MEASURING MAXIMUM SUBWOOFER OUTPUT ACCORDING ANSI/CEA-2010 STANDARD

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INTRODUCTION

The Consumer Electronics Association (CEA), in 2006, has released a *"standard Method of Measurement for Powered Subwoofers"* [1]. This standard aims to create a reliable testing method and a rating procedure to let manufacturers and customers compare powered subwoofers in an simple way.

The CEA standard is built upon a tone burst sequence performed at various frequencies and levels, until a certain distortion threshold is reached. While the test is intended for powered subwoofers, the same burst test can be applied to a broad case of electro-acoustic devices such as non-powered subwoofers drivers, tweeter drivers and compression drivers.

Despite being available since late 2006, the standard has only recently gained popularity in the audio community, at least this is what we can see from the support requests from our clients base. Starting from the CLIO 10.31 software release a set of tools specifically designed to perform tests according to the standard are included into our software.

In this document we will show how to perform maximum output measurements according to the standard in a reliable and repeatable way using CLIO FW-01 hardware and CLIO 10.31 software[1].

CEA-2010 (ANSI) TEST PROCEDURE

Test signal

The CEA-2010 standard test is based on a series of hann-shaped bursts signals which are sent to the subwoofer under test. The resulting pressure time response, measured in a ground plane environment, is recorded and transformed to frequency response and maximum peak level, using an FFT analysis.

Conventional distortion analysis testing is carried out with steady sine tones, this allows for very precise reading of the fundamental and harmonic components using DFT techniques. With steady tones, even if the tones duration is limited to the analysis window time, the crest factor of the stimulus is very low leading to the thermal stress of the loudspeaker driver under test.

1 At the time of writing the only resource to perform an ANSI/CEA-2010 test is a script for the Igor Pro software made by Don Keele. The script allows to perform ANSI/CEA-2010 tests using a PC Sound Card and a calibrated microphone. The script is freely available on request from the author http://www.xlrtechs.com/dbkeele.com/.

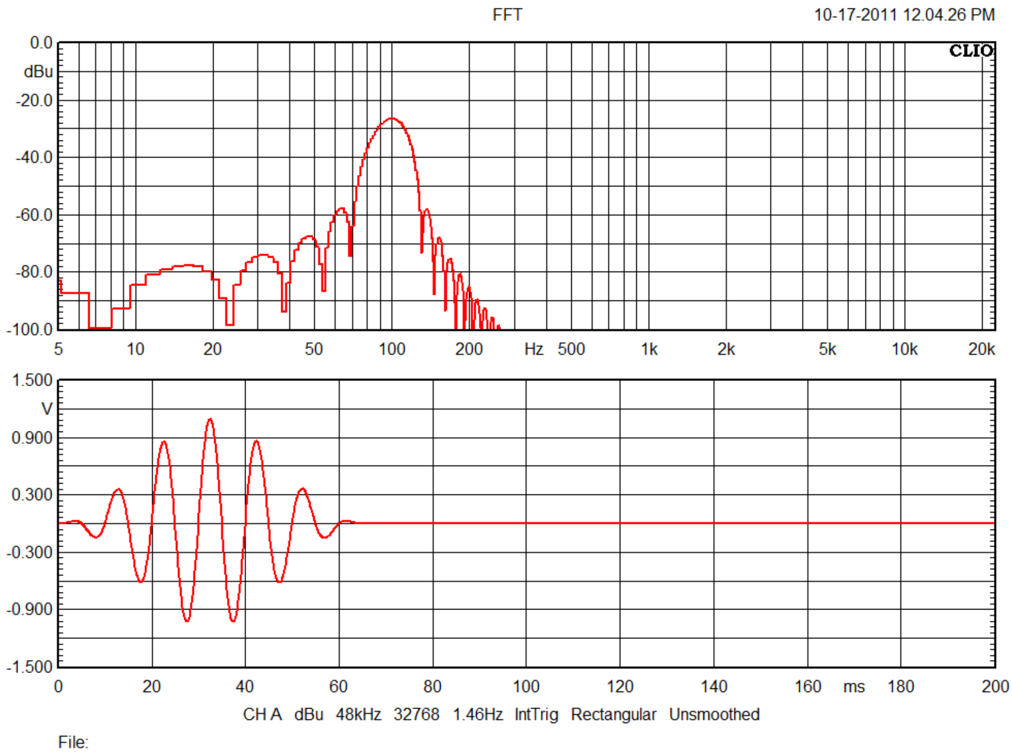


Figure 1: Waveform and magnitude spectrum of a 6.5 cycles 100 Hz hann-burst

Using a burst signal the crest factor can be freely increased, adjusting the on and off duration, starting from the 3 dB crest factor of the sine wave.

The test signal used for the CEA-2010 test is a 6.5 cycles hann-burst signal defined as the time product between a continuous sinewave and an Hanning window of 6.5 cycles length [2]:

$$f(t)=\begin{cases}\left(1-\cos\frac{(2\pi f_0 t)}{6.5}\right)\frac{\sin(2\pi f_0 t)}{2} & ,\mathit{for}\ 0\leqslant t\leqslant\frac{6.5}{f_0}\\ 0 & ,\mathit{elsewhere}\end{cases}$$

this signal has the property to be constrained both in the time and in frequency domain. In figure 1 the waveform and the FFT spectrum of a 6.5 cycles hann-burst at 100 Hz is shown.

The bandwidth of the signal is exactly one third of octave, as requested by the standard. It must be noted that a third octave bandwidth can be achieved using other time windows, but the 6.5 cycles hann has the property to minimize the sideband components of the spectra.

Figure 2 shows the joint time-frequency content (wavelet) of the burst, it is possible to notice that the signal energy is well constrained both in frequency and in time. The choice of the off duration of the signal allows for the desired increase of the crest factor. If we push the off duration to the zero limit, we end up with the crest factor of the hann-burst sine wave only which is 5.14 dB.

