CONEQ

CONEQ™ Workshop

Acoustic Power Frequency Response
Measurement and Correction System

QUICKSTART GUIDE

(for software version 3.1.0)

real sound lab

TABLE OF CONTENTS

OVERVIEW

ABOUT CONEQ™ TECHNOLOGY

Real Sound Lab's CONEQ™ is a technology to measure and correct the acoustic power frequency response (APFR) of electro-acoustic transducer devices, such as loudspeakers. With CONEQ™ every loudspeaker sounds better – clear, natural, and without attenuations – within its whole frequency range. The CONEQ™ technology is applied in two steps. First, a precise measurement of how well the loudspeaker transmits energy at each frequency is done, and a compensation filter is automatically produced. Second, the filter is applied to the audio signal by any of the software or hardware tools supporting CONEQ™.

ABOUT THIS MANUAL

This manual allows to quickly start using the CONEQ™ Workshop application – the tool for measuring and filter synthesis. For a full list of available features please see the CONEQ™ Workshop Reference Manual.

The screenshots in this manual are taken on the Windows operating system. The corresponding screens on Mac OS will look similar.

SYSTEM REQUIREMENTS

CONEQ™ measurement is done by sending a series of test signals to a device-to-be-measured (typically, a loudspeaker) and recording the output of the device (typically, using a microphone). Proper measurement is crucial to achieve the best possible results with the CONEQ™ technology. That is why several points about the system set-up must be taken into account before using CONEQ™ technology:

1. The sound card or audio interface (audio device) and, if necessary, drivers must be properly installed and configured.

2. An omnidirectional measurement microphone with flat frequency response curve must be used. An acceptable alternative is to use an omnidirectional microphone with a known, electronically available individual frequency response curve in a format that is compatible with CONEQ™ Workshop.

3. The audio device must be working properly and be compatible with the CONEQ™ Workshop application. The audio device must be capable of simultaneous (full duplex) playback and recording, and both the audio device and the measurement microphone, along with the connecting cables, must be in perfect working order.

4. The loop-back test should be performed as described below.

Failure to take the steps mentioned above will increase the probability of incorrect measurements, which may cause undeserved disappointment about the achieved results, CONEQ™ Workshop software, or CONEQ™ technology in general.

STEP 1: SET–UP

INSTALLING THE SOFTWARE

First, install the CONEQ™ Workshop software application package. CONEQ™ Workshop runs on a variety of Windows™ operating systems (Windows XP SP3 and newer) as well as the latest updates of Mac OS X 10.5 and 10.6.

Run the CONEQ™ Workshop set–up program to do the installation. CONEQ™ Workshop requires Microsoft .NET Framework 2.0 (on Windows) as well as the latest eLicenser Control Center software. The CD version of the installation software will check for the presence of needed components and install them if necessary.

The download version of the CONEQ™ installation software does not contain these components and they must be downloaded separately:

- Microsoft .NET Framework 2.0: http://www.microsoft.com/downloads/details.aspx?FamilyID=0856eacb–4362–4b0d–8edd–aab15c5e04f5&displaylang=en

- eLicenser Control Center: http://www.elicenser.net/en/latest_downloads.html

COPY–PROTECTION

CONEQ™ Workshop is protected against illegal copying by the eLicenser USB device. The device was delivered together with the software. It is recommended to connect the eLicenser USB device only after the installation.

The eLicenser device delivered with the Unlimited edition of CONEQ™ Workshop is ready to use right out of the box. The eLicensers of the Annual and Limited editions contain a non–active time–limited license. It must be activated to start the countdown and enable use of the software.

To activate a time–limited license, connect the eLicenser and open the eLicenser Control Center application (on Windows use "Start -> All Programs -> eLicenser -> eLicenser Control Center", on Mac locate the eLicenser Control Center in the Applications folder). The connected eLicensers will appear on the list. Select the CONEQ™ Workshop Annual/Limited license and choose "Actions -> Start License Usage Period" from the menu (see figure 1). Follow the instructions and after successfully completing the activation process, the CONEQ™ Workshop software is ready to run.

The activation process requires an Internet connection. If the computer where the CONEQ™ Workshop is to be used is not on–line, then activation can be done on any other computer after installing the eLicenser Control Center application there. The latest version of the eLicenser Control Center application can be downloaded from http://www.elicenser.net/en/latest_downloads.html

SETTING UP AUDIO PLAYBACK/RECORDING HARDWARE

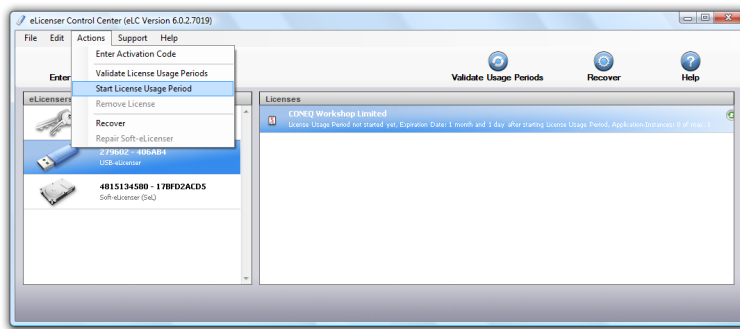CONEQ™ Workshop needs properly working audio hardware to make correct measurements.

Figure 1: Activation of the time–limited license for CONEQ™ Workshop Annual/Limited.

No equalizers and other sound enforcement

If the audio device or mixer has equalizer or other sound enforcement/improvement functionality, it shall be bypassed or the equalizer pattern set to flat.

No input monitoring on the output

The input of the audio device shall not be routed by the device's mixer to that device's output (i.e. you should not be able to hear your voice on the speakers when you speak into the microphone). Otherwise, CONEQ™ will be recording multiple copies of more and more distorted test signal, producing erroneous results.

Loopback test

To check the I/O interface of the audio device, we recommend to perform a test measurement by setting up an analogue measurement loop.

To set up the loop, connect the output of the audio device back to its input using the appropriate cable (not included).

> **IMPORTANT!**   *It is very important to switch off phantom power during loopback measurement BEFORE connecting the input to the output because feeding 48V current to the output of the audio interface will most likely damage the device irreparably.*

> **IMPORTANT!**   *Be careful to set the input and output levels so as to avoid clipping or even damaging the equipment.*

To execute the test measurement, perform STEPS 2 and 3 as described below. If the measured APFR curve is flat as in figure 2 and there is just one narrow spike in the beginning of the impulse response graph as in figure 3 then the audio device is adequate for CONEQ™ measurements.

