

CLIO Pocket Review

by

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I have been using CLIO electro-acoustic measurement systems for about 20 years, going all the way back to CLIO 4.0, a DOS based system using the HR-2000 signal generator/audio analyzer PCI board. So I was especially excited when the folks at Audiomatica asked me to beta test their latest creation, CLIO Pocket. As its name implies the CLIO Pocket audio interface literally fits in your pocket! (see photo 1). CLIO Pocket is a lower cost electro-acoustic measurement system primarily intended for the experienced amateur speaker builder, but it also represents a highly portable measurement system for the professional doing a lot of on-site work.



Photo 1 And...it fits in your pocket!

CLIO Pocket arrives nicely packaged in a padded carrying case. The case contains the CP-01 audio interface, a USB cable, a impedance test cable, the MIC-02 microphone with a 2.7m cable and the installation software. Basically, everything one needs to start taking measurements. (photo 2)



Photo 2 CLIO Pocket

The CLIO Pocket system comprises the CP-01 Audio Interface (hardware) and software designed to run on Windows XP, Vista, 7, 8 and 8.1. It will also run on Apple Mac OSX.

The CP-01 audio interface measures approximately 125 X 90 X 24mm. It is made up of two systems, a signal generator and an audio analyzer. On the front face of the CP-01 you can see a blue LED, an RCA input jack to the audio analyzer and an RCA output jack from the signal generator. Connection to the computer is via a USB 2.0 port which powers the CP-01 and interfaces to the software.

Installation and Calibration

Hardware installation is fairly straightforward. After CLIO pocket is connected to a USB port and recognized by your computer two additional USB drivers available on the distribution disk must be installed manually. Then the software can be installed.

Before CLIO Pocket can be used you must go through a calibration process. Start the program and allow the CP-01 warm up for 15 to 20 minutes (The blue LED should be lit.). Then an initial sine wave analysis is performed using the FFT option. If this is successful the calibration

process can proceed. Just select "calibration" from the main menu. The process is fully automatic and takes about a minute to complete. As described in the manual, several tests can then be run to validate the calibration.

CLIO Pocket Functions

At the heart of CLIO Pocket setup and control are three windows; the options window, the generator control window and the measurements settings window. In the options window you can set the sample rate (48 or 96kHz), measurement units like microphone sensitivity, graphics options and notes on saved measurements. The 96kHz sample rate sets a maximum analysis bandwidth of 40kHz.

In the signal generator window you can select sine, two sine, all wave, chirp, white noise and pink noise signals. You can also select the new CEA tone burst used for subwoofer testing. Upon selecting sine it can play continuously or you can generate a tone burst by setting time on and time off values. Selecting two sine you can set the frequency of each sine wave and the relative amplitude. This signal set is useful for inter-modulation distortion tests. All-wave and pink noise signals are available in lengths of 4K, 16K and 64K (This becomes important in the FFT measurement option, see below). Chirp lengths of 4K to 256K are available. You can also select compatible WAV files from this window.

The measurement settings panel is where you really get down to the business of CLIO Pocket. Clicking on the measurement setting icon opens the CLIO Pocket Options window where you find measurement and processing options for FFT, Log Chirp, Waterfall, Thiele-Small parameters, math post processing options and a notepad to attach descriptions to saved measurements.

Selecting the FFT tab you can set the FFT size at 4K, 16K or 64K and set measurement units of dBV, dBu, dBRel or dB SPL. Available windows include Rectangular, Hanning, Hamming, Blackman, Bartlett and Flatop. Averaging can be exponential or linear. Hold options include no hold, max hold and min hold. Frequency processing is by FFT with smoothing options from 1/48 octave to 1 octave or RTA plot. There is also an event trigger option.

Turning to the Log Chirp window you can select chirp lengths of 16K and 64K. Measurements units of dBV, dBu, dBRel, dB SPL or Ohms are available. Time data processing options include impulse response, step response, energy-time curve and Schroeder decay with rectangular and auto half-Hann windows. A capture delay can also be set. Frequency processing options include smoothing from 1/48 octave to 1 octave and display of normal, minimum and excess phase and group delay.

The Thiele-Small window sets up estimation of the T/S parameters using two impedance measurements of the driver under test. The impedance

data is obtained from log chirp measurements. Both the added mass and known volume techniques are implemented.

The waterfall window sets up the parameters for computing the cumulative spectral decay of an impulse response measured in the log chirp mode. In this window one can set the start and stop frequencies, smoothing, dB range, number of spectra, and time shift between spectra.

Clicking on the math tab reveals a number of post processing operations that can be applied to the log chirp data. The options include adding two files together, dividing one file by another, merging a low-frequency file with a high-frequency file, level shifting a file by a specified dB amount, and finally, implementing the microphone-in-a box low-frequency measurement technique [1&2]. I will illustrate the use of many of these math functions in the examples to follow.

