Audiomatica's CLIO Pocket Electro-Acoustical Portable Measurement System

Photo 1: The CLIO pocket really is small enough to fit in your pocket.

I have been using CLIO electro-acoustic measurement systems for about 20 years, going all the way back to the 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, the CLIO Pocket.

By
Joe D'Appolito
(United States)

Photo 2: The CLIO Pocket is a powerful, lightweight portable measurement system.

The CLIO Pocket is a lower cost electro-acoustic measurement system intended for the experienced amateur speaker builder, but it also represents a highly portable measurement system for the professional who is doing a lot of onsite work. And, as its name implies the CLIO Pocket audio interface literally fits in your pocket (see **Photo 1**).

The CLIO Pocket arrives nicely packaged in a padded carrying case (see **Photo 2**). The case contains the CP–01 audio interface, a USB cable, an impedance test cable, the MIC–02 microphone with a 2.7-m cable, and the installation software. Basically, it contains everything you need to start taking measurements.

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 125 mm × 90 mm × 24 mm.

It consists of two systems—a signal generator and an audio analyzer. On the CP–01's front face 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.

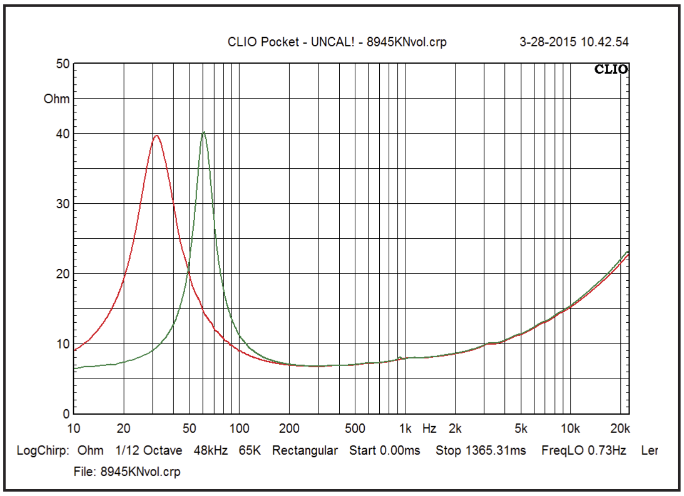

Figure 1: Impedance data for Thiele-Small parameter estimates

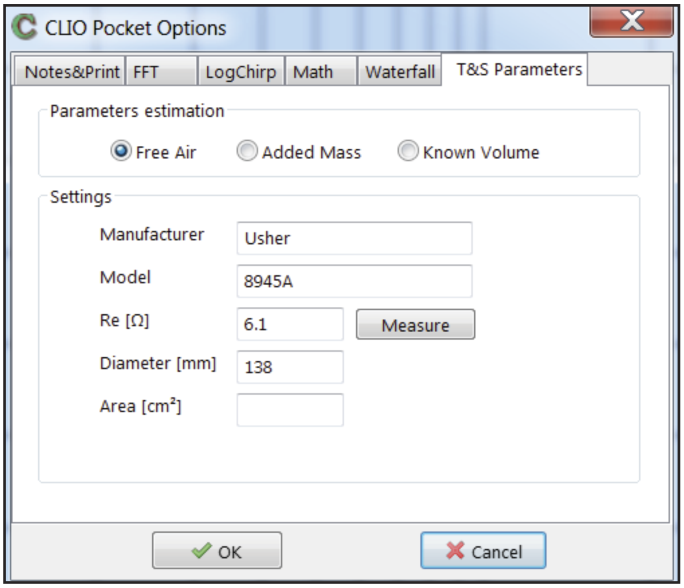

Figure 2: Driver data for Thiele-Small analysis

Installation and Calibration

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

Before the CLIO Pocket can be used, you must go through a calibration process. Start the program and allow the CP–01 to warm up for 15 to 20 minutes. (The blue LED should be lit.) Then, an initial sine wave analysis is performed using the Fast Fourier Transform (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 the 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 96 kHz), measurement units (e.g., microphone sensitivity), graphics options, and notes on saved measurements. The 96-kHz sample rate sets a maximum analysis bandwidth of 40 kHz.