If any deviation (e.g. as in figures 4 and 5) is observed then the sound path must be checked for sources of distortion. Such causes can be resampling in operating system
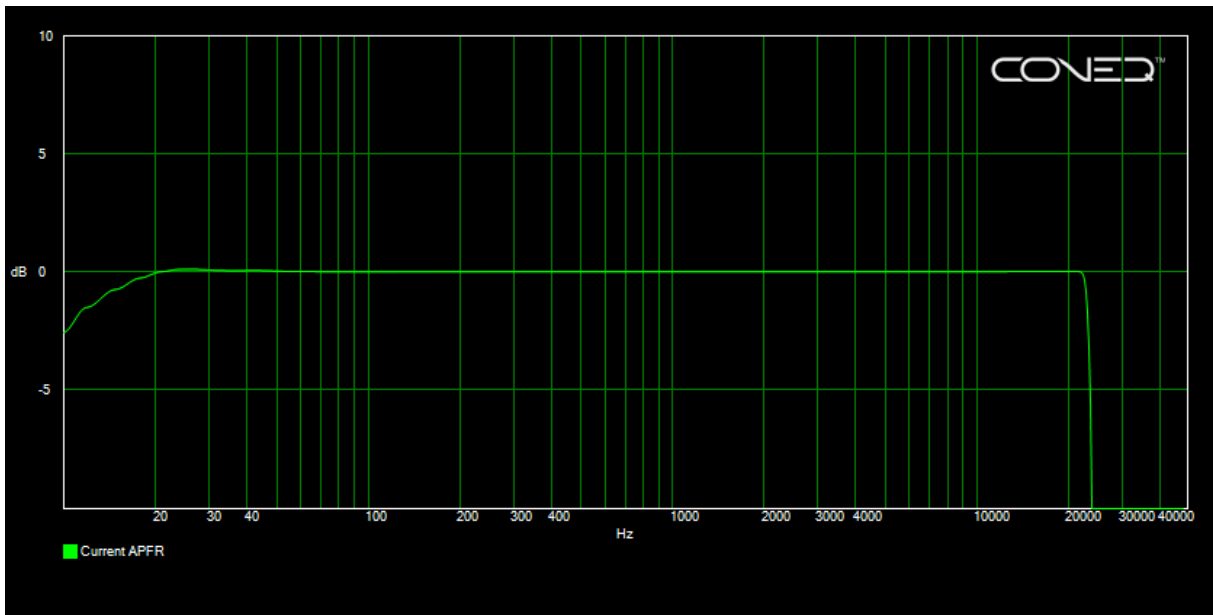
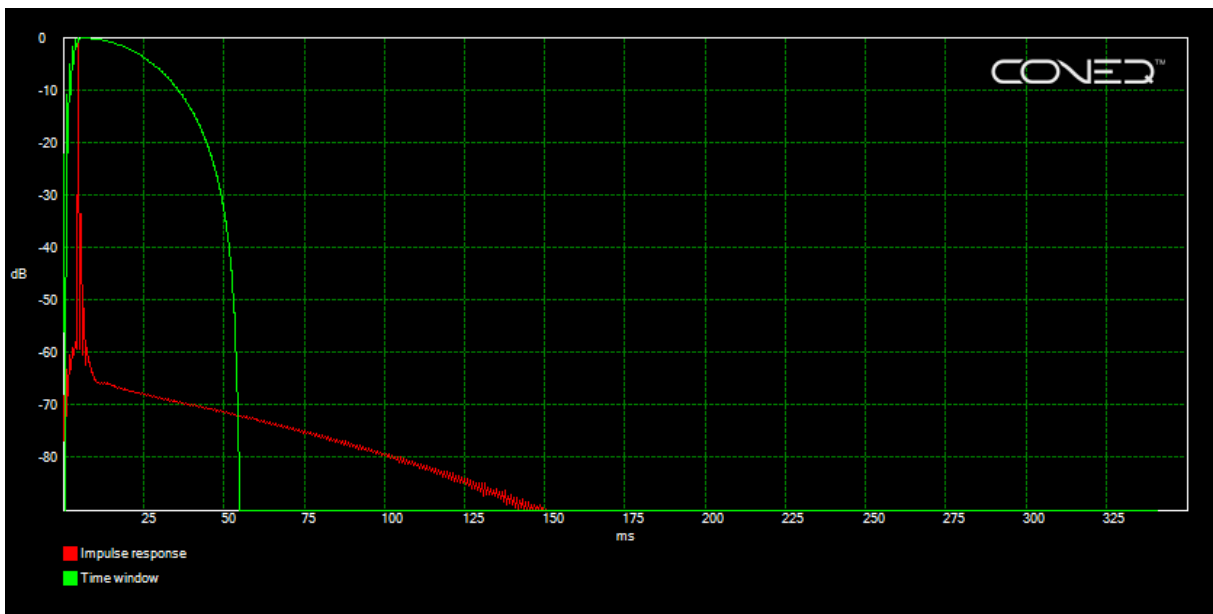*Figure 2: A correct loopback frequency response graph for the range 20–22500 Hz.*

Figure 3: A correct loopback impulse response graph.