Examples

Thiele-Small Parameters: In this example we will calculate the T-S parameters of a 7" woofer-midrange driver using the "known volume" method. Estimating the T-S parameters in CLIO Pocket is a multi-step process. Prior to estimating the parameters two impedance measurements are needed. Shown in Fig 1, they are a free-air measurement (red) and a measurement with the driver mounted in a know volume of 12.8 liters (green). The impedance data is taken in the log chirp processing option. A 64K chirp length was chosen for improved low-frequency accuracy. Each measurement is stored for later recall during the T-S processing.

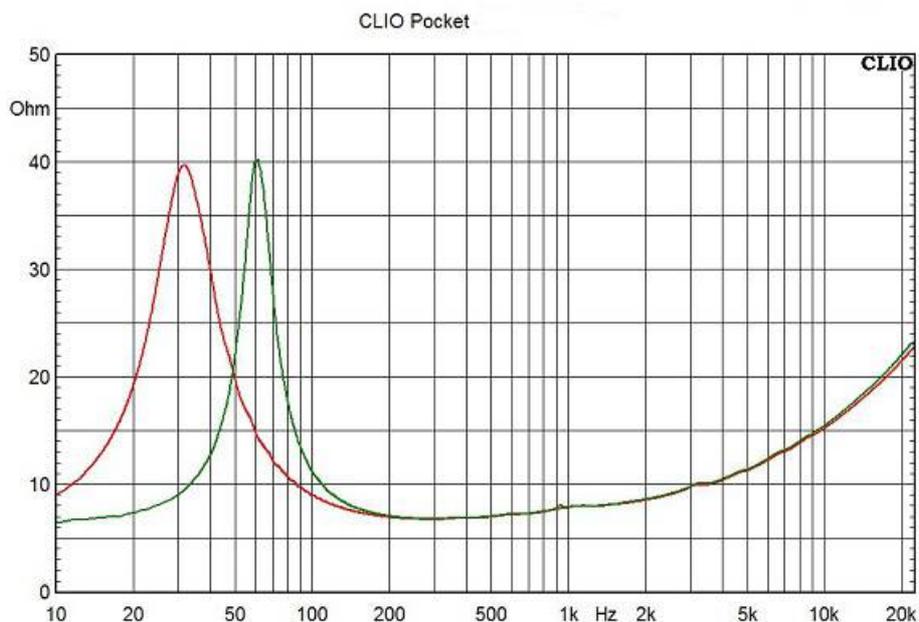


Fig 1 Impedance data for T-S paramter estimates

Now load the free-air impedance measurement, open the CLIO Pocket Options window and click the T&S parameters tab opening the data entry

menu for T-S measurement, Fig 2. Here you enter information describing the driver including manufacturer, model number voice coil resistance (R_E), diaphragm diameter or area. If you do not know R_E , click on the "measure button" and CLIO Pocket will measure it. Then click on the Free-Air button as this is the impedance data to be processed first.

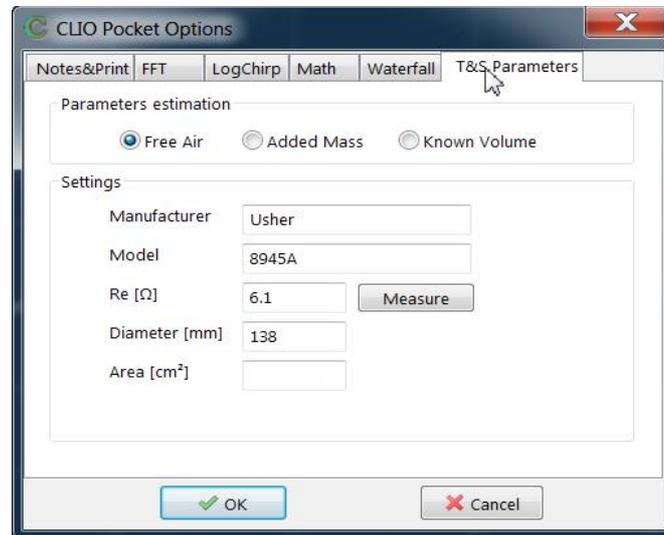


Fig 2 Driver data for T-S analysis

Close the measurement settings menu and click on the T&S icon in the upper tool bar. As shown in Fig 3, a window appears showing parameters that can be calculated from the free-air impedance data. Notice that CLIO Pocket has calculated driver cone area, S_D , from the input diameter.