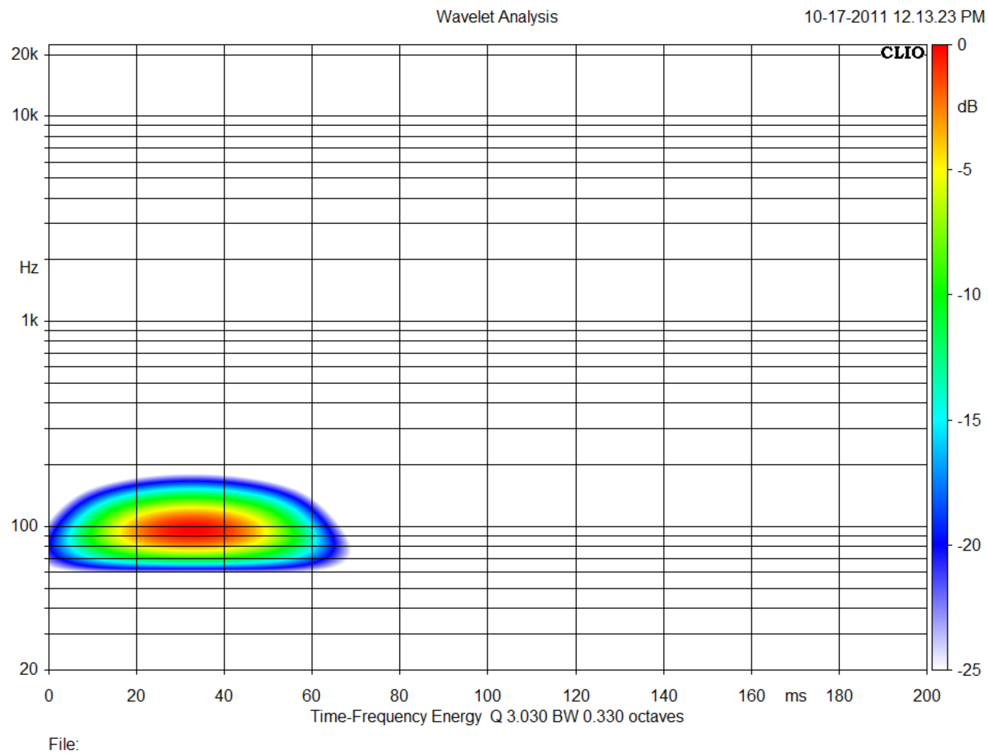


Figure 2: Joint time-frequency analysis (wavelet) of a 6.5 cycles 100 Hz hann-burst

Typical repetition time for the stimulus is 1 second, but the CEA-2010 standard does not give a definition for the repetition time of the burst signal, probably because the idea is to excite the driver and record with a single shot. As we will see later, using CLIO it is possible to speed up significantly the test using a repetitive signal while interactively checking the FFT spectrum of the acquisition against the distortion limits.

Distortion limits

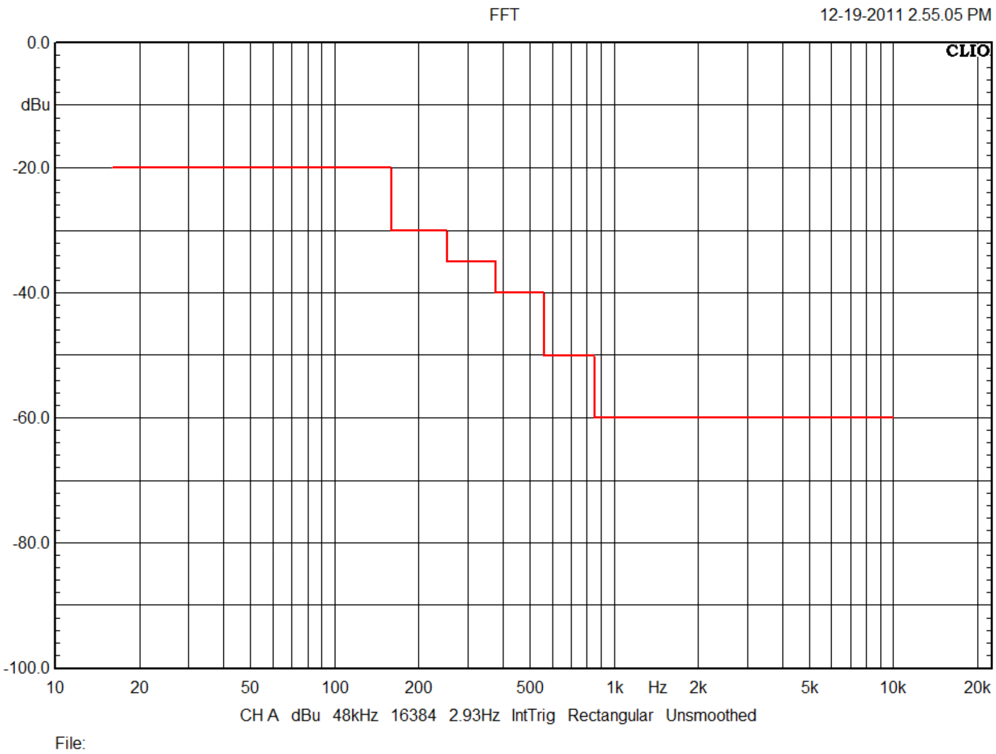
The response of the subwoofer under test to the burst signal is measured using a microphone in ground plane configuration at a distance of at least 1 m. An FFT analysis is performed on the measured response and the magnitude spectrum of the signal is calculated.

The spectrum is compared to a distortion limit curve that takes into account the fact that higher order harmonics are much more audible than low order. The limit curve is defined by a set of points and it is relative to the burst fundamental frequency f_0. Details on the set of points can be found on table 1 of the CEA-2010 standard, an example of the limit curve for a fundamental frequency of 100 Hz is shown in figure 3.

Test setup

The CEA-2010 standard gives also information on test setup. We will not go here into deeper details of the standard, we limit ourselves to consider that the measurement shall be done in ground floor configuration and that rigid surfaces shall be sufficiently distant so that reflections do not overlap with the driver burst response.

As mentioned before the measurement distance shall be at least 1 m.



f_{LOW} (Hz)	f_{HIGH} (Hz)	Limit (dB)	Notes
16	1.59 f_0	0	Fundamental
1.59 f_0	2.52 f_0	-10	2nd harmonic
2.52 f_0	3.78 f_0	-15	3rd harmonic
3.78 f_0	5.61 f_0	-20	4th, 5th harmonic
5.61 f_0	8.50 f_0	-30	6th, 7th, 8th
8.50 f_0	10 k	-40	Hi order >9th

Figure 3: Limit curve for fundamental frequency of 100 Hz and table with ANSI/CEA-2010 limits

PERFORMING A CEA-2010 BURST TEST WITH CLIO

The CLIO 10.31 software release features ***a new generator stimulus*** and ***custom FFT options*** that, when used together, allow to perform a CEA-2010 burst test in a very simple way.

