

WAVE FILE EQUALIZATION WITH CLIO 11

by D. Ponteggia – dp@audiomatica.com

INTRODUCTION

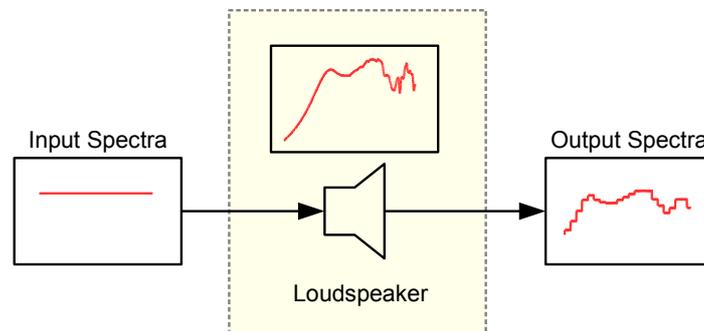
Starting from CLIO software release 11.40, two equalization tools for wav files have been added.

The STIPA EQ button is available in the Acoustical Parameters menu, while the “wav file Equalizer” is within the MLS&LogChirp menu under MLS Processing Tools.

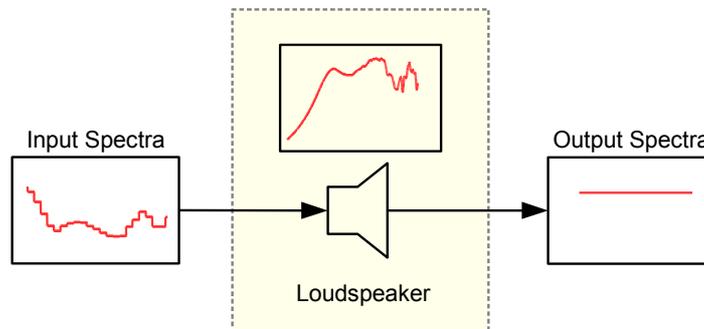
STIPA EQ

Needs for such processing tools emerged from a careful reading of the STI measurement standard[1]. However there are many circumstances where general purpose equalization tools are required to obtain an acoustical sound pressure signal with a given frequency spectra.

Since the conversion from electrical signal to acoustic pressure is performed with loudspeakers well known for having a limited frequency bandwidth, the spectral information carried by the electrical signal is usually linearly distorted by the transducer.



This calls for a pre-equalization (linear distortion) of the input signal, that we can simply define pre-equalization.

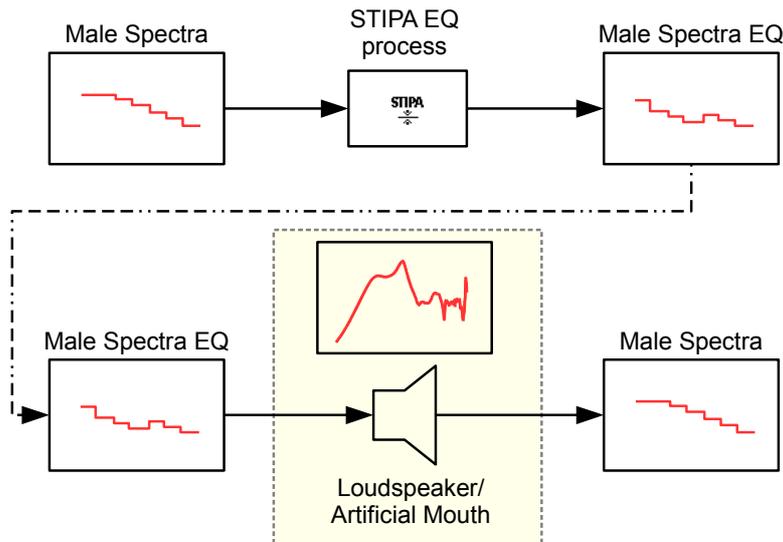


In fact the STI standard require a given signal with precise spectra through a mouth simulator loudspeaker. This calls for a very linear frequency response from the loudspeaker, which is very difficult to achieve without applying equalization.

This has led to the idea to measure the mouth simulator response and then pre-equalize the wave file that has to be reproduced by the source.

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In this way it is possible to compensate for the non-flat response of the loudspeaker by equalizing the wave file.