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

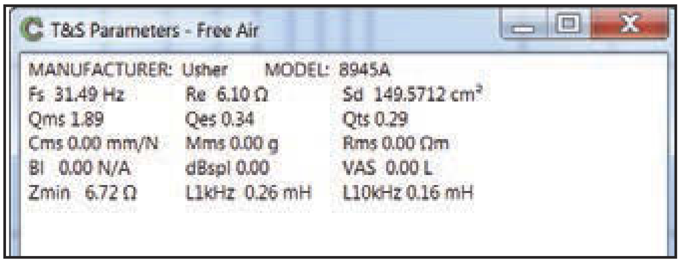

Figure 3: Thiele-Small free-air parameters

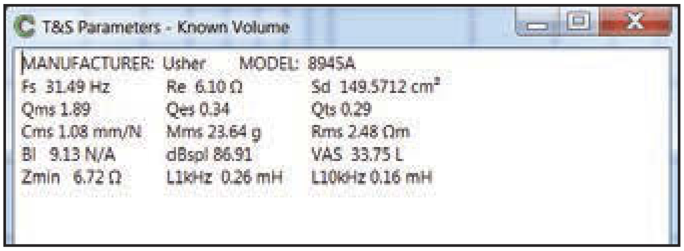

Figure 5: Final results of Thiele-Small parameter estimates

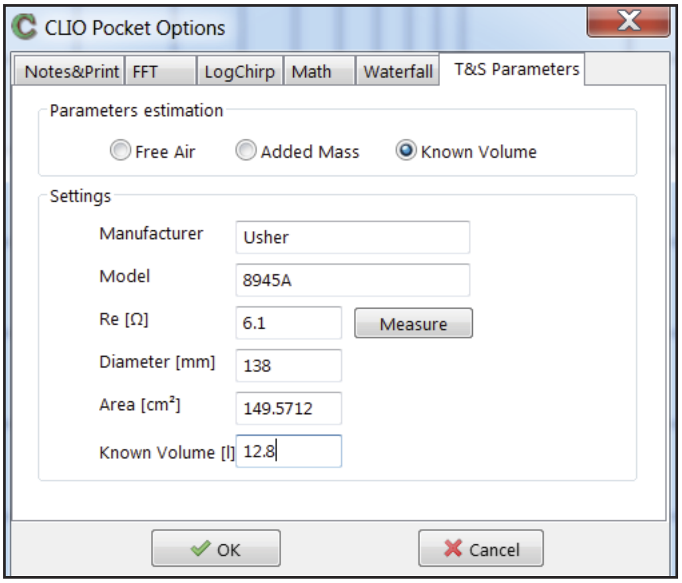

Figure 4: Data input for known-volume Thiele-Small analysis

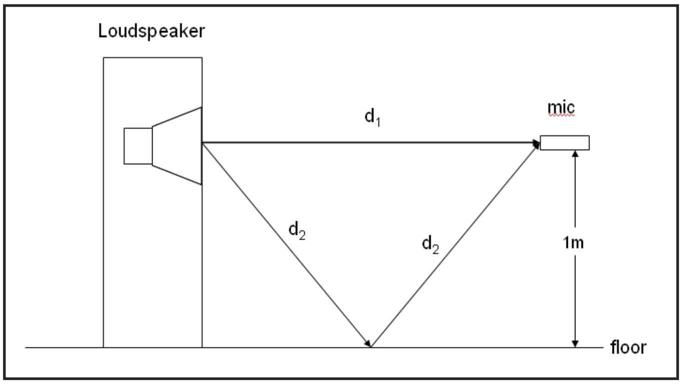

Figure 6: Test setup

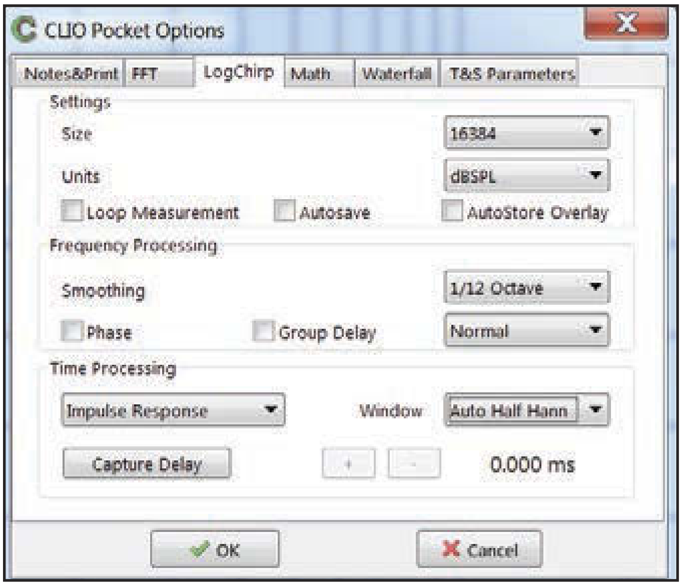

Figure 7: Parameter selection for Loudspeaker Response test

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 intermodulation distortion (IMD) tests. All-wave and pink noise signals are available in lengths of 4K, 16K, and 64K. (This