CLIO CEA-2010 TONE BURST GENERATOR

A powerful hann-burst tone option has been added to the Signal Generator. Selecting the CEA Burst option in the generator opens a dialog with the burst options (figure 4).

The generator settings are: burst frequency f_0 in Hz, Number of Cycles and Repetition Time in ms. While the CEA-2010 standard requests for a 6.5 cycles burst, we left the possibility to modify this parameter as it gives the opportunity to use different "burst-on" durations. For example it is possible to use a 7 cycles burst which is amplitude symmetrical, instead of 6.5 cycles which is not amplitude symmetrical, while

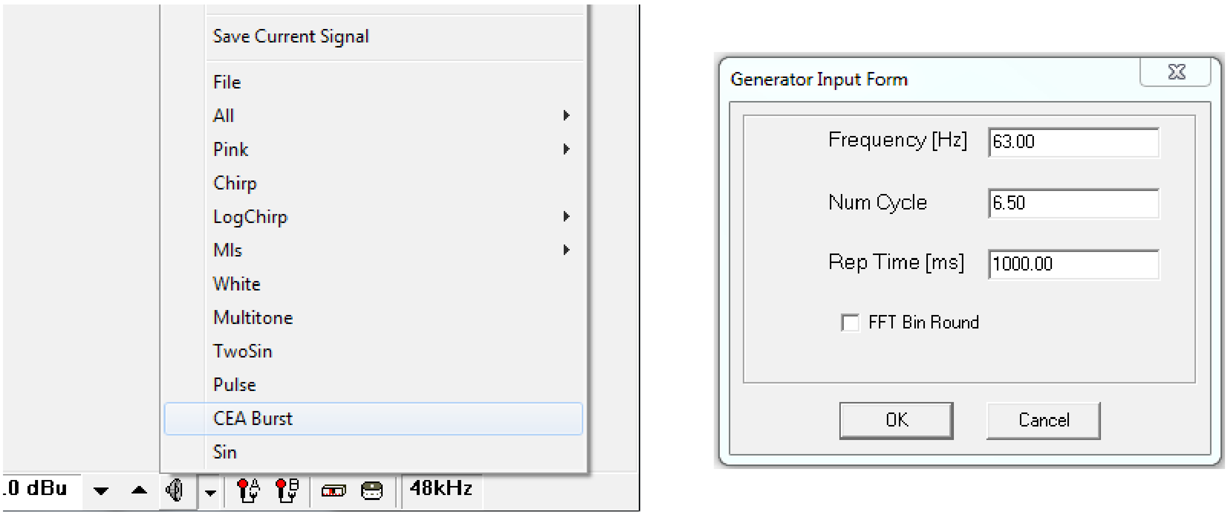


Figure 4: CEA Burst generator option and dialog

retaining almost the same 1/3rd octave bandwidth. It is also possible to use longer bursts, with substantial less bandwidth, to test specific frequencies instead of third octave bands.

CLIO FFT CEA-2010 POWER TESTING SCHEME

A check-box "Enable power test" option has been added to the FFT Settings menu under ANSI/CEA-2010 (Figure 5). When this option is checked, along with the "Internal Trigger" option under General options, the CLIO software automatically calculates and draws the ANSI/CEA-2010 ***threshold limit curve***. When using this option, the FFT must be on "dBSPL" units in order to work properly.

The "Enable power test" option applies a ***time window*** (see Figure 7) on the acquired burst response. This helps to window out environmental reflections. Consideration on room correction factor (RCF) are still applicable as described by the standard.

The "Enable power test" option activates the ANSI/CEA-2010 ***peak level detector*** (see Figure 8), which is an indicator of the SPL peak level. This level is calculated from the peak level of the acquired waveform, filtered with a zero-phase bandpass filter

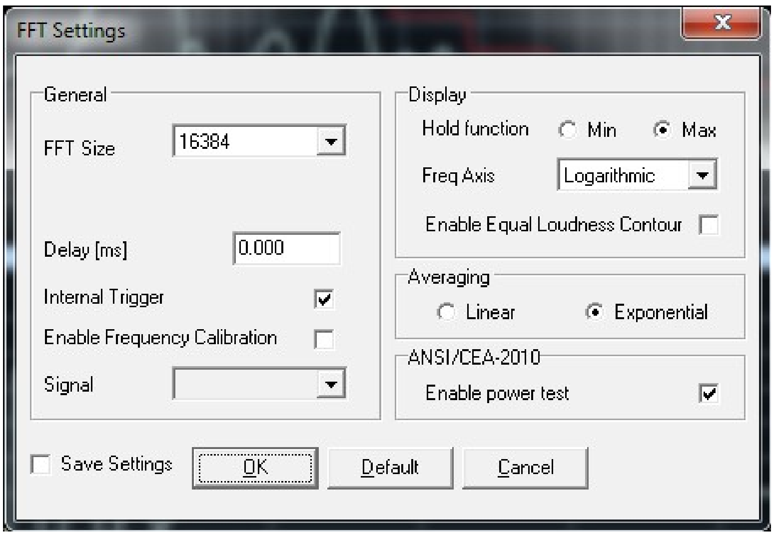


Figure 5: FFT setting for ANSI/CEA-2010 test

centered at the test frequency. The CEA-2010 standard is pretty vague on this point, as it states:

"The peak SPL of the fundamental ±3 Hz shall then be recorded. That is, the peak SPL is the highest SPL within the range bounded by 3 Hz below and 3 Hz above the fundamental."

Here the terms peak and highest SPL are not sufficiently clear to be understood in a unambiguous way. Using the bandpass zero-phase filter, the components around the fundamental are filtered without altering the time envelope of the waveform. Then the peak value of the pressure in Pa is taken and converted back to a SPL level.

SUBWOOFER MAXIMUM OUTPUT LEVEL PRACTICAL TESTING

We show here an ANSI/CEA-2010 test of an ACE-bass B2-50 powered subwoofer. This system has two drivers on one side of the cabinet and one port underneath. According to the standard recommendation we put the microphone at 1 meter off the side of the box, in order to be equidistant to the box sources (see figure 6).