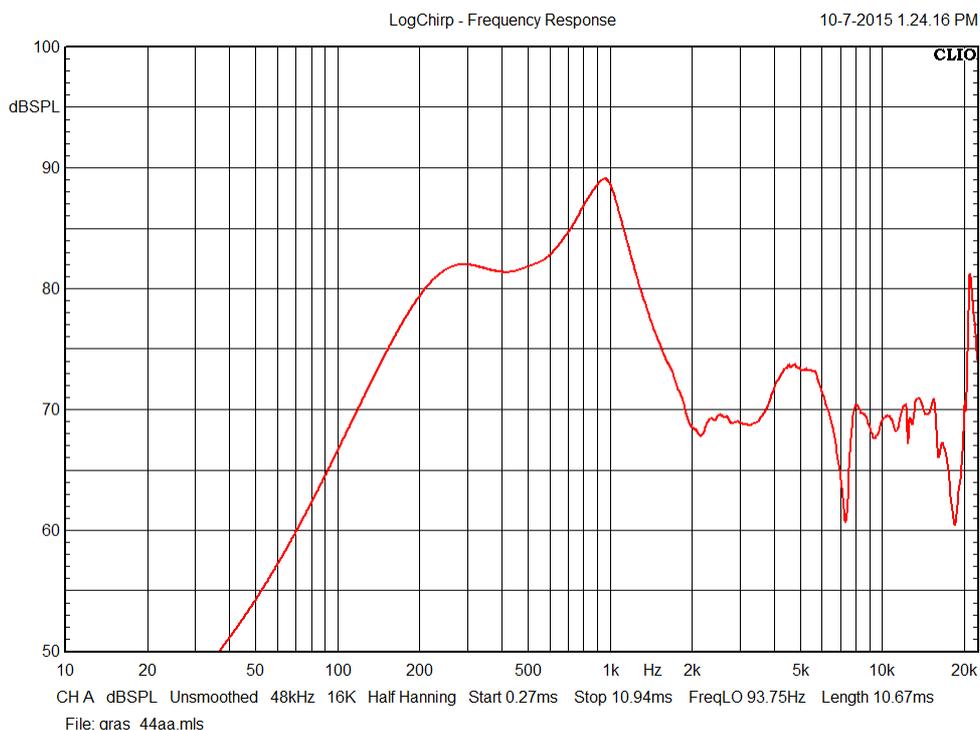
Therefore we introduced the STIPA EQ process in the Acoustical Parameters menu, which can be used to pre-equalize a wave file to be played with an artificial mouth or comparable loudspeaker.

The STIPA EQ processing works by inverting the artificial mouth or loudspeaker measured response and convolving the input wav file with the calculated filter.

In the STI/STIPA case the wav file that shall be used is a pink noise with a given spectra.

While the inversion process has a simple and intuitive meaning, implementation is much more complex than it seems.

As an example, given the frequency response $H_{am}(f)$ of the artificial mouth we used in our application note on STI measurements:



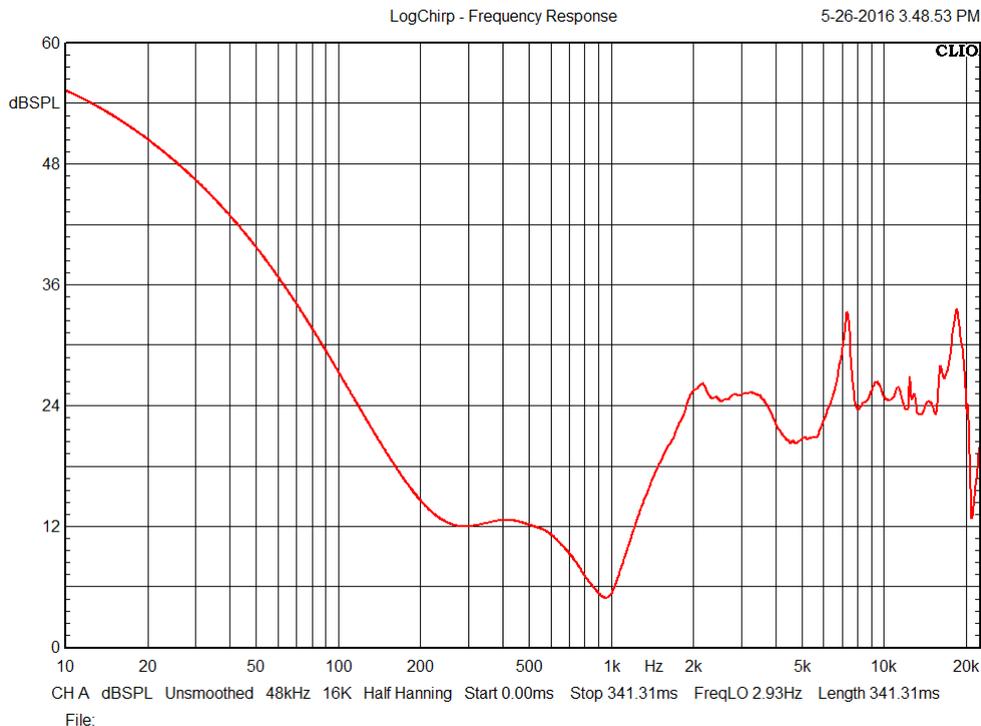
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It is possible to invert it by a simple mathematical transformation:

$$H_{inv}(f) = \frac{1}{H_{am}(f)}$$

It is evident that the mathematical inversion we have can generate very high levels for frequencies outside the electro-acoustic device operating pass-band.

The bare inversion of the above artificial mouth response gives us a huge gain under 100 Hz.

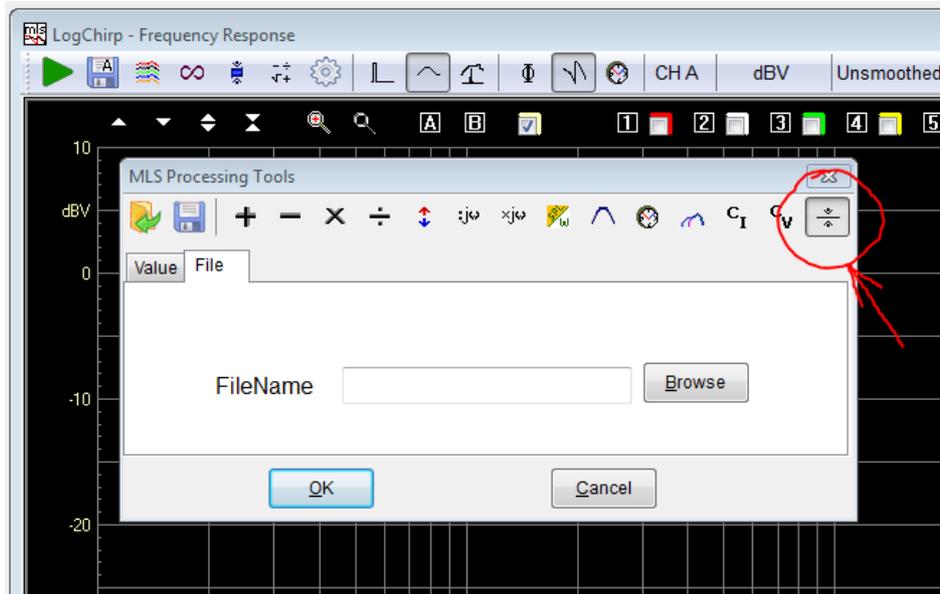


In order to generate an usable inverted response, the inversion process has to be restricted to a given bandwidth.

In case of the STIPA EQ processing this is already handled by the software which inverts the function only on the range from 88 Hz up to 11.3 kHz. These are the limits of the 125 Hz and 8 kHz octave bands used in the STI/STIPA calculations.

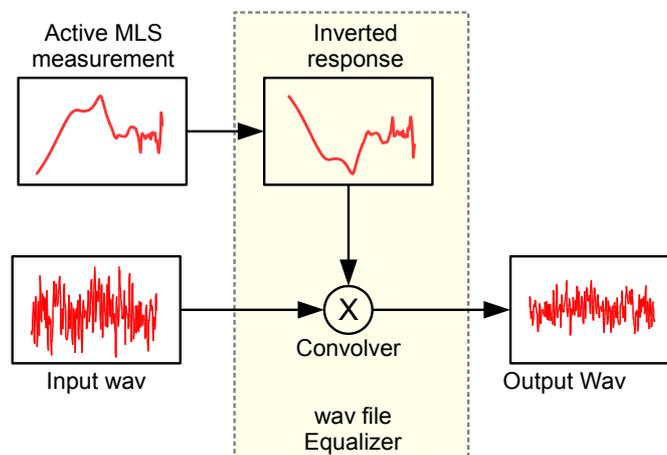
MLS&LOGCHIRP WAV FILE EQUALIZER

The inversion and equalization process can also be useful outside the STI/STIPA application. A general purpose equalization tool has been implemented in the MLS&LogChirp post processing menu:



The operation is slightly more complicated than before as not only the transducer response is needed but we will see also that a target response has to be defined.