becomes important in the FFT measurement option discussed later.) Chirp lengths of 4K to 256K are available. You can also select compatible .wav files from this window.

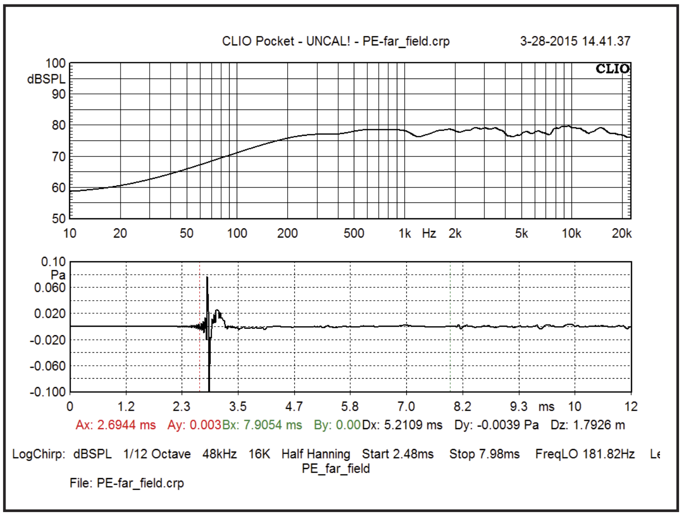

Figure 8: Time and frequency response for our two-way example

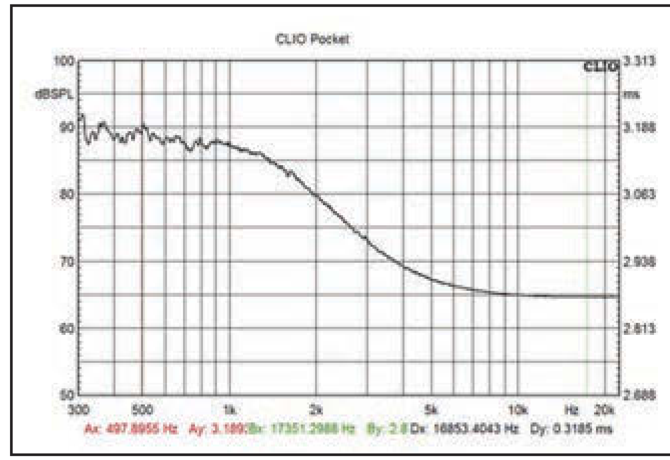

Figure 9: Excess group delay for our two-way loudspeaker example

However, the measurement settings panel is where you really get down to the business of the 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 (T-S) 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 dBSPL. Available windows include Rectangular, Hanning, Hamming, Blackman, Bartlett, and Flattop.