drivers or hardware, active limiters or clipping due to too high signal level, feedback, active equalizer, broken cable, and many other causes.
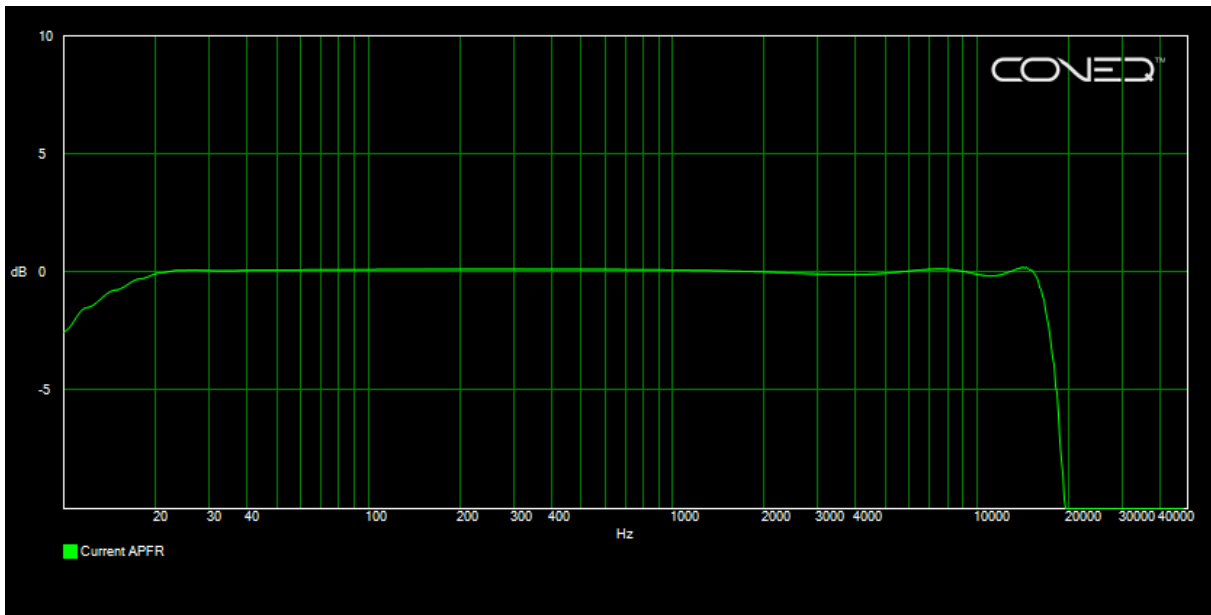
Figure 4: Loopback frequency response graph showing irregularities that suggest problems with the set–up (in this case, 96kHz signal sample rate was resampled by Windows to 48kHz).
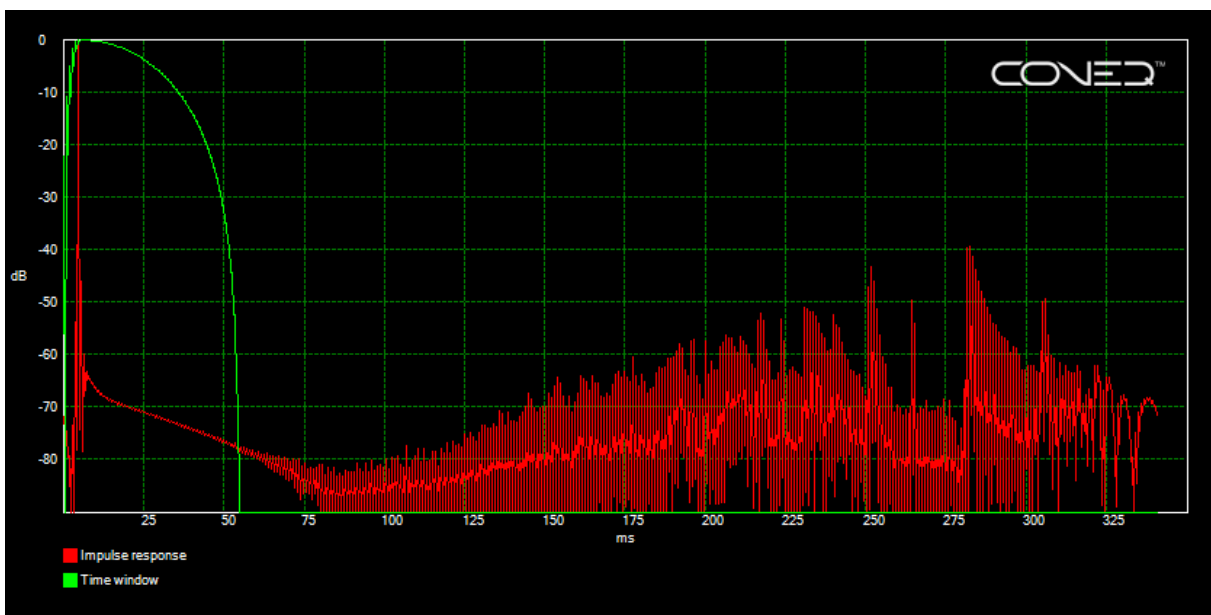
Figure 5: Loopback impulse response graph showing irregularities with the set–up (in this case, clipping happened due to too loud input signal).

CONNECTING THE DEVICE UNDER TEST

Connect the DUT (Device Under Test) to the output of the audio device. The DUT might be a loudspeaker or loudspeaker array, a signal processor, or a chain of devices that together make up a sound system.

The typical use of CONEQ™ Workshop is to measure a loudspeaker or loudspeaker array. This scenario is assumed everywhere in this guide, unless specified explicitly. In this case

connect the measurement microphone to the input of the audio device.

CONEQ™ Workshop can be used to measure the frequency response characteristics of any chain of devices. In this case connect the output of the chain to the input of the audio device. Be careful to match the signal levels as improper connections may irreparably damage the audio devices.

At the end of STEP 1 the audio hardware is ready for use with CONEQ™ Workshop.

STEP 2: CREATING A NEW PROJECT

Follow these steps to start working with a project:

1. Connect the eLicenser USB device to the computer;

2. Start CONEQ™ Workshop;

3. Choose "Project -> New" from the menu.

4. Choose a path where the project will be saved and give the project a name.
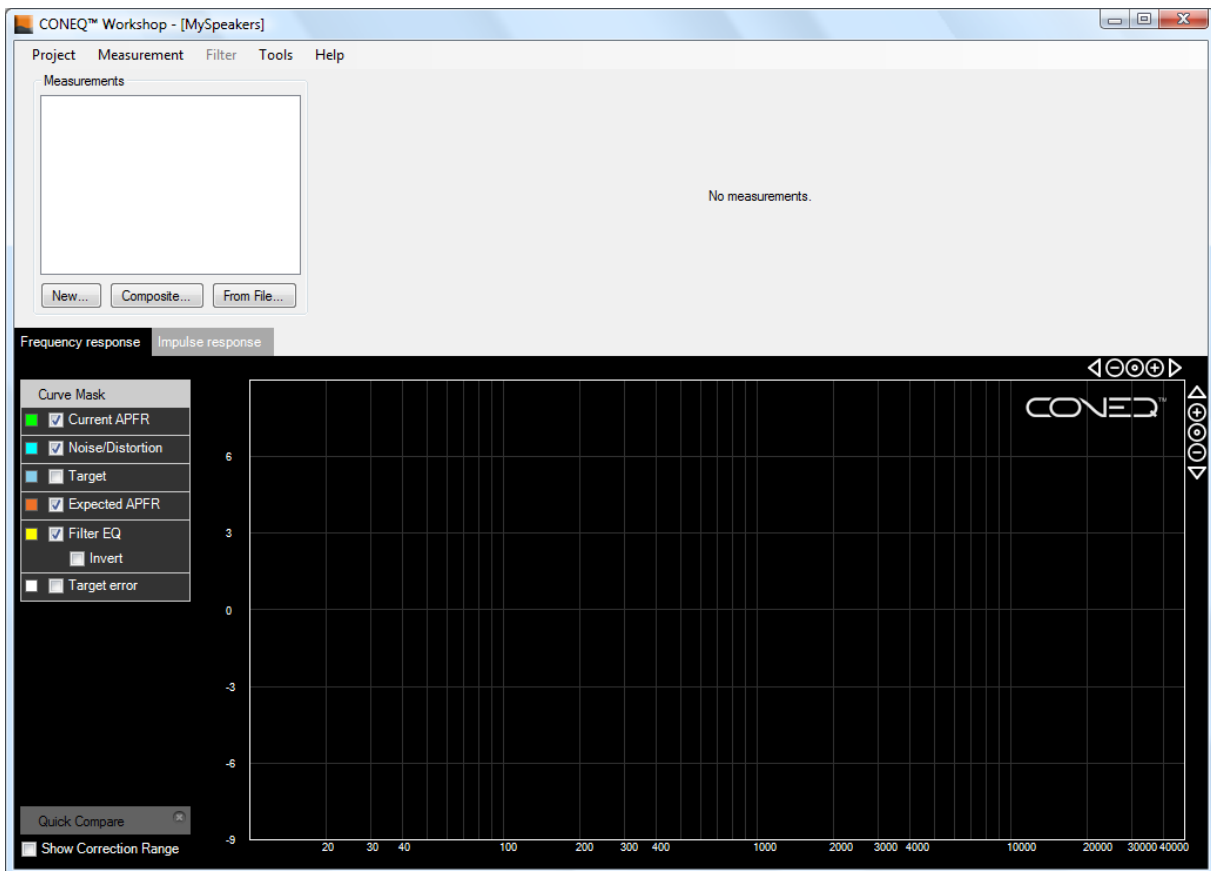

Figure 6: Main application window with a new project just created.

At the end of STEP 2, a new project window is open and the first measurement can be made.

STEP 3: MAKING A MEASUREMENT

Click on the "New..." button, located below the "Measurements" list in the project window. A "New measurement" window as in figure 7 will open.
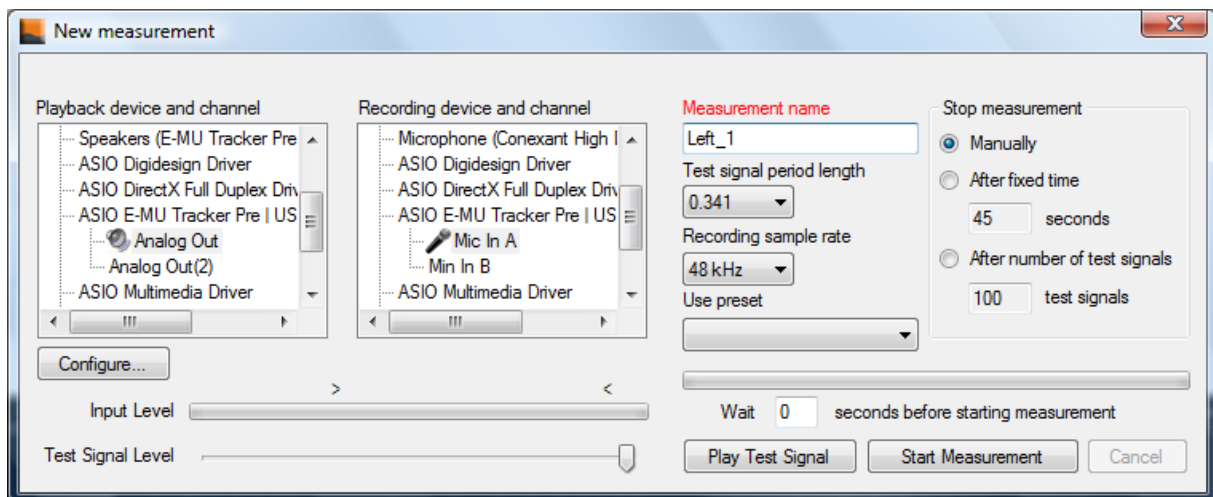

Figure 7: The new measurement window.

CHOOSING PLAYBACK AND RECORDING DEVICES

Select the desired playback and recording devices from the appropriate lists.

Select the playback channel to which the test signal should be sent and the recording channel where the microphone is connected.

The device lists will include a computer's internal sound card (if applicable) and other audio devices which are recognized by the system. The lists are updated continuously and will reflect any changes to the list of available devices in real-time.

SETTING MEASUREMENT PARAMETERS

Type in the measurement name (e.g. "Left_1"). Measurement cannot be recorded without giving it a name.

Choose the test signal period. The default period of 0.341 seconds is suitable for small to medium size rooms. Longer sweep periods are required for larger and very reverberant or very noisy venues, or when measuring low frequency drivers (subwoofers).

Select the recording sample rate which is supported by the audio device. 96 kHz is preferred to obtain a more precise measurement in the high frequency area.

Choose the way the measurement will stop. It is possible to end the measurement automatically after either a fixed time has elapsed or after a certain number of test signals are produced. Manual method allows to stop measurement by pressing the "Stop Measurement" button.

SETTING UP GAIN

CONEQ™ Workshop provides a control for the output signal level. By default it is set to −30dBFS to prevent very high output signal levels. However, this control is purely digital and affects the resolution of the test signal. Therefore, if the used sound output devices (e.g. audio interfaces, amplifiers) have their own hardware level controls then use them to attenuate the output signal and set the slider in CONEQ™ Workshop to the maximum level.

Click the "Start Test Signal" button to start playing the test signal on the selected playback device and channel. Slowly increase the output level of the system until the test signal can be heard. The CONEQ™ test signal is a rapidly swept sine-wave (sometimes called "sweep"); once you hear it, you will unmistakably recognize it in the future.

Adjust the loudness to a comfortable listening level where you would be able to clearly hear anyone speaking at the same time. A higher level is generally preferred, as it results in a better signal-to-noise ratio. Be careful, however, not to drive the amplifier(s) into clipping or overdrive the loudspeaker(s). If a loudspeaker is driven into distortion, the measurement will be skewed and loudspeaker damage could occur.