The tool inverts the active MLS&LogChirp measurement and then convolves the input wav file with the inverted response.



Time windowing and other post-processing are considered since the **active measurement** is the result of the windowing functions and other post-processings on the measured impulse response.

It should be also noted that the wav file needs to be a **mono** file, with the **same sampling rate** and **size** of the MLS&LogChirp response.

The inverted response gain is scaled in order to avoid saturation at the output of the convolution process.

If we directly apply the wav file Equalizer post processing to the frequency response of a loudspeaker we will likely end up with a very low levels in the convolved output wav signal. This happens because an electro-acoustic device is band-pass in nature while, as we saw before in the STIPA EQ case, the inversion process takes place in

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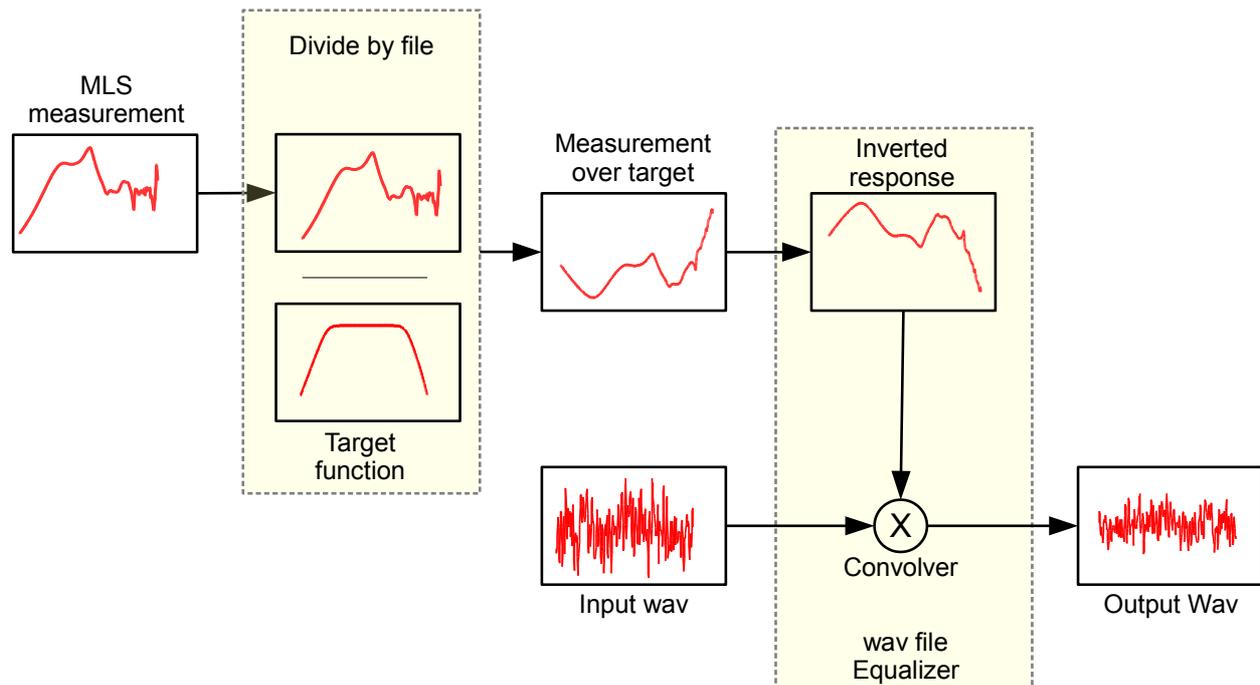
the whole frequency domain, from the first point up to the Nyquist frequency.