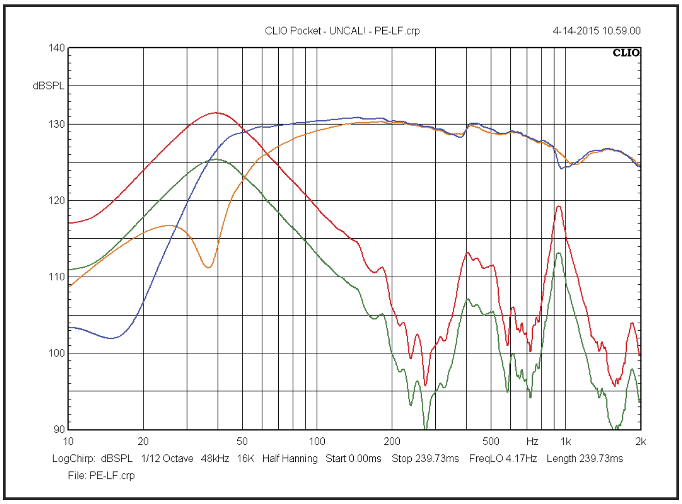

Figure 10: Near-field measurements and final low-frequency response

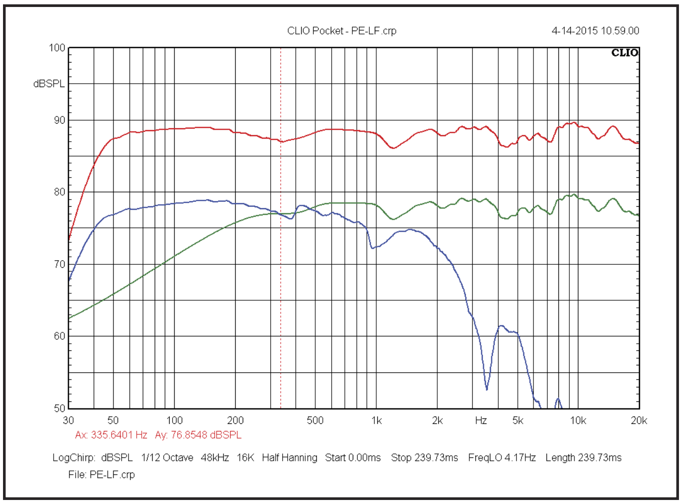

Figure 11: Far-field, low-frequency, and full-range responses

Averaging can be exponential or linear. Hold options include no hold, maximum hold, and minimum hold. Frequency processing is by FFT with smoothing options from 1/48 octave to 1 octave or real-time analysis (RTA) plots. 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, dBSPL, 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.

