that the interpolation will take into account all points that fall within 25 cents of the new interpolated point, and not only the two closest neighbours.

Engineers need to get used to the unit cent instead of Hz. But in this case the terminology is musically relevant, as the logarithmic scale corresponds to the way pitch and musical intervals are perceived.

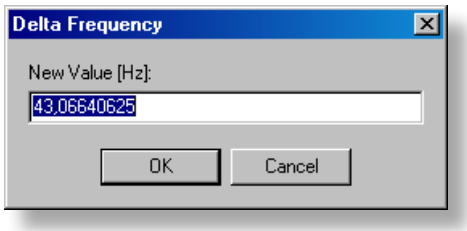
It is for this reason that the X-axis uses the unit cent. This ensures that the frequency resolution corresponds to how we hear.

DATA EXPORT

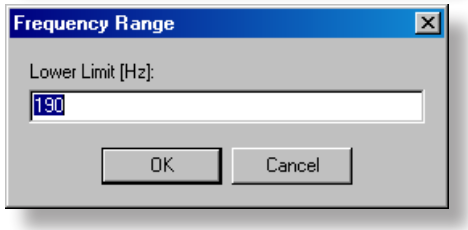
- **To export a measurement in .dat format (to use with other applications):**

Right click on any icon of the curve to be exported in the “Currently displayed Curves” window to open the Context Menu, and click on the command “Export”.

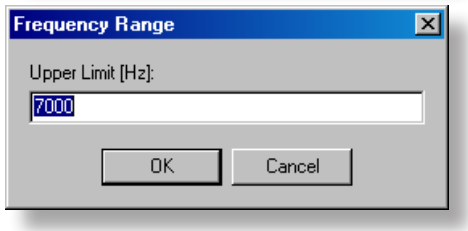
The command “Save to BIAS” is not relevant for admittance curves of STRINGED INSTRUMENTS:



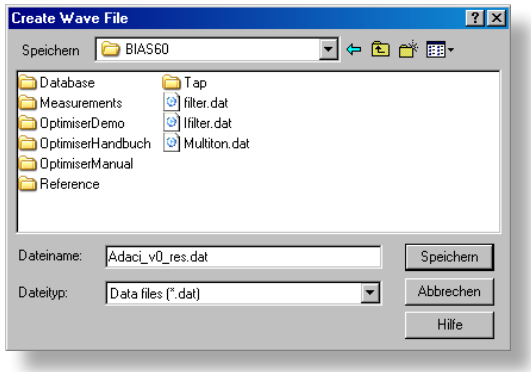
The value in this field specifies the frequency grid, e.g. a value of 0.5 means that an admittance point will be written every 0.5 Hz.



In this field, the starting frequency of the curve is specified



This value sets the end frequency of the curve



Choose the name (and extension) of the file and the directory where it will be saved.

EXPORT - SUMMARY

Which alternatives are there to export data, and to use it with other applications?

It is possible to:

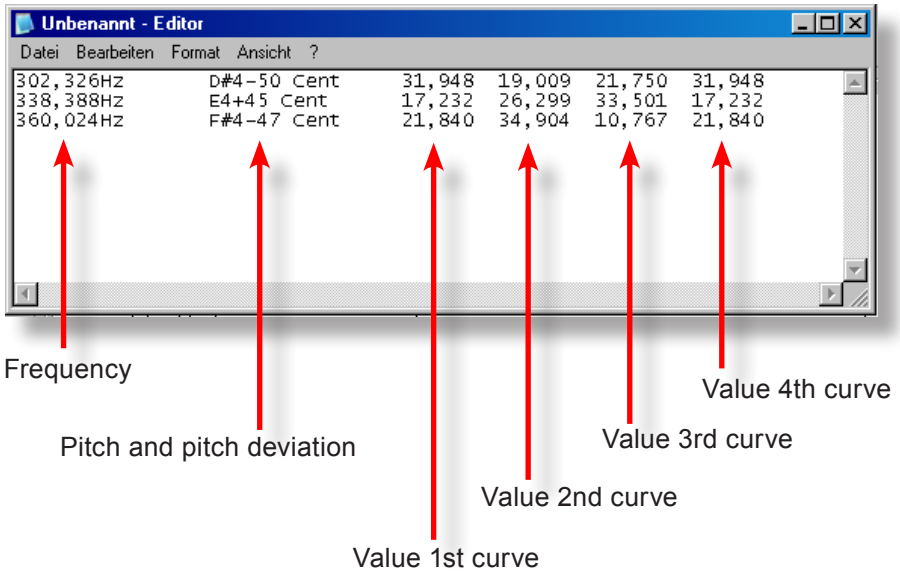
- Save a measurement in .dat format to be used e.g. in Excel (see page 63)
- Export the maxima and minima points of a curve with frequency, pitch and pitch deviation from an equally tempered scale, and relative impedance values with the help of the NumDisplay command
- Make all the points of a curve available in text format with the help of the NumDisplay command:
  - Set the detection threshold to the value “0”
  - Copy all the content of the window, and paste it in e.g. An empty excel spreadsheet (see page XXX)
- Select the values shown by the cursor. All current values of the cursor will be inserted automatically into the windows clipboard.
  - Open a text editor and paste the current values with Ctrl-V (see picture below and page XXX)

HINT:

A VIAS file is a text file with a header and 5 columns with the following values:

1.Frequency
2.Magnitude
3.Phase
4.Real part
5.Imaginary part

It is possible to read any VIAS measurement with any text editor for further work



To change the frequency detection parameters for the display and lock-in filter:

THIS IS IRRELEVANT WHEN DOING IMPULSE MEASUREMENTS!

minFreq and **maxFreq**
The frequency range in which the signal detection of the lock-in filter will operate is set in these two fields

minLev Specifies the minimum level in dB. Levels below this will not be detected.

minDet: In this example, if more than 60% of the captured periods are consistent, the value will be shown on the graph, otherwise the display of the measured curve will be disabled, until the given number of periods are again consistent. For fast sweeps, choose a lower value.

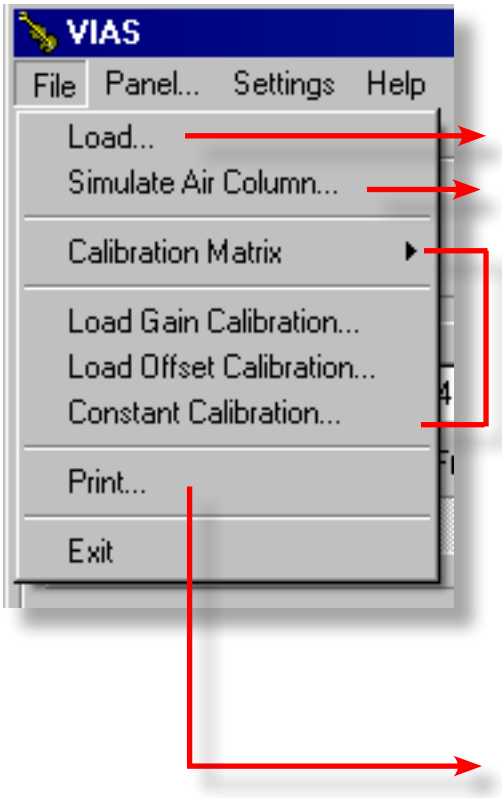
LogAbsTol The entered value must be between 0 and 1. It determines the frequency starting range.

LogRelTol: In a logarithmic sweep, the frequency distance between two consecutive measuring points should not vary arbitrarily. For very fast sweeps, choose a higher value..

Absolute tolerance is related to frequency differences in Hz, whereas relative tolerance is related to frequency differences in percentage.