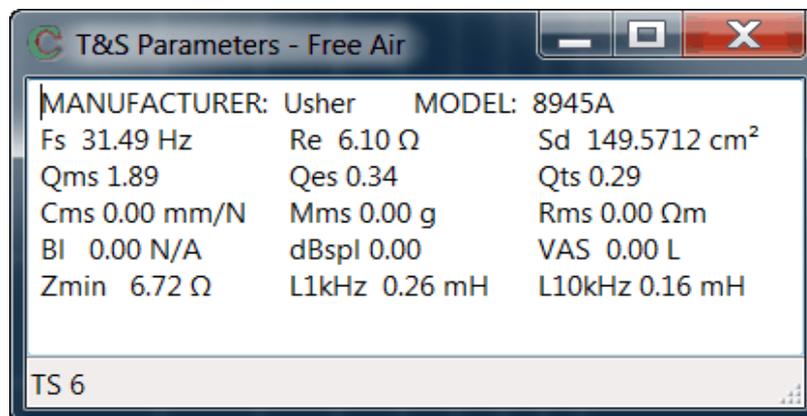


Fig 3 T-S Free-air parameters

Now load the known volume impedance data, open the T&S parameters measurement window again, click the "Known Volume" button and enter the test box volume, 12.8l in this case (Fig-4). Close the window and again click on the T&S icon in the upper tool bar. Now, as shown in Fig 5, a window appears showing the full set of T-S parameters. If desired, the T-S data can be exported as a text file.

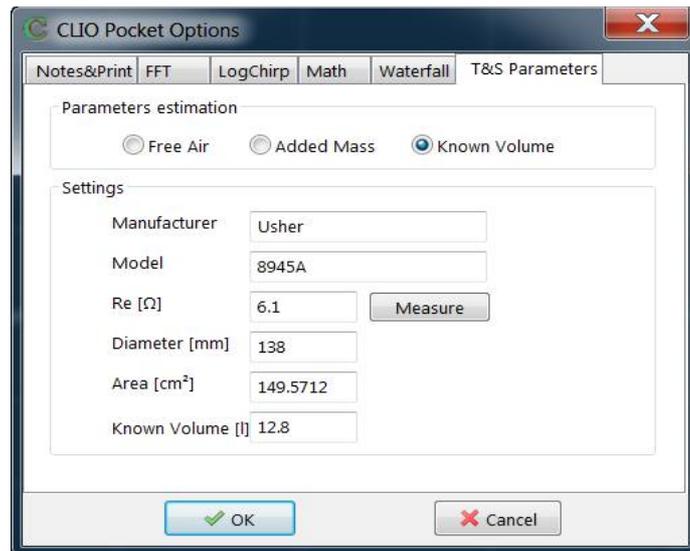


Fig 4 Data input for know-volume T-S analysis

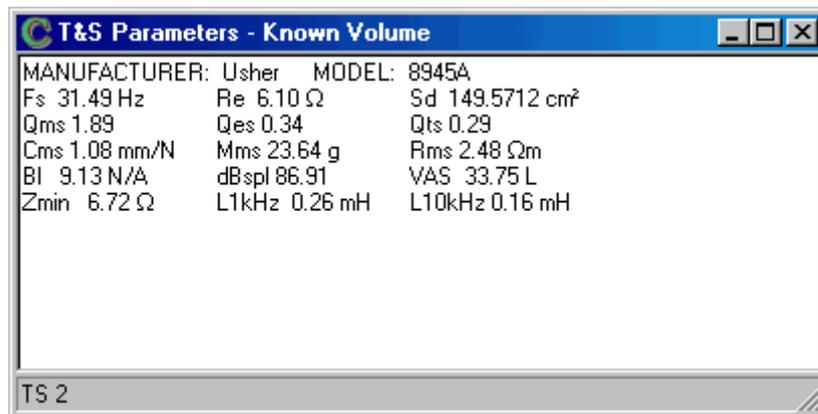


Fig 5 Final results of T-S parameter estimates

Loudspeaker Frequency Response: Loudspeaker frequency response is measured using the Log Chirp option. This example will examine the response of a small two-way vented loudspeaker. In the absence of an anechoic chamber, loudspeaker response measurements will invariably be corrupted by later arriving reflections from nearby surfaces. A typical set up a hobbyist designer might encounter is shown in Fig 6. In this example the MIC-02 microphone is placed on the tweeter axis at a distance of 1m. The first corrupting reflection will come from the floor bounce.