If the environment is noisy with other people present (such as stage lighting or construction crews), it's important to establish a level that is higher than the ambient noise.

Adjust the input gain by using the input gain control on the device, using the meter in CONEQ™ Workshop as a guide. The CONEQ™ Workshop level meter (a horizontal bar just below the lists of devices) should stay predominantly between the recommended minimum and maximum level marks (">" and "<", respectively) and never fill completely because that means signal clipping (overload).

PERFORMING THE MEASUREMENT

Starting and stopping

While the test signal is playing, click "Start measurement" to start recording a measurement (the name of the button will change to "Stop measurement"). The measurement timer will start displaying the elapsed time and the test signal counter will increase as the measurement progresses.

The measurement will stop either automatically according to specified criteria or when the "Stop measurement" button is pressed.

If you need some time to get to the measurement position, enter the amount of time in the "Wait seconds before starting measurement" field. This is the time CONEQ™ Workshop will ignore from the start of the recorded measurement. The same amount of time will be discarded from the end of the measurement (only in the manual stop mode) to allow you to get back to the computer and stop the measurement without affecting the results.

Duration

When measuring a loudspeaker system, the basic principle of CONEQ™ is to acquire several hundred measurement points around the loudspeaker system, thereby gathering enough information to calculate the loudspeaker's true Acoustic Power Frequency Response (APFR). A minimum of 150 measurement points is recommended. Once 250 measurement points are acquired, there is only a small advantage in acquiring more. Each test signal results in one measurement point. Using the default test signal period of 0.341 ms, about three measurement points per second are recorded. Recording 200 measurement points takes slightly more than a minute.

In the case of measuring a sound card or other electronic signal processor, only 10 – 15 test signals need to be recorded in order to obtain a valid measurement.

Coverage area

To do a proper measurement it is useful to know the manufacturer's specification of the loudspeaker's intended angle of coverage. For example, if the loudspeaker is specified as a 90 x 40 degree device, you have to replicate that angle of coverage within the room. In many situations, placing some marking tape on the floor can be a useful guideline.

When the measurement is started, move the measurement microphone slowly and evenly throughout the angle of coverage of the loudspeaker system, working from top to bottom and from left to right, for approximately 200 test signals (about 68 seconds when using the default test signal period). An example of a measurement surface and the microphone traverse path in front of a loudspeaker is shown in the figure 8.
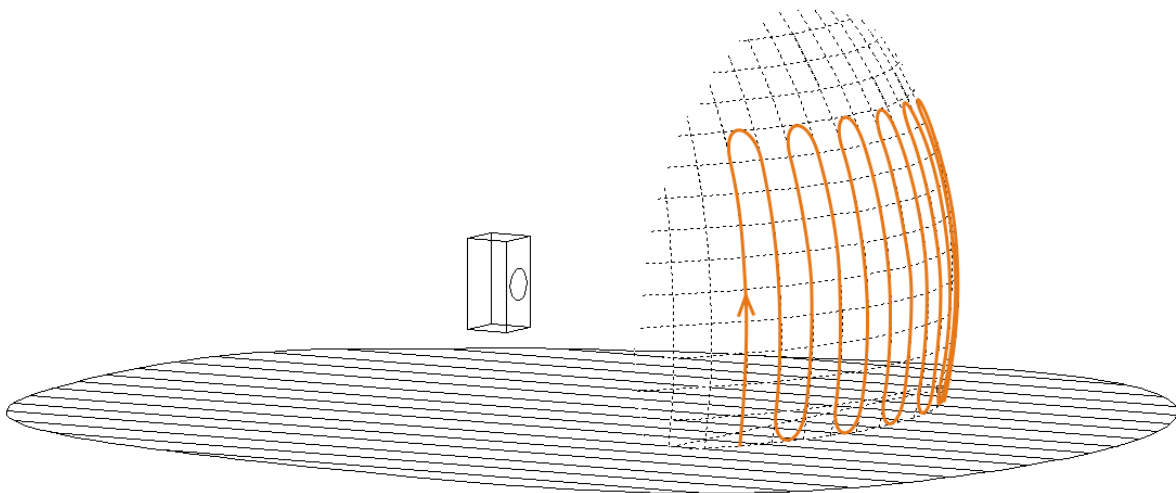

Figure 8: Measurement surface and microphone traverse path in front of a loudspeaker.

Distance

As a rule of thumb, measurement is taken at a similar distance from the loudspeaker, as the size of the loudspeaker cabinet plus the distance from the loudspeaker to the nearest reflective surface. Typically this will be no less than one metre and not more than five to six metres.

Measuring too close will result in measuring each individual driver of the loudspeaker which is not desired as we look at the loudspeaker cabinet as a system.

Measuring too far might gather too much of the room reflections which is useful information but should not be used to automatically generate speaker correction filters.

Interpreting results

When measurement stops, CONEQ™ Workshop calculates the acoustic power frequency response and the first CONEQ™ correction filter for this measurement. When ready, the graph showing the frequency response curve of the DUT will appear. See the figure 9 for a typical example.
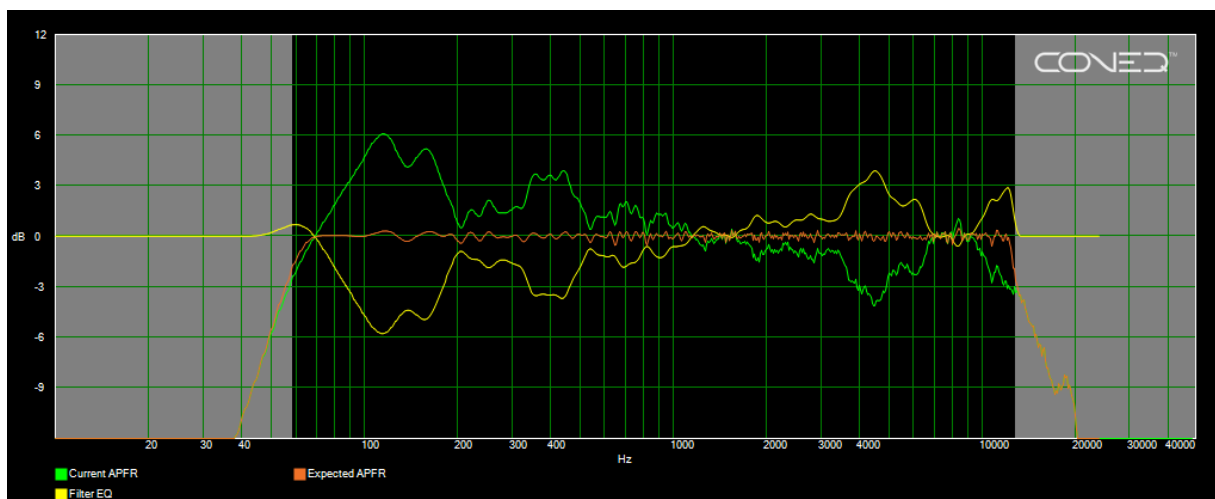

Figure 9: An example of the frequency response graph.