As measurement distance we chose 1 m only, even if the recommended distance is 2 m. This is due to the fact that the measurement room of our laboratory is not big enough to avoid reflections. According to the standard a room correction factor should be calculated and applied but we can skip this step here and go directly to the test procedure.

The instrument connection set up is very simple: we connect the microphone, an Audiomatica MIC-02, to the CLIO fw-01 input A and the subwoofer input to the CLIO fw-01 output A.

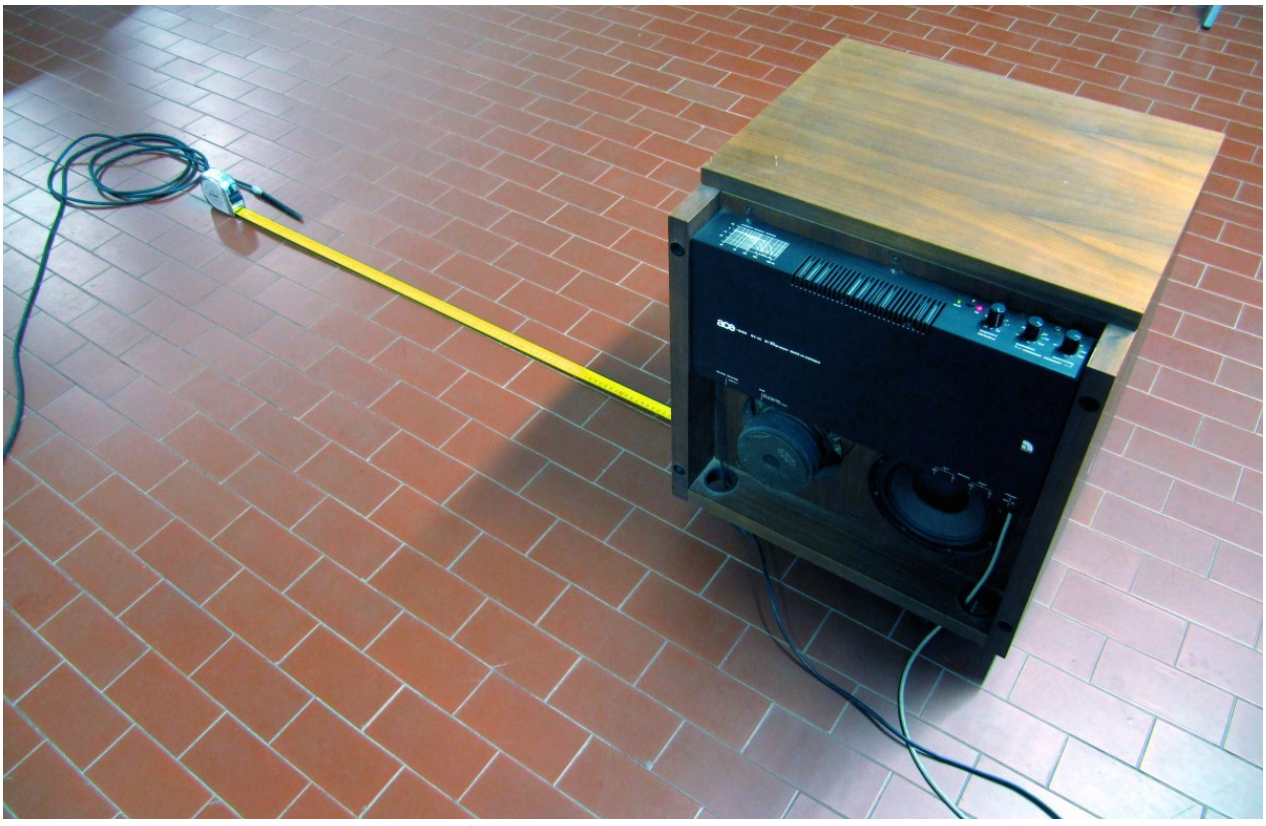
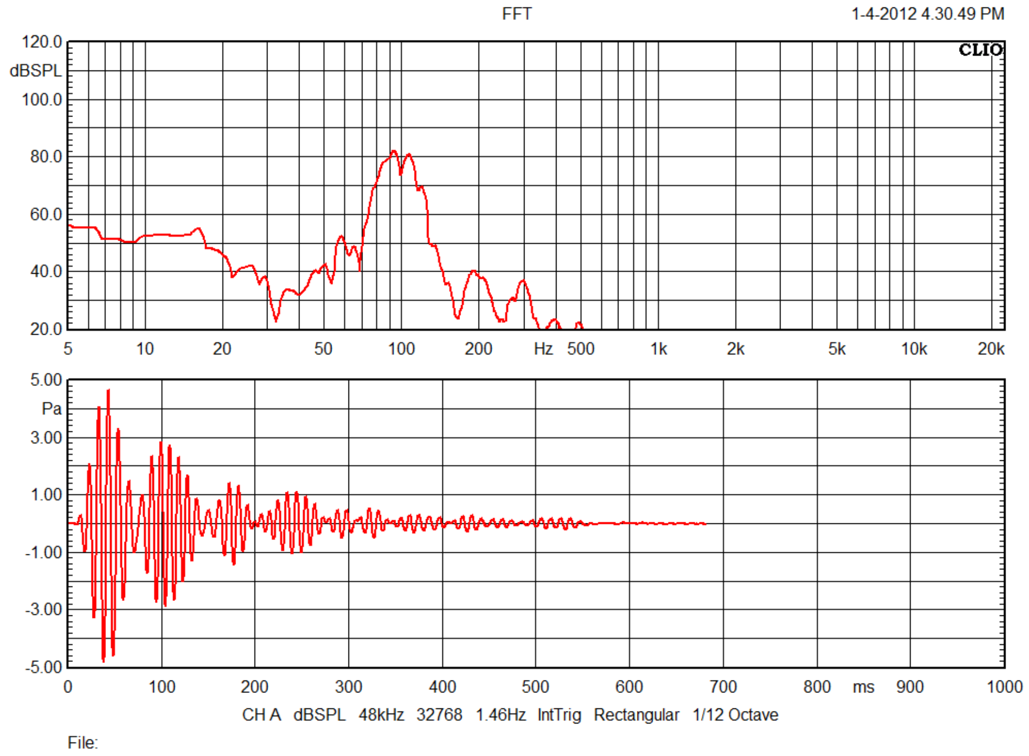