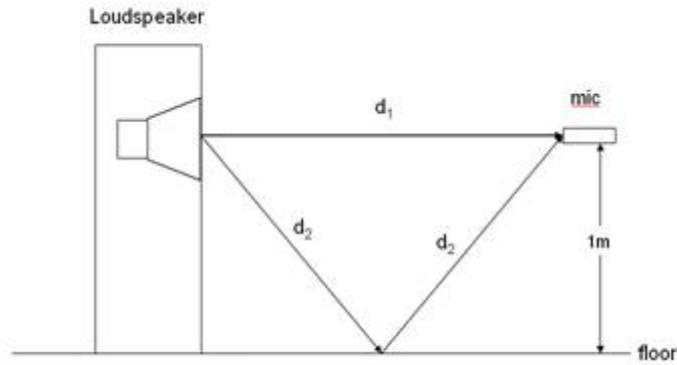


Fig 6 Test set up

Parameters for the test are selected in the Log Chirp window (Fig 7). Chirp length is set at 16K. dB SPL is selected for the Y-Axis frequency response display. Time processing will produce the impulse response. A Half-Hann window will be applied to the selected time interval and the computed frequency response will be displayed with 1/12th octave smoothing.

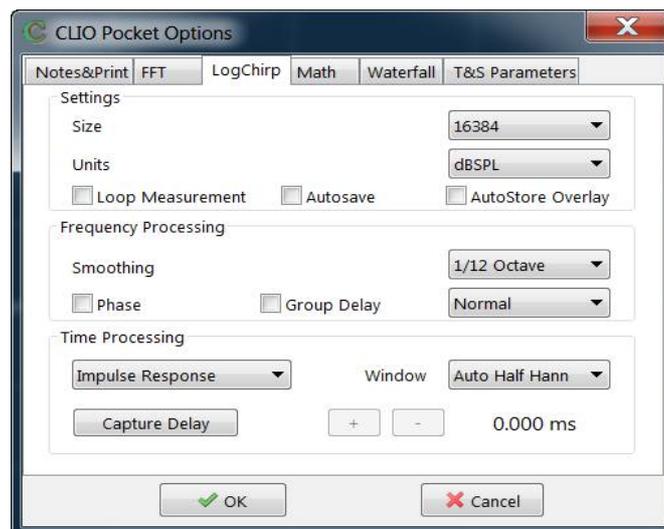


Fig 7 Parameter selection for Loudspeaker Response test

The resulting measurement is shown in Fig 8.

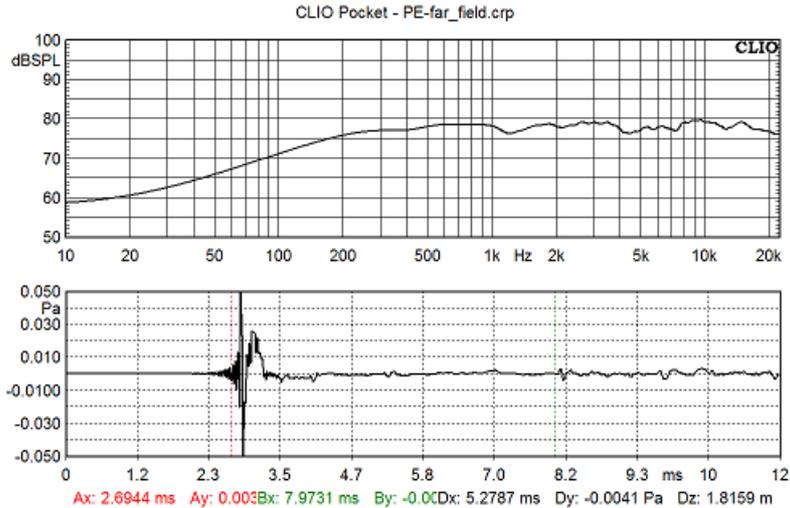


Fig 8 Time and frequency response for our two-way example

Frequency and time domain plots can be shown individually, but CLIO Pocket has a very useful split screen display where both time and frequency plots are shown together. Examining the time display first and ignoring the transient build-up of the FIR anti-aliasing filter, the direct signal from the loudspeaker arrives at the microphone at about 2.7ms. The floor reflection appears at about 8ms. So we have 5.3ms of reflection free response which corresponds to a low-frequency limit of

$$f_{\min} = 1/0.0053 = 188\text{Hz}$$

So the computed frequency response is valid only above 188Hz. Plotted response below 188Hz is simply an artifact of the FFT. 188Hz is also the resolution of the response data. The FFT algorithm least-squares fits the points between 188Hz intervals. Above 200Hz response fits within a 3.5dB window.

At this point we can open the Log Chirp window and request plots of phase and group delay. Perhaps the most interesting plot is the excess group delay plot. The concept of excess group delay is discussed in detail in [3]. For our purposes it is a measure of signal arrival time vs. frequency. Fig 9 shows a plot of excess group delay for our two-way example.