To avoid this it is necessary to calculate a new response to be inverted, which is the combination of the measured response of our device and a target function.

The whole process involves:

- the generation of a band-limited target function¹
- then the device response shall be divided by the target function
- finally the response can be inverted and the wav file convolved with the inverted response

The following figure illustrates the process:

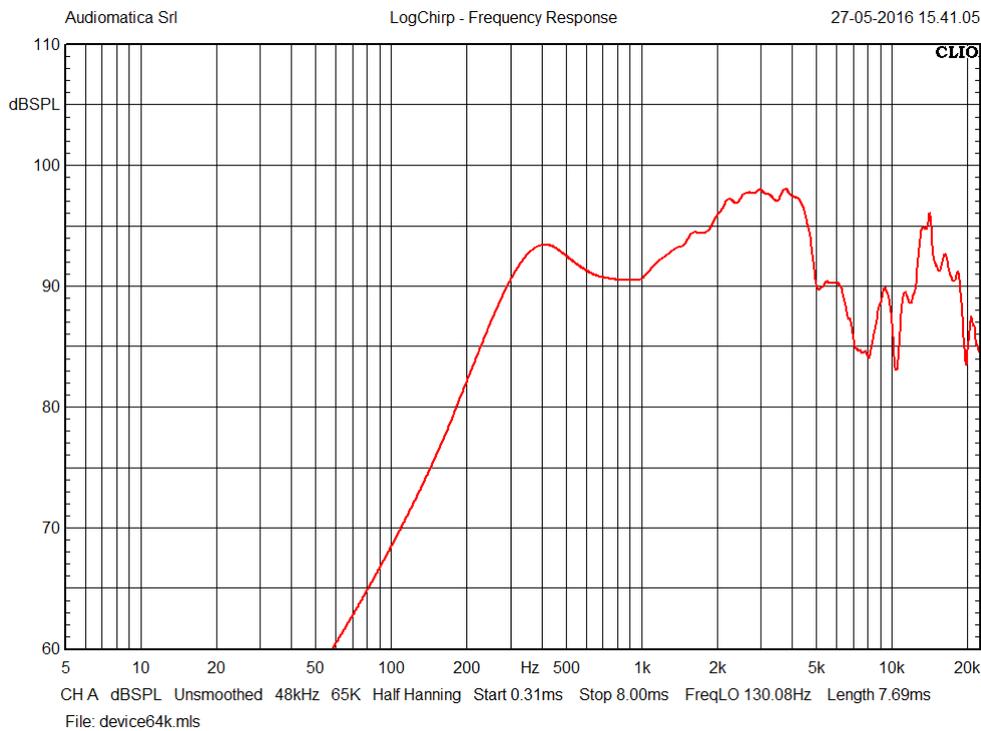


¹ In theory the target function can be any frequency response that we would like to meet with the wav file equalization.

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Let's proceed with a practical example where we would like to pre-equalize a wave file to get a flat frequency response (in its usable bandwidth) from a 2 inch loudspeaker driver in a small box.

The quasi-anechoic response of the speaker is shown in the following figure:

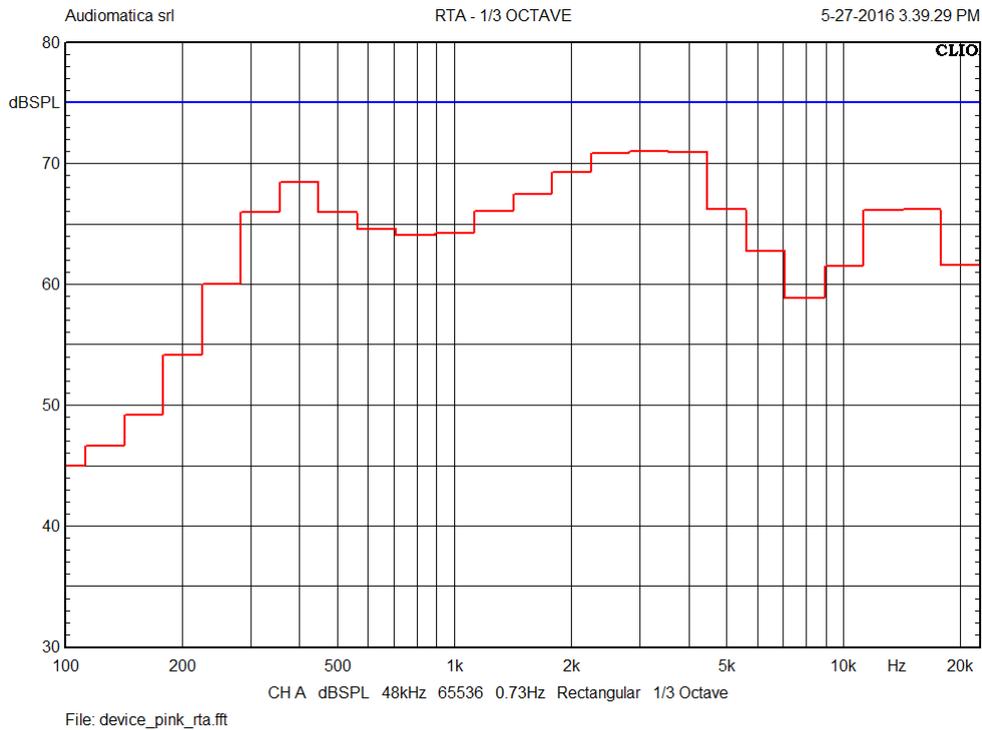


As can be expected for such a small speaker there is a high pass roll off below 300 Hz; the response is far from flat also in the mid to high frequency range.

Suppose that we would like to use as a wave file a pink noise. We can choose the pink noise with size 64k (the same as the impulse response measurement) from the CLIO generator.

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The following figure illustrates the pink noise response of the box as a third of octave RTA (red curve) alongside the spectra of the same pink noise (blue curve), which is of course flat on a fraction of octave reading.



If we try to apply the wav file equalizer processing directly to the loudspeaker response, we will get a very low level signal, since the inverted response of the loudspeaker will try to compensate the high pass behavior of the device².

We need then to define a target function which will not include the low frequency region under about 300 Hz. In order to this we need to perform a little hack.

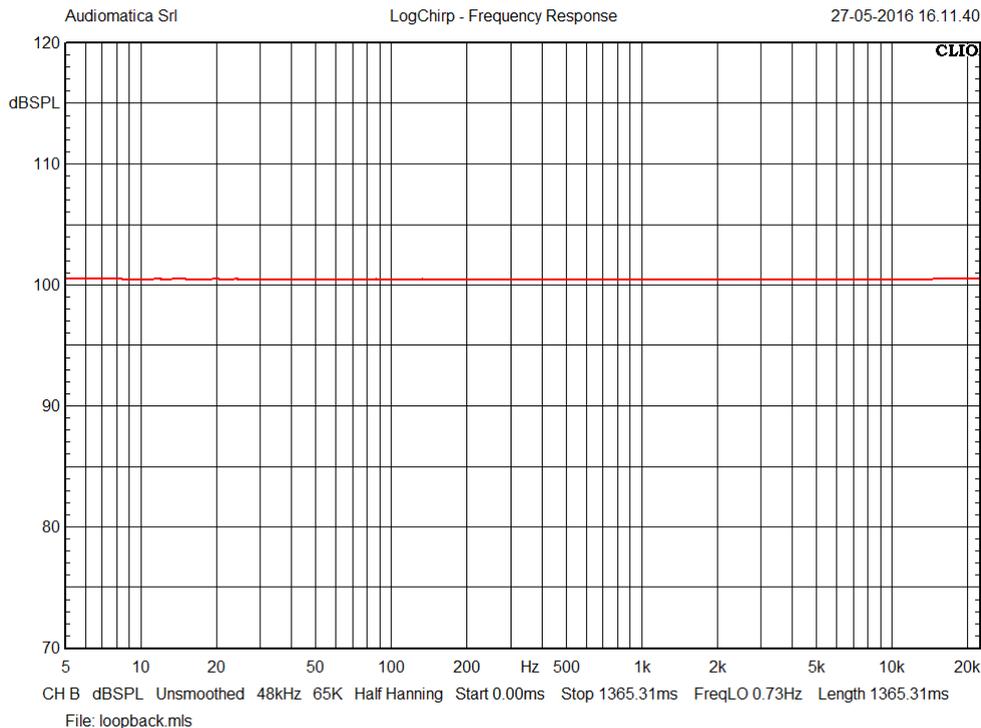
First of all we have to put the CLIO system in loop and get the flat frequency response of the measurement system. The **same measurement unit** of the device response should be used, so in this case it will be dB SPL.