COMMAND GROUP "FILE"

The “File” menu



Load data

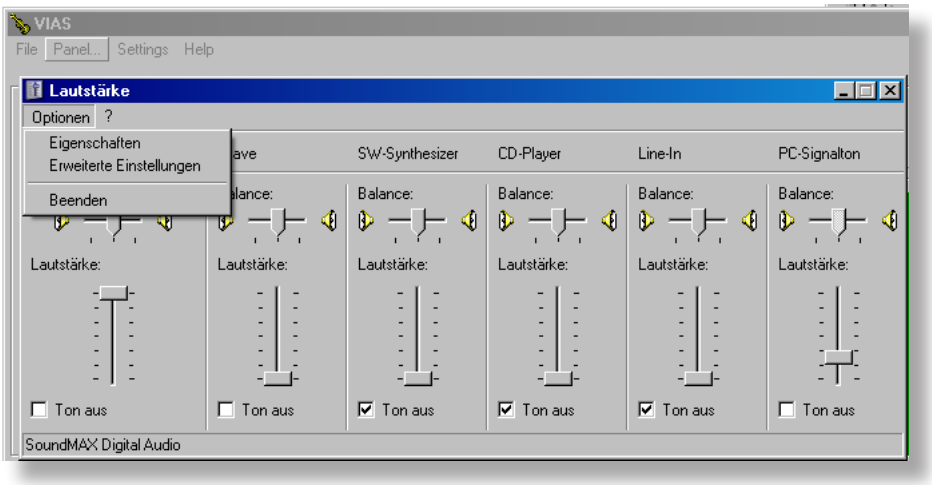
Start the “Physical modeling” tool. **Only for BIAS!**

These commands are used to calibrate the BIAS measuring head. The first time that VIAS is run, the BIAS default calibration data will be automatically loaded. **We suggest you keep these data!** Details on how to calibrate are found at the end of this user‘s manual.

With help of the VIAS program, it is also possible to obtain calibration data from two high precision (uncalibrated!) measurements of two known volumes, which can be later exported into BIAS.

This procedure requires some experience, and will be described in another section.

Prints the content of the display area with legends.



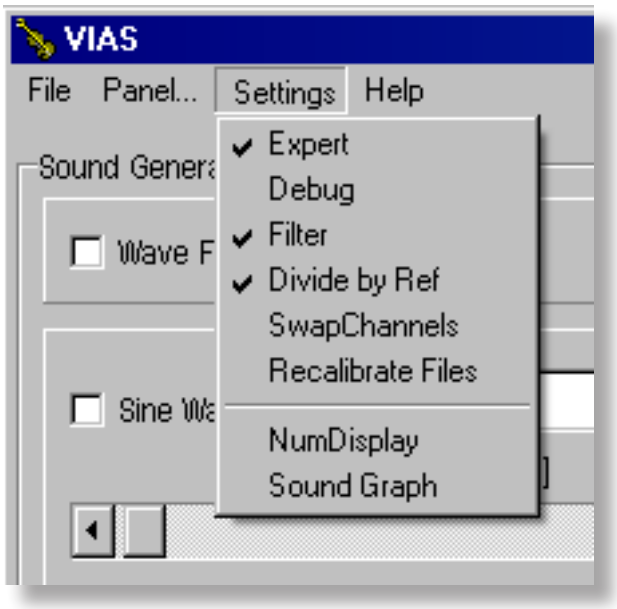
The “Panel...” command

This command opens the Windows sound card window, where you can change the settings of your sound devices.

COMMAND GROUP "SETTINGS"

The “Settings” menu

In this menu, several operations can be turned on/off, so that other measuring settings can be used as well.



The picture shows the standard settings.

Expert enables access to all functions of the program

Debug opens a debug window, where intermediate data is shown

Filter tuns on/off the lock-in filter. In the picture, it is turned on. If for any reason your .wav excitation file does not contain purely sinusoidal signals, the lock-in filter should be turned off, as in this case the frequency detection is not possible, and the measuring level display is disabled.