Figure 6: Tested subwoofer with microphone in ground plane configuration



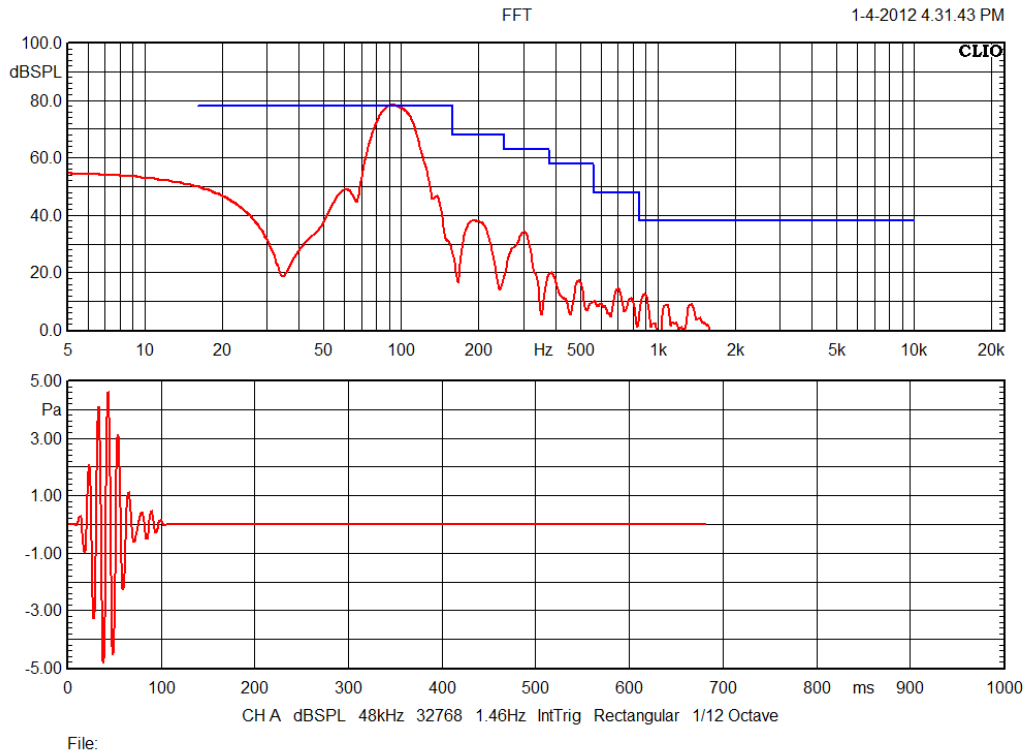


Figure 7: Comparison between burst time response with reflection (upper graph) and burst time response with time windowing (lower graph)

Let's start with a ***preliminary measurement*** (Figure 7): using the CEA-burst options we generate a 6.5 cycles 100 Hz burst, with a safe output level of -32 dBu. Pressing **F8** key we increment the level in 1 dB steps until we reach a suitable signal-to-noise ratio.

Then we open the FFT menu and start an FFT analysis on channel A with the internal trigger option enabled. We chose dBSPL as Y scale unit and 1/12 octave as smoothing[2]. The minimum FFT size should be of 32768 points, since the lowest ANSI/CEA-2010 test frequency is 20 Hz, which means, for a 6.5 cycles, a duration of around 325 ms. The result of this FFT analysis is on the upper graph of figure 7, where the effect of room reflections is clearly visible.

At this point we enable the ANSI/CEA-2010 option in the FFT menu settings, as previously shown in figure 5. Looking at the lower graph of figure 7 the effect of the time windowing is clear. While in this case the room reflections are not completely rejected, the spectrum is easier to read and not corrupted by reflections.

We are now ready to go on with the ANSI/CEA-2010 test procedure starting with the 20 Hz test frequency. Again we start with a convenient low output level of -24 dBu, and carefully increment the level in 1 dB steps until the FFT spectra do not reach the ANSI/CEA-2010 limit. Once the limit is reached we stop the generator and annotate the “CEA pressure peak” level reported by the slave meter readout.

Then we repeat the process for the other test frequencies: 25, 31.5, 40, 50, 63 Hz.