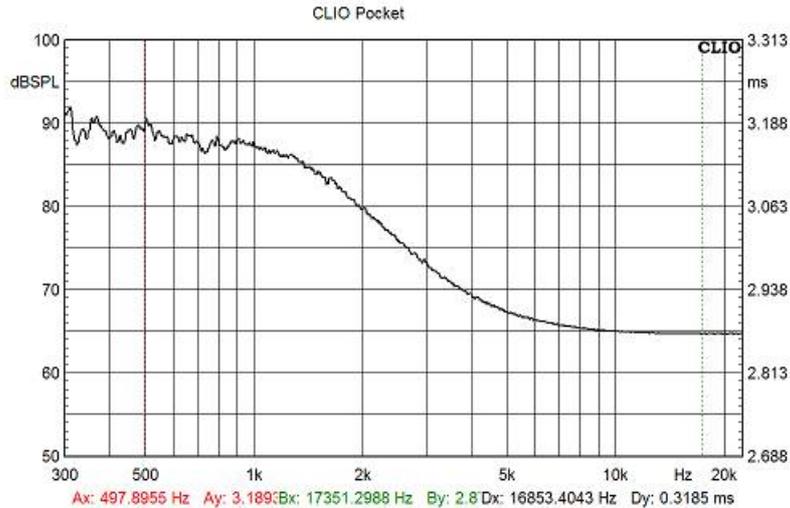


Fig 9 Excess group delay for our two-way loudspeaker example

High frequencies from the tweeter will arrive first. The green cursor set at 17.3kHz shows a tweeter arrival time of 2.87ms. The red cursor set at 500Hz shows a woofer arrival time of 3.19ms. Thus the woofer is delayed relative to the tweeter by 0.32ms or 320µs. This delay is caused by the woofer frequency response and the low-pass filter used in the crossover network.

We have the frequency response above 188Hz. Without an anechoic chamber we can get a good approximation to the low-frequency response of our two-way example using the Keele near-field method. This technique is described in detail in [2&4]. Here is where the power of CLIO Pocket's post processing math functions comes in to play. The procedure involves measuring the woofer and port near-field responses, scaling the port response by the port/woofer diameter ratio and then adding the two responses accounting for both magnitude and phase. This low-frequency response is then merged the high-frequency response to get the full range response of our example. The port/woofer diameter ration is:

$$R = 68\text{mm}/138\text{mm} = -6.14\text{dB}$$

Fig 10 shows the measured near-field port response (red), the port response reduced by 6.14dB using CLIO Pocket's "dB shift" math option (green), and the near-field woofer response (orange). Now using the "add file" math post processing option, the near-field woofer response and the scaled port response are added to get the final low-frequency response estimate (blue).

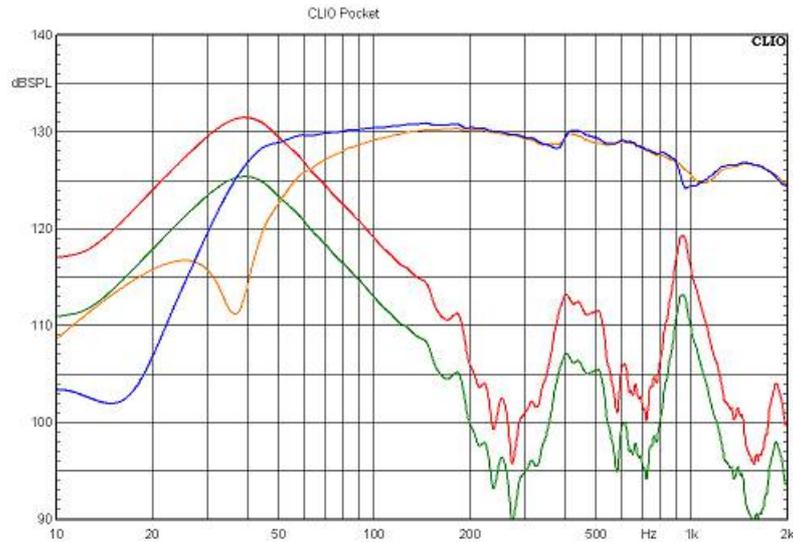


Fig 10 Near-field measurements and final low-frequency response

We need one more step to get the full range response of our two-way example, merging the far-field and the near-field responses to get the full range response. First use the "dB level shift" math function to level match the near and far-field responses. Fig 11 shows the far-field response (green) and the low-frequency response (blue) level shifted to match the far-field sensitivity. The two plots meet around 350Hz. Using the "Merge LF file" math option, the low-frequency response is merged with the far-field response at 350Hz to get the final full range response (red) which has been level shifted up 10dB for clarity.