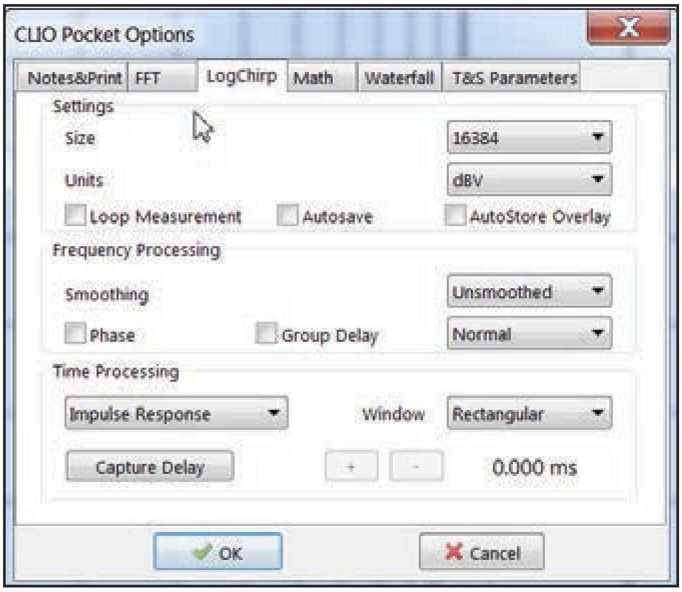

Figure 12: Log Chirp parameters for subwoofer equalizer test

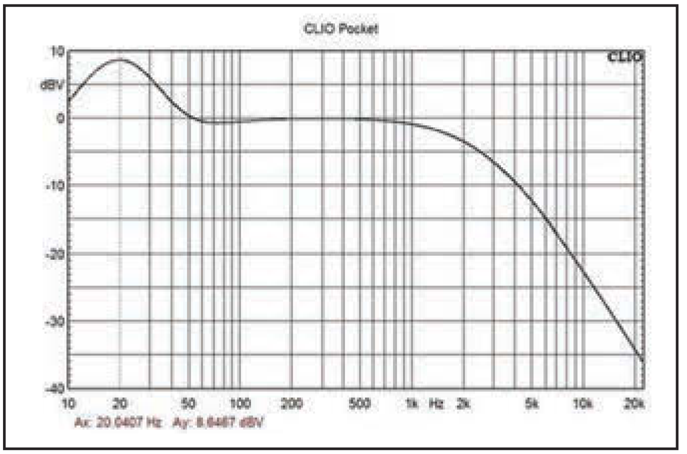

Figure 13: Equalizer frequency response

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 the known volume techniques are implemented.