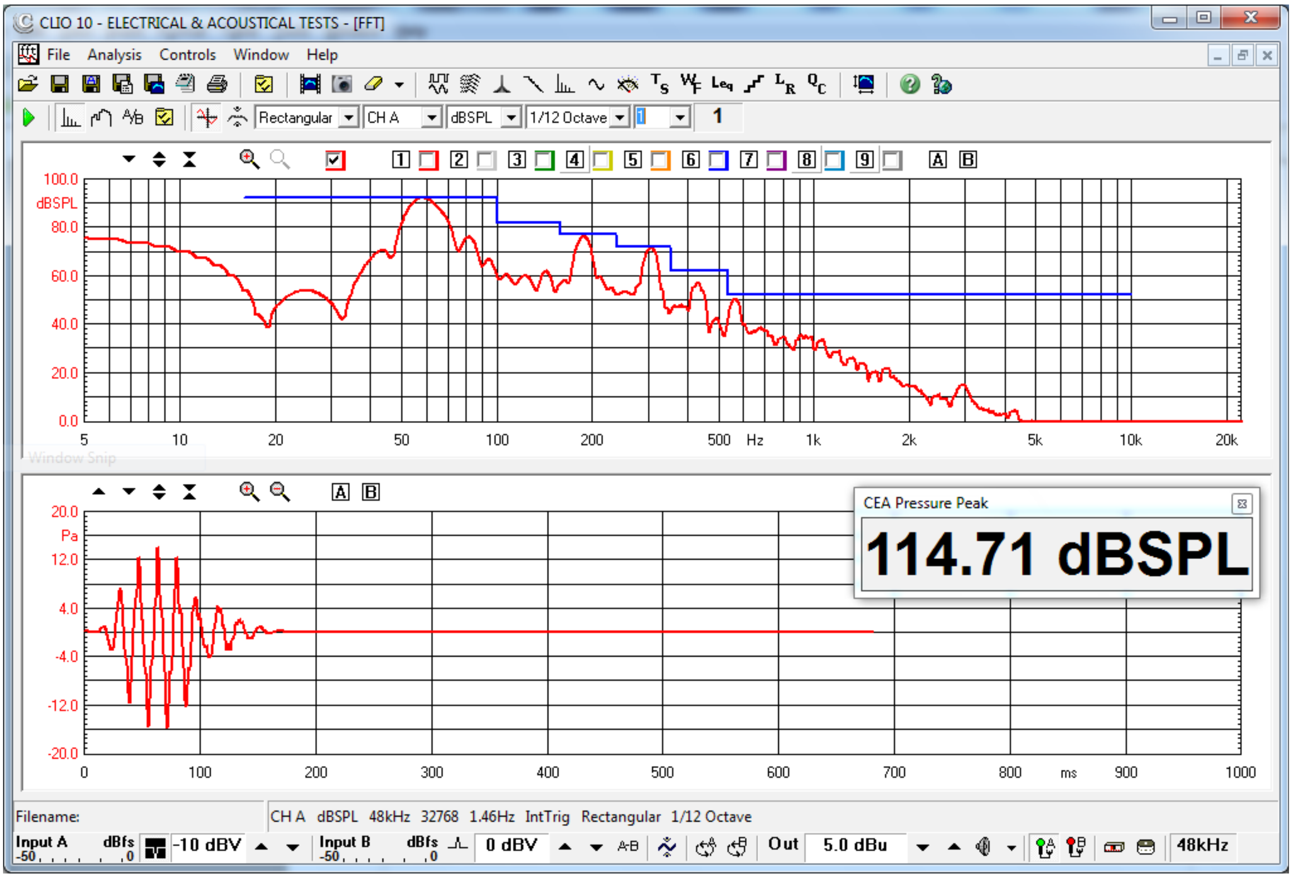


Figure 8: CLIO 10 running ANSI/CEA-2010 test

2 The 1/12 octave smoothing is requested by the ANSI/CEA-2010 standard.

Figure 8 shows the complete instrument setup when taking the final 63Hz measurement.

We end up with a data collection table, as suggested by the standard, where the test frequencies and the peak levels are reported. We added the first column to annotate the CLIO output level.

CLIO output level (dBu)	Tone Burst Frequency (Hz)	Maximum SPL (dB)	CEA 2010 Rating
-10	20	99.3	96.0
-12	25	95.4	
-12	31.5	93.2	
-9	40	103.5	110.7
-4	50	113.8	
5	63	114.7	

Table 1: Data collection table

Data in the last column is calculated as average of the maximum SPL of the 20, 25, 31.5 and 40, 50, 63 Hz frequencies.

The CEA-2010 rating of this subwoofer would be reported as:

Ultra-low bass (20-31.5 Hz): 96.0 dB

Low bass (40-63 Hz): 110.7 dB

With some active subwoofers it may happen that incrementing the input level, the limit curve is not reached while the output level is not increasing. This is due to some compression mechanism on the subwoofer active electronics, in those cases the standard requires to write down the reached CEA pressure peak level and to proceed to another frequency band.

CONCLUSIONS

Using CLIO FW-01 and CLIO 10.31 software it is possible to perform maximum output subwoofers tests according to the ANSI/CEA-2010 standard in an easy and interactive way. Thanks to the input/output and microphone calibration of the CLIO system the user can concentrate on the practical issues of the ANSI/CEA-2010 test.

REFERENCES

[1] ANSI/CEA Standard, *"Standard Method of Measurement for Powered Subwoofers ANSI/CEA-2010"*, November 2006.

[2] Keele D., *"Development of Test Signals for the EIA-426-B Loudspeaker Power Rating Compact Disc"*, presented at the 111th Convention of the Audio Engineering Society, New York (Sept. 2001).