Divide by Ref: To eliminate the influence of different excitation levels on the resulting measurement, the measuring signal will be divided by the shown reference signal (actual level on the speaker membrane in the measuring head).

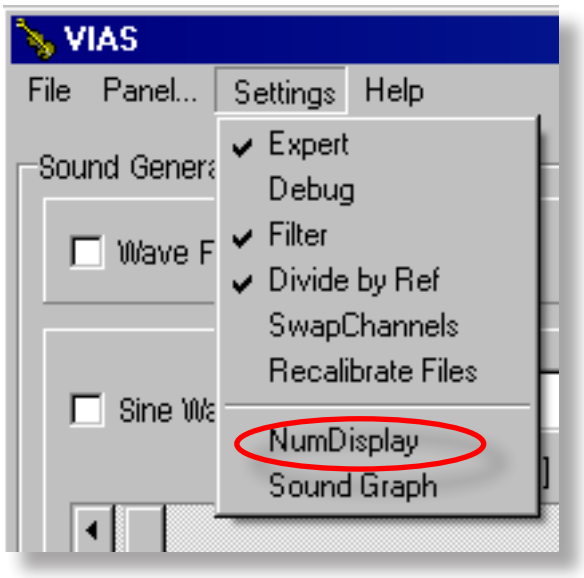
SwapChannels swaps the reference and measuring signal channels in the sound card. When this command is used together with the division command, the reference signal can be displayed and studied. E.g. to determine if the excitation signal is saturated, turn off the “DividebyRef” command, and turn on the “SwapChannels”. The reference signal will be displayed and plotted instead of the measured signal.

Recalibrate Files: This command loads and already saved (uncalibrated) curve, and calibrates it automatically.

FIND MAXIMA AND MINIMA

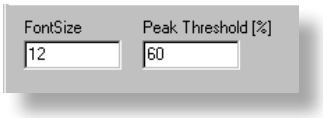
NumDisplay is a very helpful command!

It identifies the frequencies and impedance values of the maxima and minima of a curve, which can be copied and pasted into other applications for further use.



1 Turn on NumDisplay

- Choose detection threshold e.g. 50% or 60% (-> maximum or minimum should be at least 60% higher than the surrounding values).



- If the threshold is set to "0" the whole curve is displayed in numerical values. The first column contains the frequency, and the second the impendance.
- Choose the font size, if necessary

2 Load a curve: The result will be shown in a text window (see picture on the next page). In this picture a threshold of 60% was chosen. This is why only the frequency and the impedance of minima and maxima are displayed (Peak = maximum, Low = minimum).

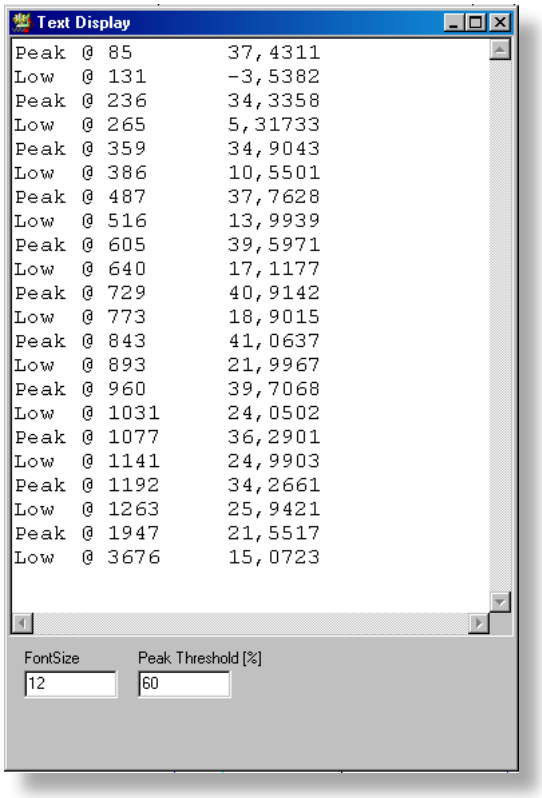
- The values can be copied to other applications for further use.