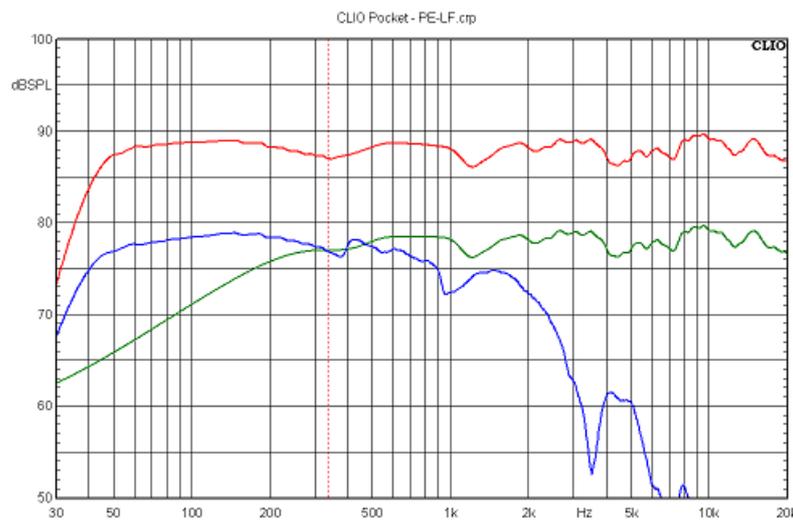


Fig 11 Far-field, low-frequency and full range responses

Besides loudspeaker frequency response, the log chirp option is also useful for measuring the frequency response of electronics. This next example measures the response of a low-frequency equalizer circuit for a closed-box subwoofer. To do this the CLIO Pocket output is connected to the equalizer input and the equalizer output is sent to the CLIO Pocket input.

Log Chirp test parameters are displayed in Fig 12. Notice the response will be measured in dBV. The resulting equalizer response is shown in Fig 13. You can see the equalizer produces 8.65dB boost at 20Hz. High-frequency equalizer response is deliberately rolled off.

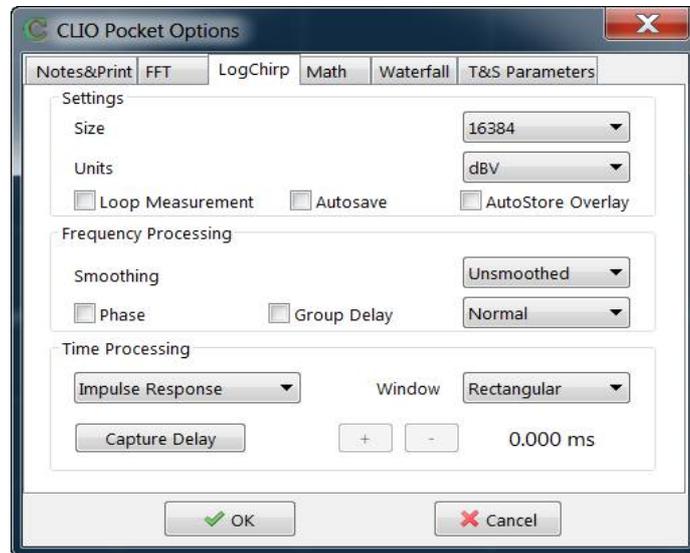


Fig 12 Log-chirp parameters for Subwoofer equalizer test

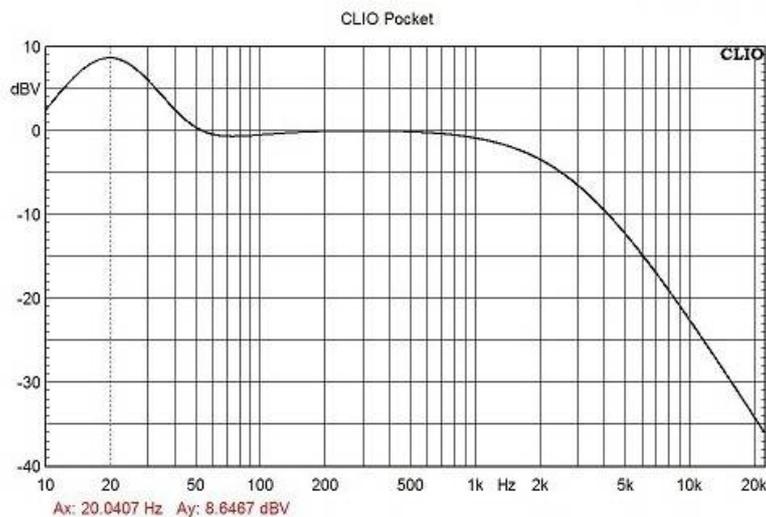


Fig 13 Equalizer frequency response

Waterfall Option: The waterfall option is used to compute the Cumulative Spectral Decay or CSD. The CSD measures the frequency content of a loudspeaker's decay response following an impulsive input. Ideally, a loudspeaker response should die away instantly. Real world speakers have inertia and stored energy that take a finite time to dissipate. For a full discussion of the CSD see [5]. The CSD computation involves a series of FFT calculations. In CLIO Pocket these calculations are performed in the Waterfall Option and displayed with a 3-dimensional waterfall plot with time running along the x-axis, frequency along the y-axis and amplitude along the z-axis.