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

Clicking on the math tab reveals several post-processing

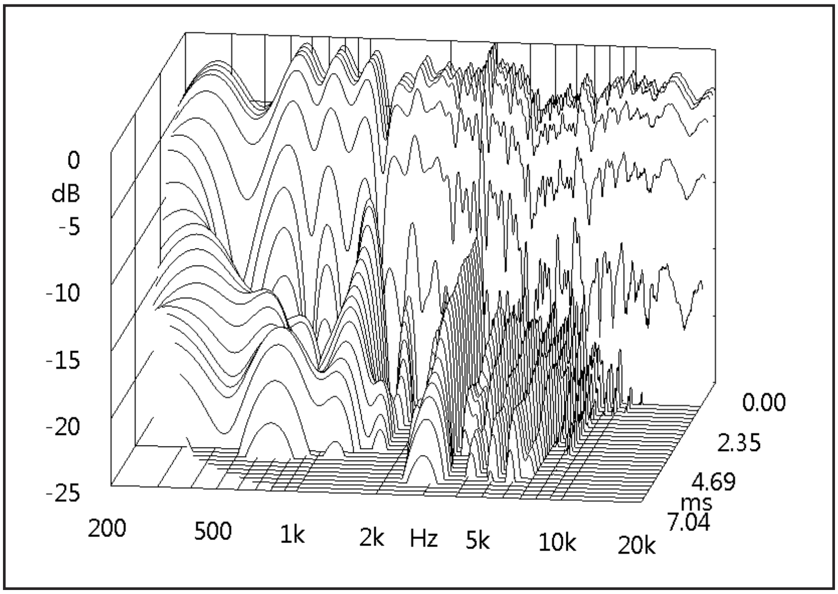

Figure 14: Two-way speaker cumulative spectral decay

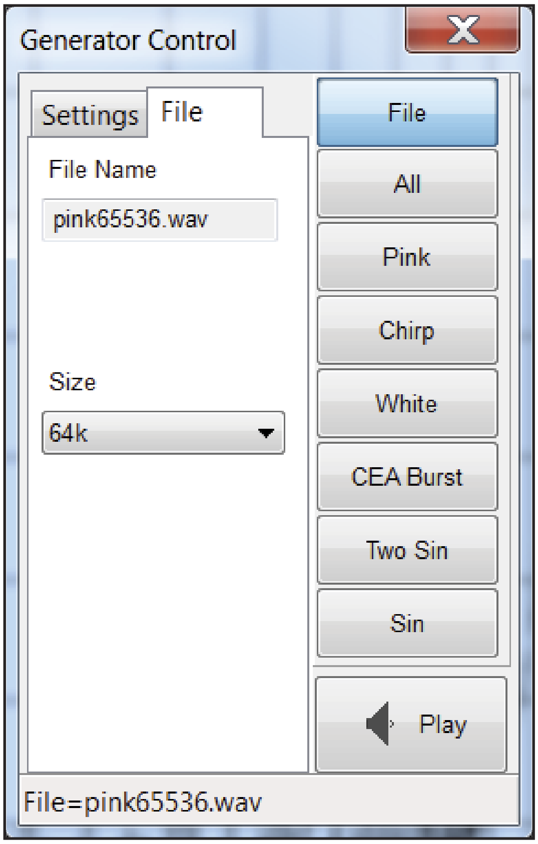

Figure 15: Pink noise setup on a generator control panel

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 decibel amount, and finally, implementing the microphone-in-a box low-frequency measurement technique.

Examples

Thiele-Small (T-S) 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 **Figure 1**, they are a free-air measurement (red) and a measurement with the driver mounted in a known volume of 12.8 ltr (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.

Next, 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 shown in **Figure 2**. Here you enter information describing the driver including manufacturer, model number, voice coil resistance (RE), and diaphragm diameter or area. If you do not know the RE, 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.

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

Load the known volume impedance data, open the T-S measurement window again, click the "Known Volume" button and enter the test box volume, 12.8l in this case (see **Figure 4**). Close the window and again click on the T&S Parameters icon

About the Author

Joe 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 nonlinear signal processing algorithms for passive sonar under government contract.