The green curve shows the actual measured acoustic power frequency response (APFR) of the DUT, the yellow curve shows the correction filter, and the orange curve shows the expected frequency response of the DUT after the filter is applied to the signal path. The greyed-out areas enclose the automatically determined correction range.

An important other curve is the cyan curve labelled "Noise/Distortion" (see figure 10). It shows the level of noise in the environment. It must be more than 10 dB below the APFR curve at all frequencies within the correction range. If it is not, then a new measurement should be taken by increasing the volume of the test signal, the sensitivity of the microphone, or reducing the ambient noise level.

Check the impulse response graph to see if there are no errors e.g. due to non-linearities (clipping, overdrive). An example of a typical impulse response graph is shown in figure 11.
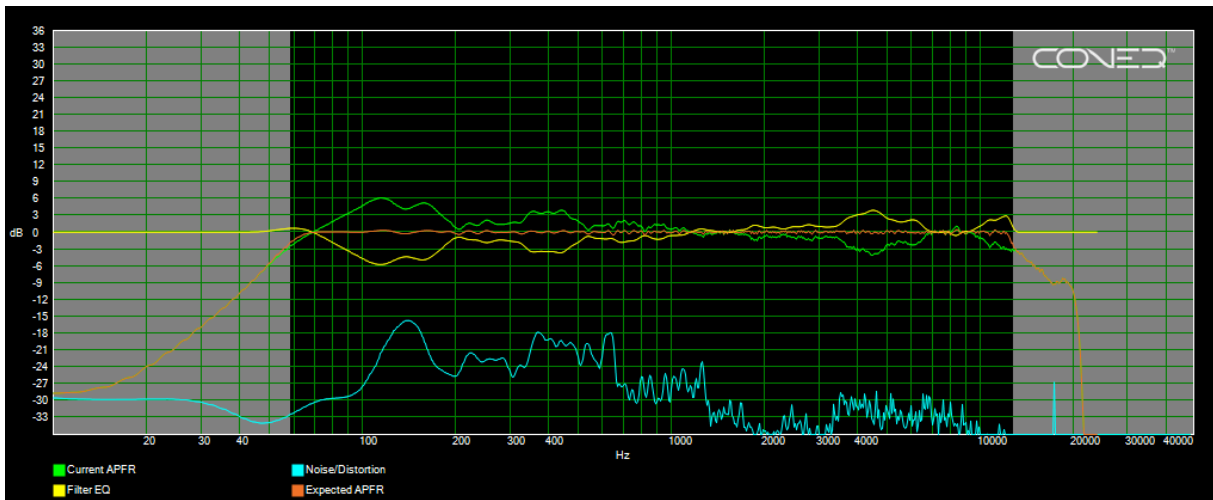
Figure 10: The noise/distortion curve that is comfortably lower than the suggested 10 dB below the APFR.
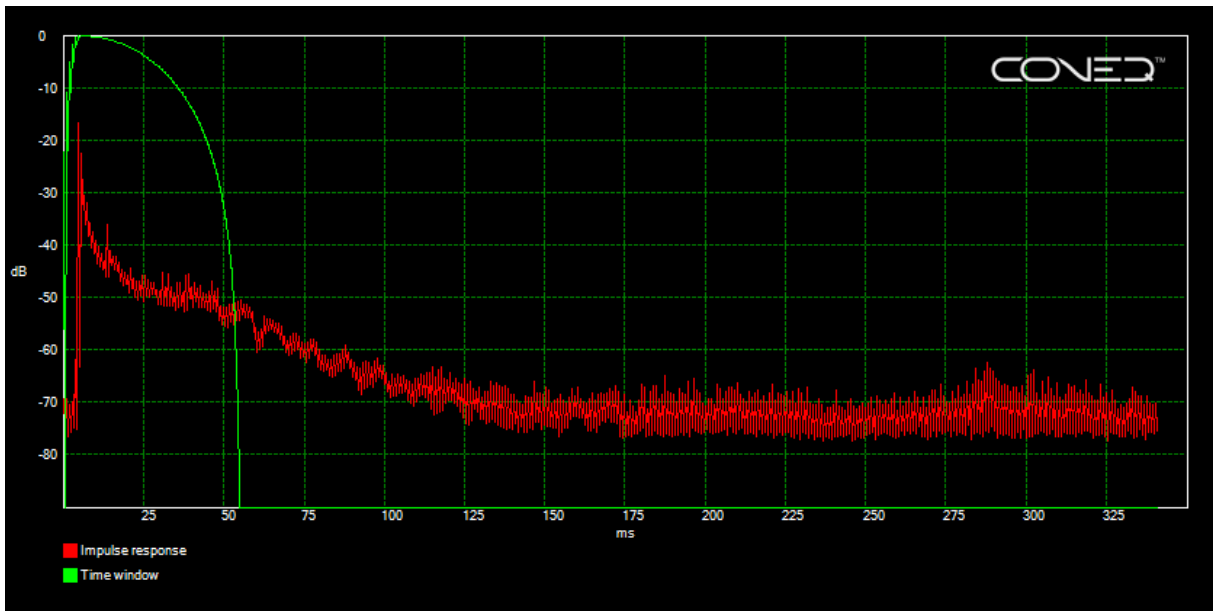
Figure 11: A typical impulse response graph.

CHANGING FILTER PARAMETERS

Filter parameters can be changed in the top right area of the project window. Click the "Recalculate Filter" button to create a new filter with modified parameters. Alternatively, choose "Filter->Apply Changes" from the menu to update the currently selected filter.

Two most important filter parameters are its resolution and sample rate. This determines how precise the filter will be as well as where it can be used.

Choose "For APEQ™ hardware equalizer" to create a filter with 4096 taps and 48kHz sample rate that can be used by the APEQ™ hardware equalizer.