The CSD for our two-way example shown in Fig 14 is computed from the impulse response shown in Fig 8.

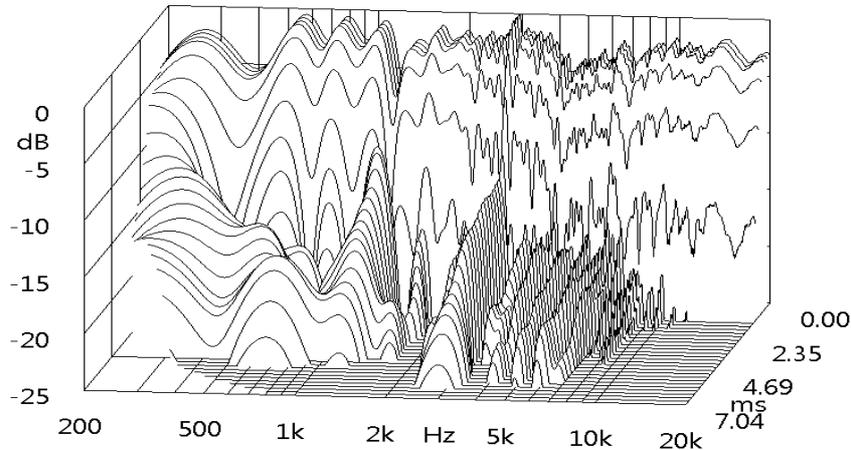


Fig 14 Two-way Speaker Cumulative Spectral Decay

The initial decay is somewhat disorganized, but after about 2ms low level decay modes appear in the 2 to 7 kHz region.

The CSD is commonly used to examine resonant decay modes of a loudspeaker. However, in the CLIO Pocket manual, Audiomatica shows a very clever application of the CSD to analyze room acoustics, and in particular to find any resonant modes in a listening room. To do this you must first get the room response to an impulse, an acoustic impulse! A spark gap is often used for this purpose, but Audiomatica does it by bursting a balloon! Check the manual available on the Audiomatica website for details.

FFT Analysis: As discussed earlier, CLIO Pocket has a number of signals available in the FFT analysis option. We will look at two that can be used in the frequency response assessment of our two-way example. They are pink noise and the all wave signal. Pink noise is the signal used to get the 1/3 octave response or RTA. The all wave signal has tones corresponding to all FFT bins. In CLIO Pocket it can be used to produce an RTA plot or a continuous frequency response plot.

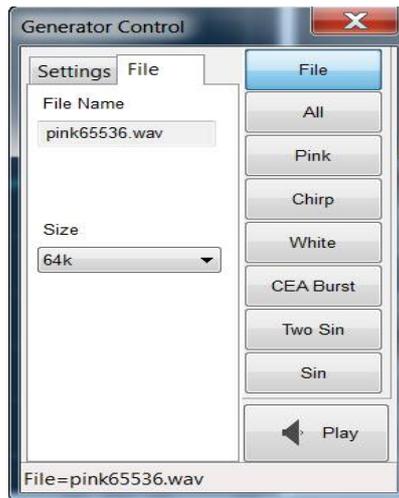


Fig 15 Pink noise set up on generator control panel

As shown in Fig 15 we open the generator control panel and select a pink noise signal of 64K length. Fig 16 shows the measurement set up for the RTA analysis using pink noise.

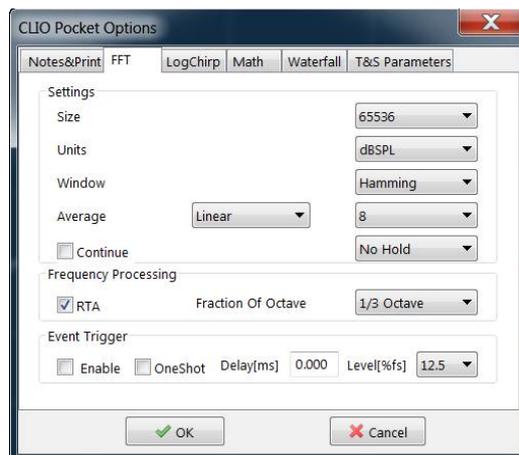


Fig 16 FFT measurement set up

Analysis length is set at 64K to match the pink noise length. This puts more FFT samples in the lowest 1/3 octave (20-25Hz) to give us a better estimate of low-end response. We are using a Hamming window, averaging 8 measurements and plotting the result in 1/3 octave bands. Notice the RTA button is selected to give the traditional RTA plot.