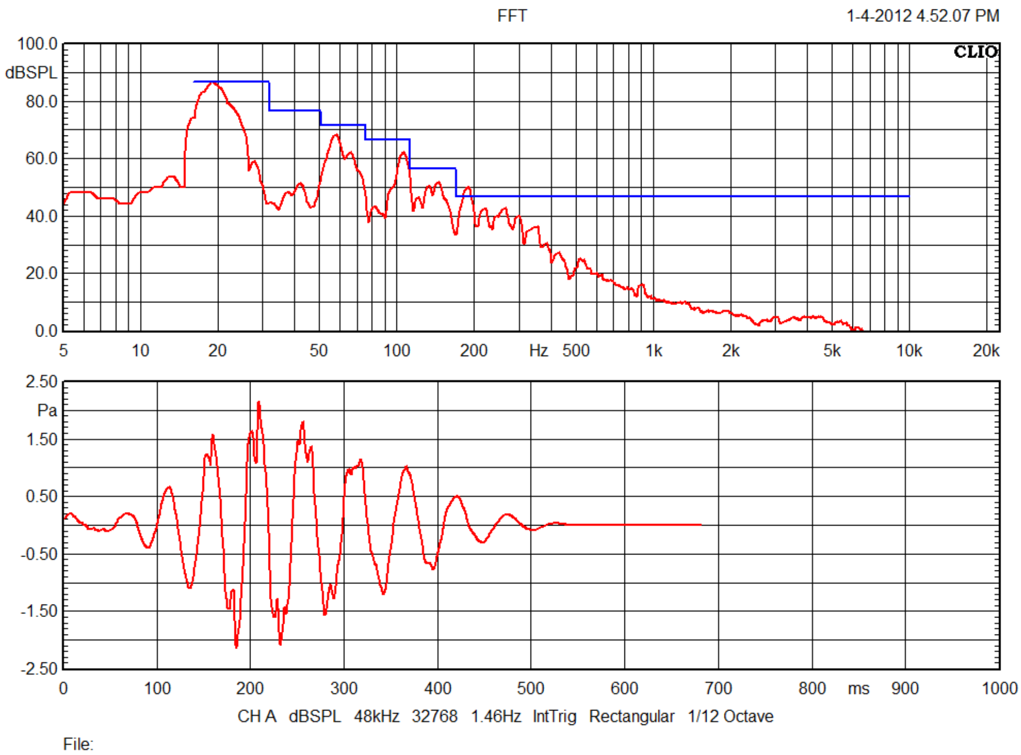


Figure 9: ACE-bass B2-50 - ANSI/CEA-2010 test @ 20 Hz

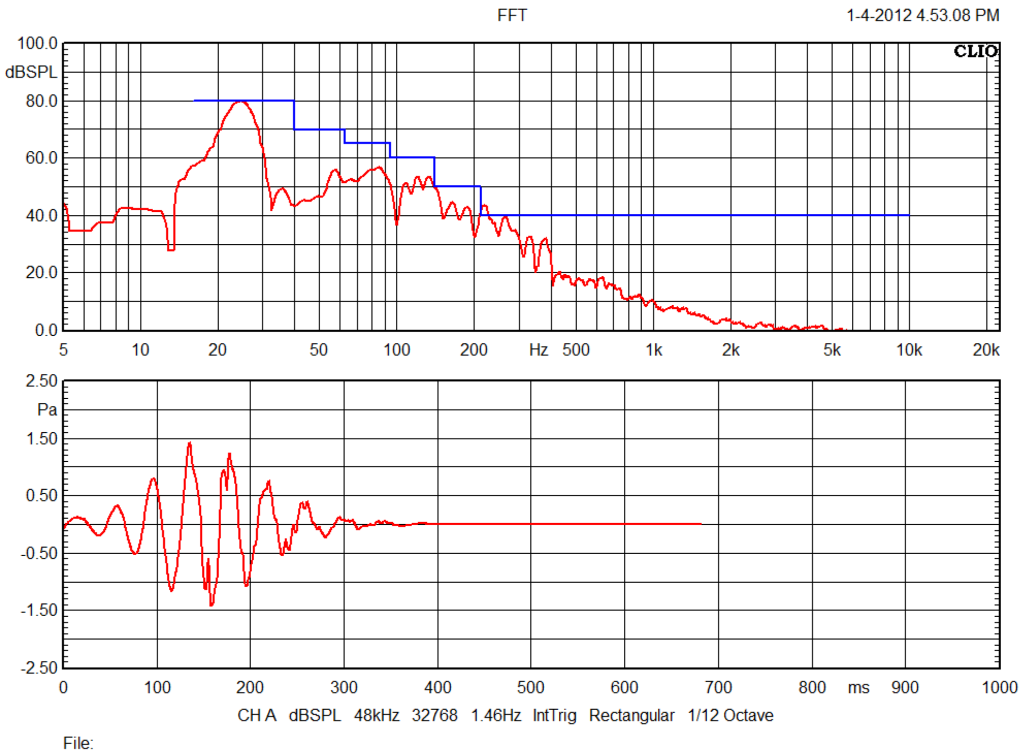


Figure 10: ACE-bass B2-50 - ANSI/CEA-2010 test @ 25 Hz

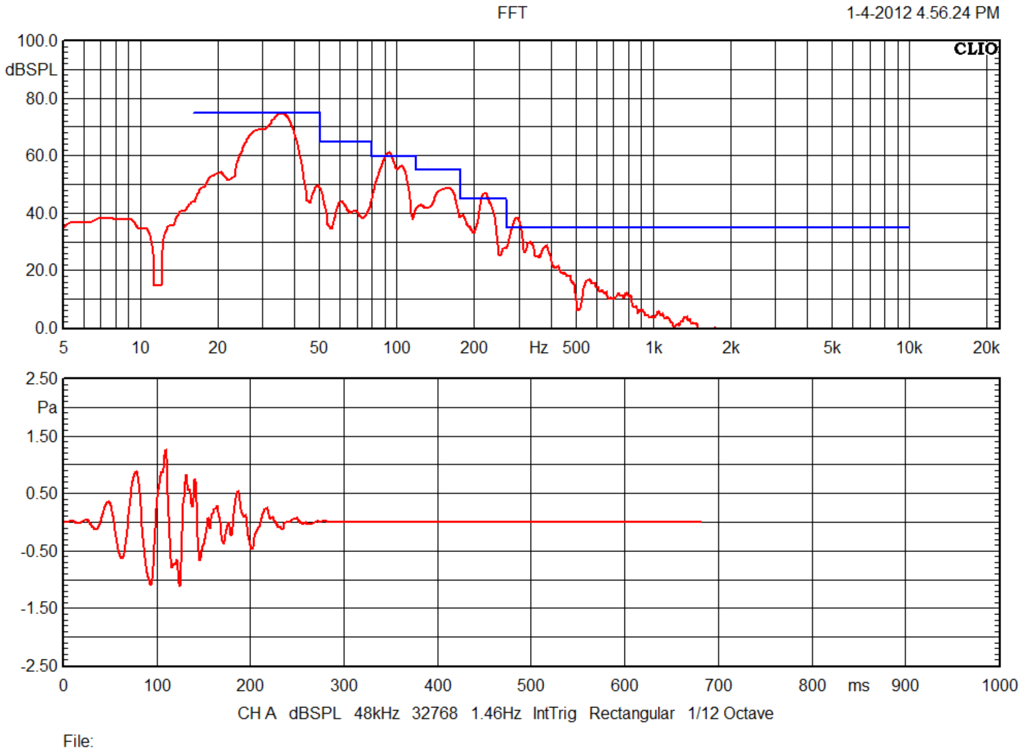


Figure 11: ACE-bass B2-50 - ANSI/CEA-2010 test @ 31.5 Hz