Choose one of the plug-in options ("For CONEQ™ P2pro/P8pro plug-in" or "For CONEQ™ P2/P8 plug-in") to create a filter with 4096/1024 taps and one of the available sample rates

that can be used by the CONEQ™ plug–ins inside a DAW (Digital Audio Workstation) or other host applications, such as Cubase, Nuendo, Pro Tools, Sonar, Audition etc.

> **IMPORTANT!**   *The sample rate of the filter must match the sample rate of the master track to which the plug–in will be applied. To create a filter for the needed sample rate, choose the sample rate from the "Sampling frequency" list and click the "Recalculate Filter" button.*

> **IMPORTANT!**   *Loudspeakers for each channel must be measured separately. Repeat the STEP 3 for the other channels that are to be corrected.*

Now, we are ready to use the generated correction filters with compatible hardware or software tools that support the "FIR" filter file format.

STEP 4: APPLYING THE CONEQ™ CORRECTION FILTERS

Either the APEQ™ hardware equalizer or the CONEQ™ software plug-ins can be used to apply the CONEQ™ correction filter to the sound path. To do so, the CONEQ™ correction filter must be saved as a "·.FIR" file. "FIR" stands for Finite Impulse Response and is the filter format used by all CONEQ™-compatible software and hardware tools.

If using the APEQ™ hardware equalizer, the currently selected filter can be uploaded to it directly from CONEQ™ Workshop by using the APEQ™ control panel on the main window (see figure 12) without having to access the "·.FIR" file directly.
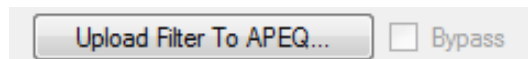

Figure 12: APEQ™ control panel on the main window.

The CONEQ™ Workshop saves the "·.FIR" files to a folder inside the project folder structure. A convenient way to access the filter file is to click on the filter in the Measurement list and select "Filter -> Open Filter Folder" from the menu. The file with the extension "·.FIR" is the filter file.

Here is how to locate the relevant files manually. Let's assume the project folder is named "MySpeakers". Let's also assume that two measurements were made, named "Left_1" and "Right_1" for the left and right channels respectively. At last, let's assume that for the left channel one new filter was created after changing some parameters and this is the filter we are looking for. The project will have the folder structure as shown in figure 13. The selected file "MySpeakers_1_Left_1_02.fir" is the filter file we are seeking.

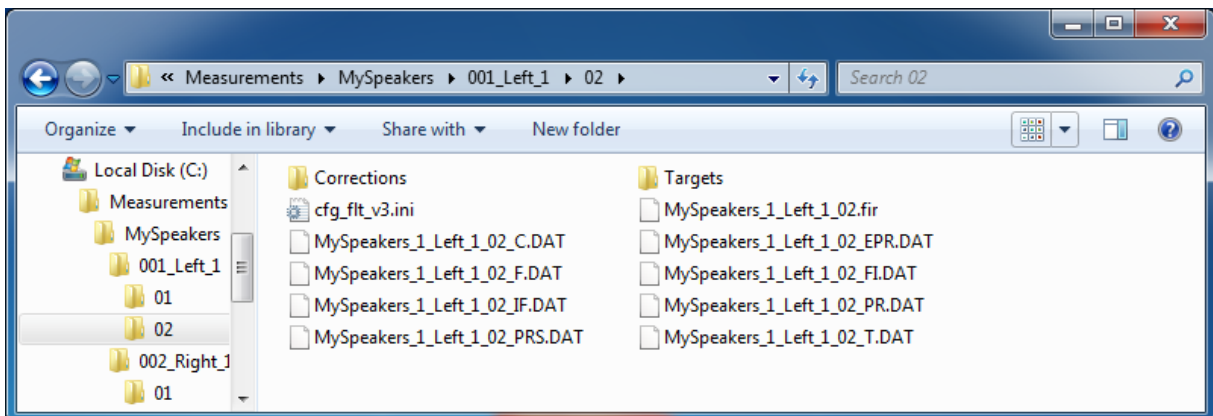*Figure 13: The project folder structure and filter file location.*

There are two folders for the Left_1 measurement. The folder "01" contains the first filter data, calculated directly after the measurement was taken. The folder "02" contains the filter created after the change of some parameters.

The filter for the right channel is located in folder "MySpeakers/002_Right_1/01" and is named "MySpeakers_2_Right_1_01.fir".

USING APEQ HARDWARE EQUALIZER

APEQ is a family of Real Sound Lab's hardware equalizers that apply CONEQ™ correction filters to audio signal. Typically, the filters are uploaded to the device either from within CONEQ™ Workshop using the APEQ™control panel or using the APEQ™ Communication Tool (C2) software that is bundled with every APEQ™ unit. The C2 tool has a User Guide that describes how to use it in more detail.

Figure 14: The APEQ–2pro two–channel hardware equalizer.

> **IMPORTANT!** *For use with the APEQ™ hardware, create and save filter files that have 4096 taps at 48kHz. Filter files with other settings are not recognized by the APEQ™ hardware equalizer. CONEQ™ Workshop provides a dedicated setting for filter parameters, designed for APEQ™ hardware equalizer.*

The APEQ™ units are true multi–mono equalisers and each channel can be used for any purpose independent of the other channels. For instance, the two channels of a two channel APEQ™ unit can be the left and right channels or they can be the centre and subwoofer channels or any other channels as needed. Each channel uses a dedicated CONEQ™ correction filter.

USING CONEQ™ PLUG–INS

Real Sound Lab offers CONEQ™ plug–ins for use with DAW (Digital Audio Workstation) applications. Currently, VST and RTAS host applications (Cubase, Nuendo, Sonar, Pro Tools, Audition, etc.) are supported. The AudioUnit (Apple Logic etc.) versions are being developed.