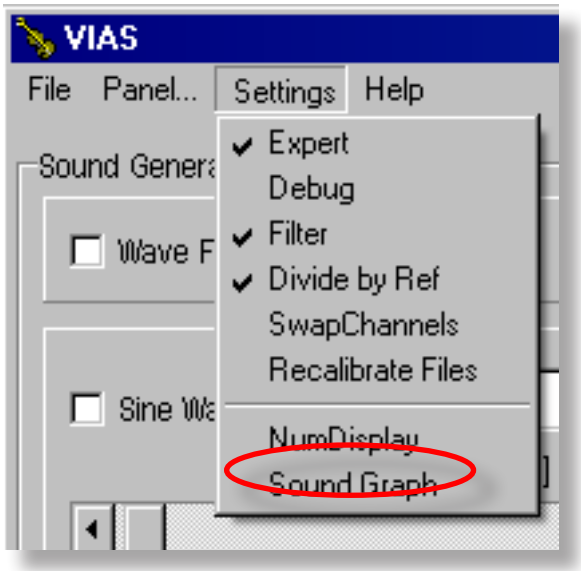
  Single rows or the whole contents of the window can be marked and deleted.

- If you load further curves while the NumDisplay window is open, the values for the new curves are appended at the end of the list.

FIND MAXIMA AND MINIMA

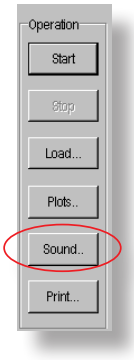
Example for a loaded Violin admittance curve





The command **Sound Graph** starts the sound analysis.

Normally the button "SOUND" at the right side of the main screen is used instead of this command.



Short description of measuring methods

BIAS input impedance measurement

Excitation with a sinusoidal sweep (10 Hz to 4096 Hz). Duration: 2 seconds. The reference signal (from the microphone placed over the loudspeaker membrane in the measuring head) and the measured signal (from the microphone inside the mouthpiece) are temporarily recorded in .wav format, and the measured signal is divided through the reference signal.

The spectrum (FFT) of this standardised signal (measured signal divided through reference signal) is calculated, resulting in the impedance curve. Transformation from time to frequency domain.

Advantages: Provides resulting impedance curve very quickly.

Disadvantages: Suboptimal use of the energy bandwidth, no flexibility in terms of frequency range.

VIAS input impedance measurement

Excitation with a slow sweep (frequency range: arbitrary, supplied by the user). Duration: Arbitrary, depending on frequency range to be measured. The measured signal (from the accelerometer) is filtered through an octave band lock-in filter, and then divided over the reference (excitation) signal.

The RMS level is calculated from this quotient, and displayed as impedance curve.

Advantages: Allows sufficient time to build standing waves, better use of the energy from the excitation signal, flexible frequency range, higher accuracy.

Disadvantages: Long measuring time

VIAS pulse hammer admittance measurement

Excitation with an impulse. Reference signal (from the force sensor built in the impulse hammer) and measured signal (from the accelerometer) are stored temporarily, and the measured signal is divided through the reference signal.

The spectrum (FFT) of this quotient is calculated and displayed as admittance curve.

Advantages: Very short measuring time, unproblematic and flexible measurement setup, reproducible results when averaging.

Disadvantages: Small amplitudes from around 4 kHz. If results over 4 kHz are required, more measurements and averaging is necessary.

VIAS admittance measurement with shaker

Excitation with a slow sweep (frequency range: arbitrary, supplied by the user). Duration: arbitrary, depending on frequency range to be measured. The measured signal (from the accelerometer) is filtered through an octave band lock-in filter, and then divided over the reference (excitation) signal.

The RMS level is calculated from this quotient, and displayed as admittance curve.

Advantages: Generation of higher oscillation amplitudes, flexible frequency range, high accuracy.

Disadvantages: Long measuring time, only possible if the mass of the excitation mechanism is negligible