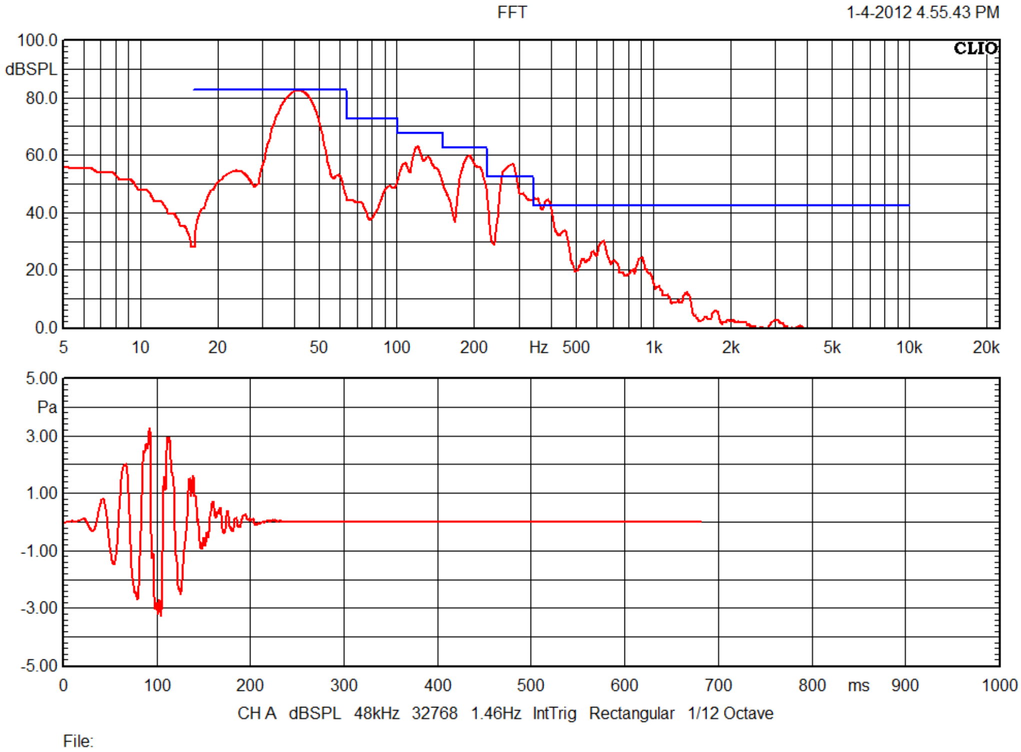


Figure 12: ACE-bass B2-50 - ANSI/CEA-2010 test @ 40 Hz

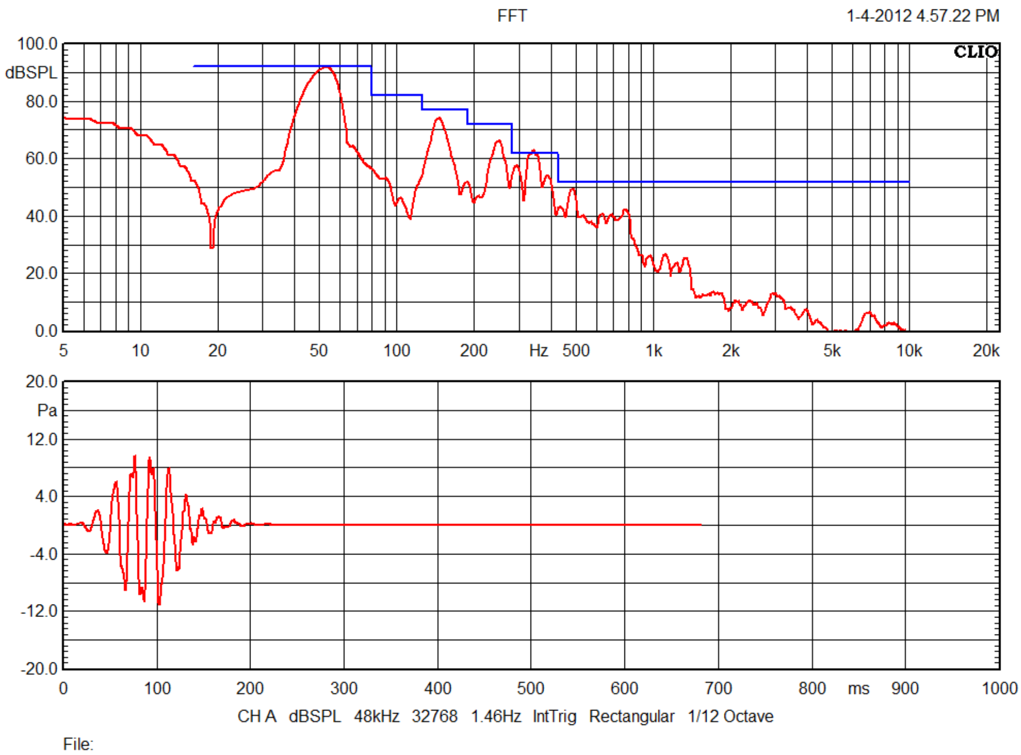


Figure 13: ACE-bass B2-50 - ANSI/CEA-2010 test @ 50 Hz

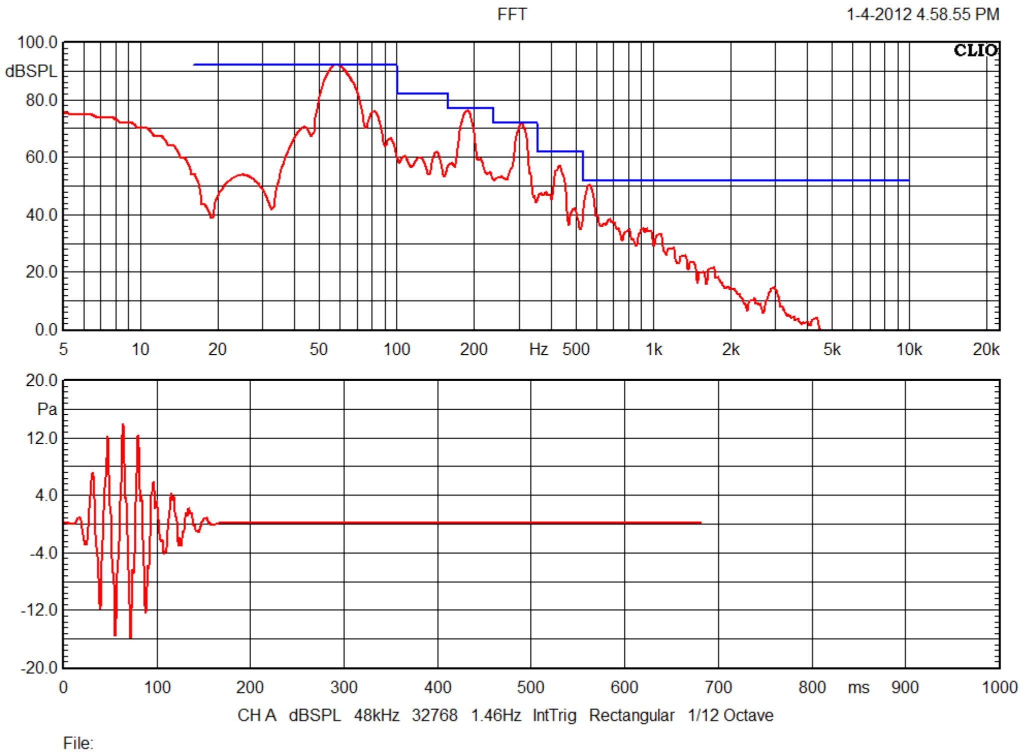


Figure 14: ACE-bass B2-50 - ANSI/CEA-2010 test @ 63 Hz