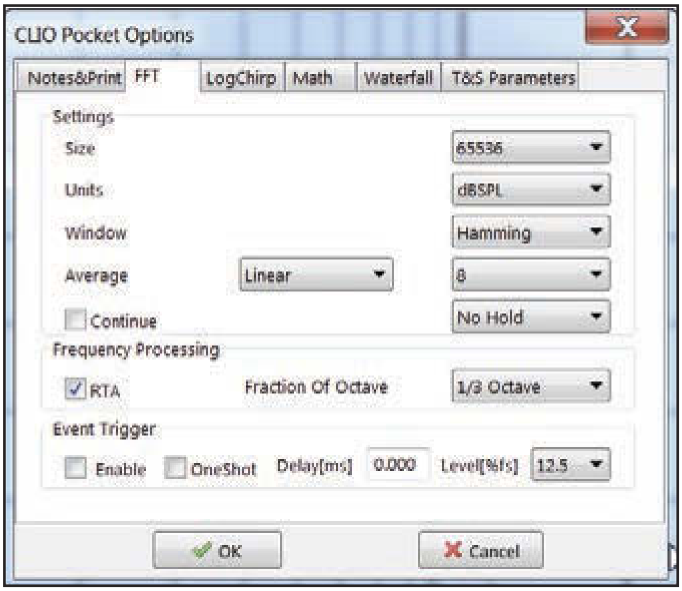

Figure 16: Fast Fourier Transform (FFT) measurement setup

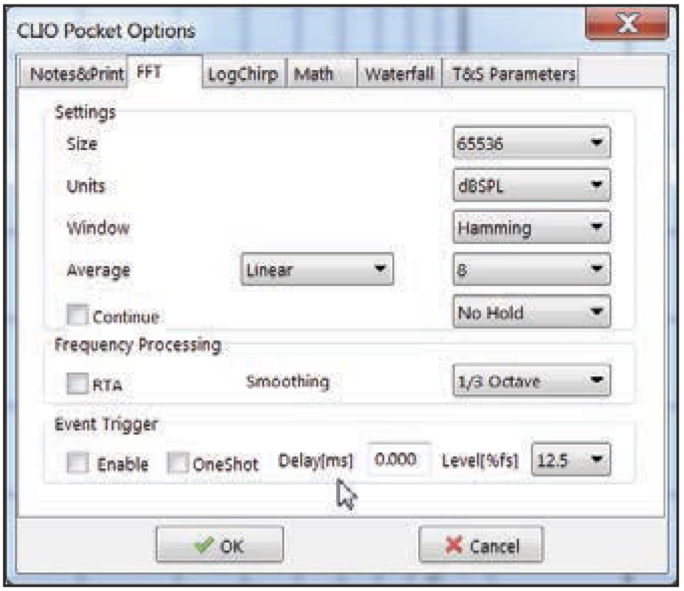

Figure 17: All-wave measurement setup

in the upper tool bar. **Figure 5** shows a window that appears with the full set of T-S parameters. If desired, the T-S data can be exported as a text file.

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. **Figure 6** shows a typical setup a hobbyist designer might encounter. In this example, the MIC–02 microphone is placed on the tweeter axis at a distance of 1 m. The first corrupting reflection will come from the floor bounce.

Parameters for the test are selected in the Log Chirp window (see **Figure 7**). Chirp length is set at 16K. The sound pressure level in decibels (dBSPL) 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 $1/12^{th}$ octave smoothing. **Figure 8** shows the resulting measurement.

Frequency and time-domain plots can be individually shown, but the CLIO Pocket has a 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 2.7 ms.

The floor reflection appears at about 8 ms. So we have 5.3 ms of reflection-free response, which corresponds to a low-frequency limit of Fmin = 1/0.0053 = 188 Hz, so the computed frequency response is valid only above 188 Hz. Plotted response below 188 Hz is simply an artifact of the

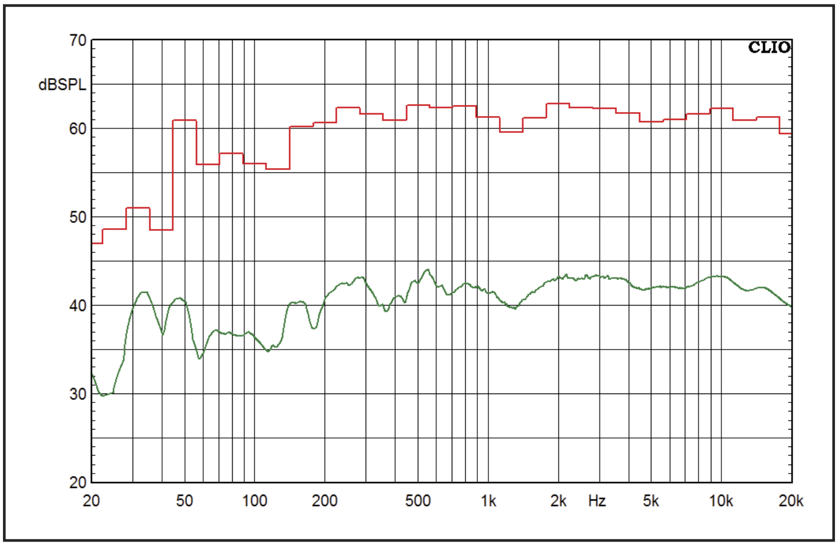

Figure 18: Real-time analysis (RTA) and all-wave response of a two-way loudspeaker

FFT. The 188-Hz number is also the resolution of the response data. The FFT algorithm least-squares fits the points between 188-Hz intervals. Above 200 Hz, the response fits within a 3.5-dB 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 my *Testing Loudspeakers* book. For our purposes, it is a measure of signal arrival time vs. frequency. **Figure 9** shows a plot of excess group delay for our two-way example.