The filter sampling frequency must match the sampling frequency of the stream (master track) to which the plug–in is applied. E.g. to work on a 48kHz audio data, a 48kHz filter file must be created by choosing the corresponding value in the "Sampling frequency field" .
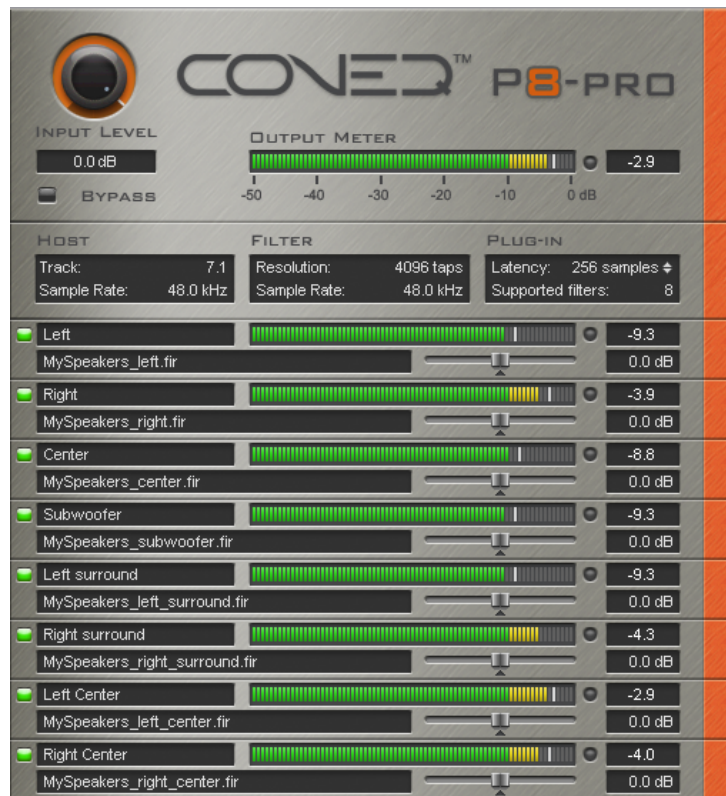
Figure 15: The user interface of the CONEQ™ P8pro plug-in.

IMPORTANT!   For use with the CONEQ™ P8/P2 plug-ins, create and save filter files that have 1024 taps. CONEQ™ Workshop provides a dedicated setting for filter parameters, designed for CONEQ™ P2/P8 plug-ins. The 4096 tap filters are not supported by these plug-ins. For higher resolution filters, use either the APEQ™ hardware unit or CONEQ™ P2pro/P8pro plug-ins.

IMPORTANT! Streams of different sampling frequencies require different FIR files. This means that to work on audio at 44.1kHz, 48kHz, and 96kHz, three separate filters must be saved for each channel.

TECHNICAL SUPPORT

Please feel free to contact us at any time about any difficulties using CONEQ™ Workshop software (our contact details are listed below). We will do our best to respond to you as quickly as possible. Our mission is to make your experience with CONEQ™ as simple and rewarding as possible. To help us resolve issues quickly, we might need one or more of the following data:

1. CONEQ™ Workshop software edition and version (It can be found in "Help -> About").

2. The operating system: Windows XP, Windows Vista, or Windows 7, Mac OS X 10.5 or 10.6.

3. Computer information: CPU type and speed, installed memory.

4. Description of the problem (as much information for us to understand the problem as possible, including screenshots and/or crash logs if relevant).

CONTACTING REAL SOUND LAB

Should you have questions or comments, please contact us using one of the following ways:

1. E-mail: support@realsoundlab.com

2. WWW: www.realsoundlab.com

3. Phone: +371 6788 9828 (Real Sound Lab SIA Headquarters, Riga, Latvia)

Thank you for choosing CONEQ™!

APPENDIX

CREATING A COMPOSITE MEASUREMENT

Sometimes it is necessary to average several individual measurements. Such cases include but are not limited to cases when we want to exclude any measurement error by repeating the same measurement several times, or when making a single measurement of the full measurement surface is not technically or physically possible.

In these cases use the measurement composition feature of CONEQ™ Workshop. The following is a description of the basic operating procedure.

First, acquire the individual measurements that will make up the composite response. After doing so, either click on the "Composite..." button just below the measurements list or choose "Measurement -> Composite" from the menu.

A window similar to the one in figure 16 will open. Type in the name of the composite measurement. Choose the measurements to use for the calculation of the composite by checking the check boxes alongside the measurement names.

Click the "Calculate" button to calculate the composed measurement. After calculation is done the composed measurement will appear on the measurements list along with other measurements.
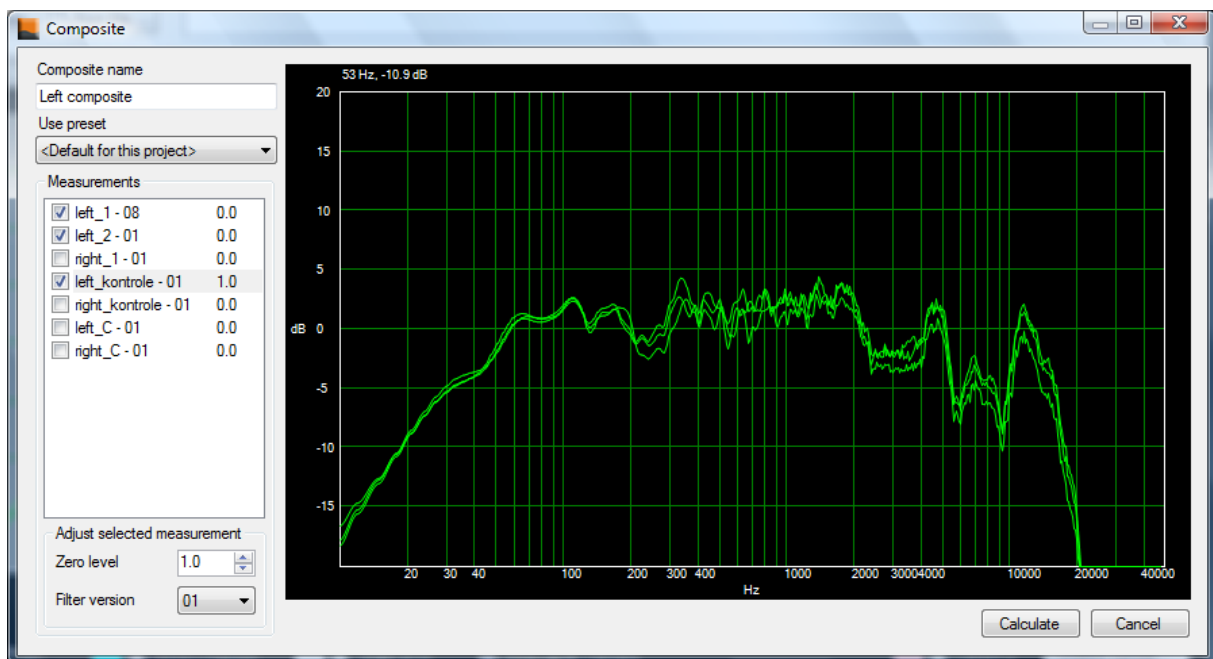

Figure 16: Measurement composition window.

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