The all wave signal is also set at 64K length. The measurement set up for the all wave analysis is shown on Fig 17. The settings are similar to the RTA analysis, but the RTA button is not checked so the resulting response plot will be a continuous curve.

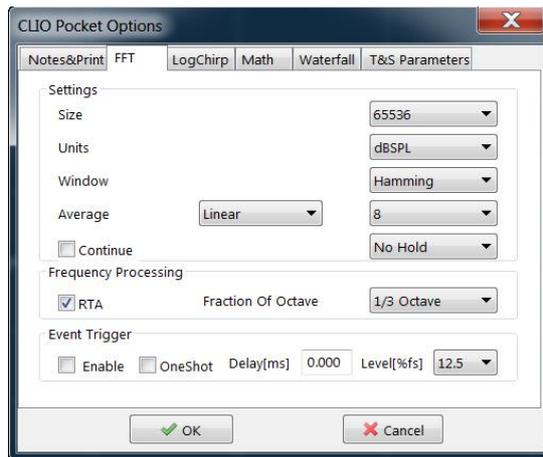


Fig 17 All-wave measurement set up

Measured RTA (red) and all-wave (green) responses are plotted together on Fig 19. They are offset by about 15dB for clarity. These responses are very similar. Both fit in a 5dB window above 200Hz. This agrees well with the chirp analysis shown earlier in Fig 8. Response below 200Hz differs from Fig 8 because the FFT measurements cover the full frequency range and thus include room effects.

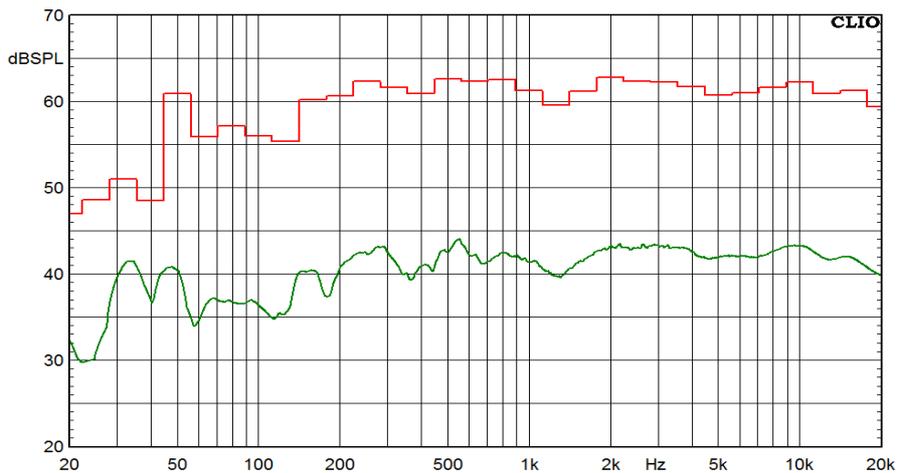


Fig 18 RTA and All-Wave response of Two-Way Loudspeaker

Summary

CLIO Pocket, presented at Los Angeles 2014 AES, is now a finished hardware product sold since March 2015; Audiomatica folks confirmed me that the software (now at release 1.21) is going to be developed further and that all users receive free upgrades for all the life of the actual 1.xx major release, but I think you can see from this review that it already provides all the measurement and analysis capability needed to design and analyze loudspeaker systems and electronic circuits. It has a rich set of stimulus signals, data acquisition modes and post processing functions.

References

- [1] R.H. Small, "Simplified Loudspeaker Measurements at low Frequencies", J. Audio Engineering Society, Vol. 20, pp. 28-33, (Jan/Feb 1972)
- [2] J.A. D'Appolito, "Measuring Loudspeaker Low-Frequency Response" (available on the Audiomatica web site.)
- [3] J.A. D'Appolito, *Testing Loudspeakers*, Chapter 6, section 6.7.5, Audio Amateur Press, 1998
- [4] D. B. Keele, "Low-Frequency Loudspeaker Assessment by Near-Field Sound Pressure Measurement", J. Audio Engineering Society, Vol. 22, pp. 154-162 (April 1974)
- [5] See [3], Chapter 7, Section 7.5.4

Bio

Dr. D'Appolito has been an independent consultant in audio and acoustics for 22 years. He is a long time contributor to AudioXpress and its predecessor, Speaker Builder. He heads his own firm, D'Appolito Laboratories, Ltd., specializing in the design, test and evaluation of loudspeaker systems for two-channel and home theater applications. He also served as Chief Engineer for Snell Acoustics from 2003 to 2010. In that position he designed or led the design of some 80 loudspeaker systems for retail and custom home installation. He is the author of *Testing Loudspeakers*, the acknowledged bible on the subject, which has been translated into four languages, including Chinese. Prior to his work in audio he led a group developing advanced non-linear signal processing algorithms for passive sonar under government contract.