High frequencies from the tweeter will arrive first. The green cursor set at 17.3 kHz shows a tweeter arrival time of 2.87 ms. The red cursor set at 500 Hz shows a woofer arrival time of 3.19 ms. Thus, the woofer is delayed relative to the tweeter by 0.32 ms or 320 µs. 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 188 Hz. 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 my article "Measuring Loudspeaker Low-Frequency Response" and Don B. Keele's "Low-Frequency Loudspeaker Assessment by Near-Field Sound Pressure Measurement" (see Resources).

Here is where the power of CLIO Pocket's post-processing math functions comes in to play. The procedure involves measuring the woofer and the 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 with the high-frequency response to get the full-range response of our example. The port/woofer diameter ratio is:

R = 68 mm/138 mm = −6.14 dB

Figure 10 shows the measured near-field port response (red), the port response reduced by 6.14 dB 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).

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.

Figure 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 350 Hz. Using the "Merge LF file" math option, the low-frequency response is merged with the far-field response at 350 Hz to get the final full range response (red), which has been level shifted up 10 dB for clarity.

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.

Resources

J. A. D'Appolito, "Measuring Loudspeaker Low-Frequency Response," www.audiomatica.com.

——, *Testing Loudspeakers*, Chapter 6, Audio Amateur Press, 1998, Item # AA-BKAA045 available at www.cc-webshop.com.

——, *Testing Loudspeakers*, Chapter 7, Audio Amateur Press, 1998, Item # AA-BKAA045 available at www.cc-webshop.com.

D. B. Keele, "Low-Frequency Loudspeaker Assessment by Near-Field Sound Pressure Measurement," *Journal of the Audio Engineering Society* (*JAES*), April 1974.

R. H. Small, "Simplified Loudspeaker Measurements at low Frequencies," *Journal of the Audio Engineering Society* (*JAES*), January/February 1972.

Figure 12 shows the Log Chirp test parameters. Notice the response will be measured in decibels of voltage (dBV). **Figure 13** shows the resulting equalizer response. You can see the equalizer produces a 8.65-dB boost at 20 Hz. High-frequency equalizer response is deliberately rolled off.

Waterfall Option: The waterfall option is used to compute the cumulative spectral decay (CSD). The CSD measures the frequency content of a loudspeaker's decay response following an impulsive input. Ideally, a loudspeaker response should instantly fade away.

Real world speakers have inertia and stored energy that take a finite time to dissipate. For a full discussion of the CSD read my book *Testing Loudspeakers*. 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-D 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 **Figure 14** is computed from the impulse response shown in **Figure 8**. The initial decay is somewhat disorganized, but after about 2 ms 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 clever application of the CSD to analyze room acoustics and 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 (www.audiomatica.com) for details.

FFT Analysis: As discussed earlier, CLIO Pocket has several 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.

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

Analysis length is set at 64K to match the pink noise length. This puts more FFT samples in the lowest 1/3 octave (20–25 Hz) to give us a better estimate of low-end response. We are using a Hamming window, averaging eight 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. **Figure 17** shows the measurement setup for the all-wave analysis. 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.

The measured RTA (red) and the all-wave (green) responses are plotted together in **Figure 18**. They are offset by about 15 dB for clarity. These responses are similar. Both fit in a 5-dB window above 200 Hz. This agrees well with the chirp analysis shown earlier in Figure 8. Response below 200 Hz differs from Figure 8 because the FFT measurements cover the full frequency range and thus include room effects.

Summary

CLIO Pocket—presented at the 2014 Audio Engineering Society (AES) show in Los Angeles, CA—is now a finished hardware product sold since March 2015. Audiomatica confirmed to 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.

This review shows that it already provides all the measurement and analysis capabilities needed to design and analyze loudspeaker systems and electronic circuits. Considering the rich set of stimulus signals, the data acquisition modes, and the post-processing functions, it is clear that much more capability will be added to the CLIO Pocket as the software develops.