The response will look like a straight line at a given SPL level, the absolute level does not matter as soon as the loop response has been measured with the correct signal to noise ratio. Proper care must be taken in selecting the right input sensitivity.

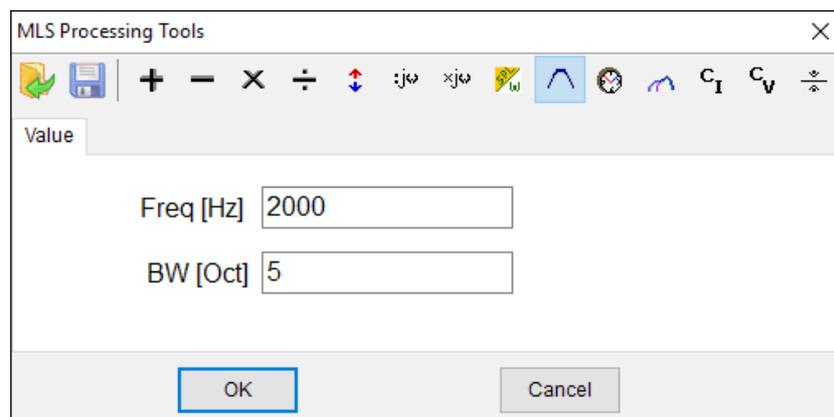
² Even if the inversion is theoretically correct, the device will not be able to reproduce the frequencies under 300 Hz.

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Here is the loop-back response in dB SPL:



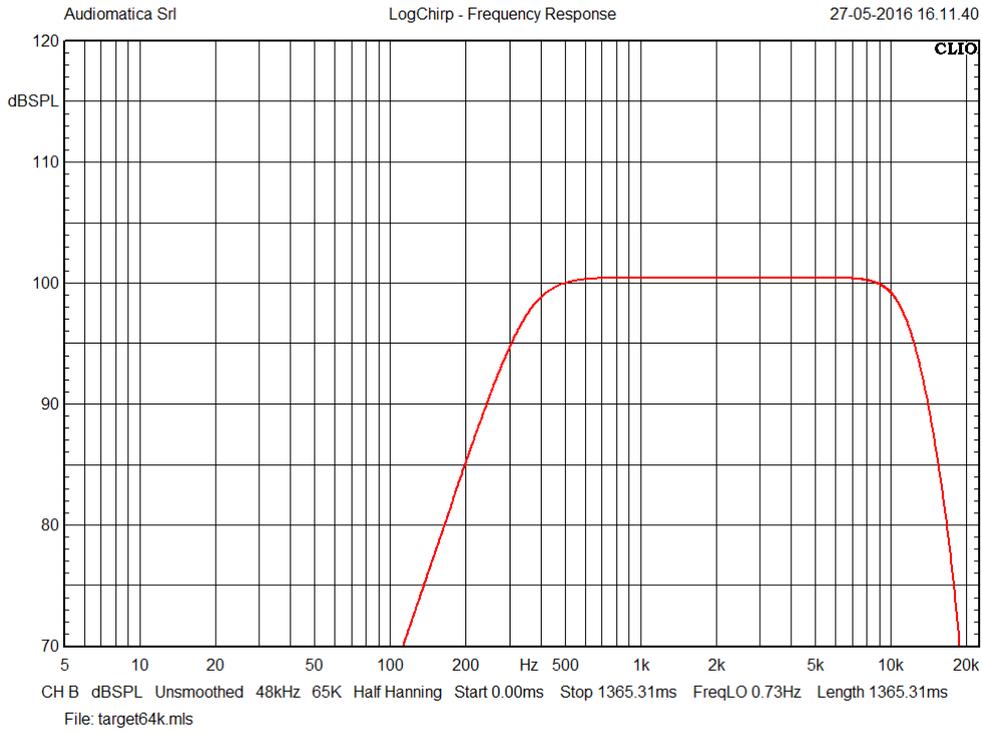
To create our target function we have now to limit the bandwidth of this response, this can be done with the octave filter post-processing:



By carefully selecting the central frequency and the bandwidth it is possible to cover most of the real world situations.

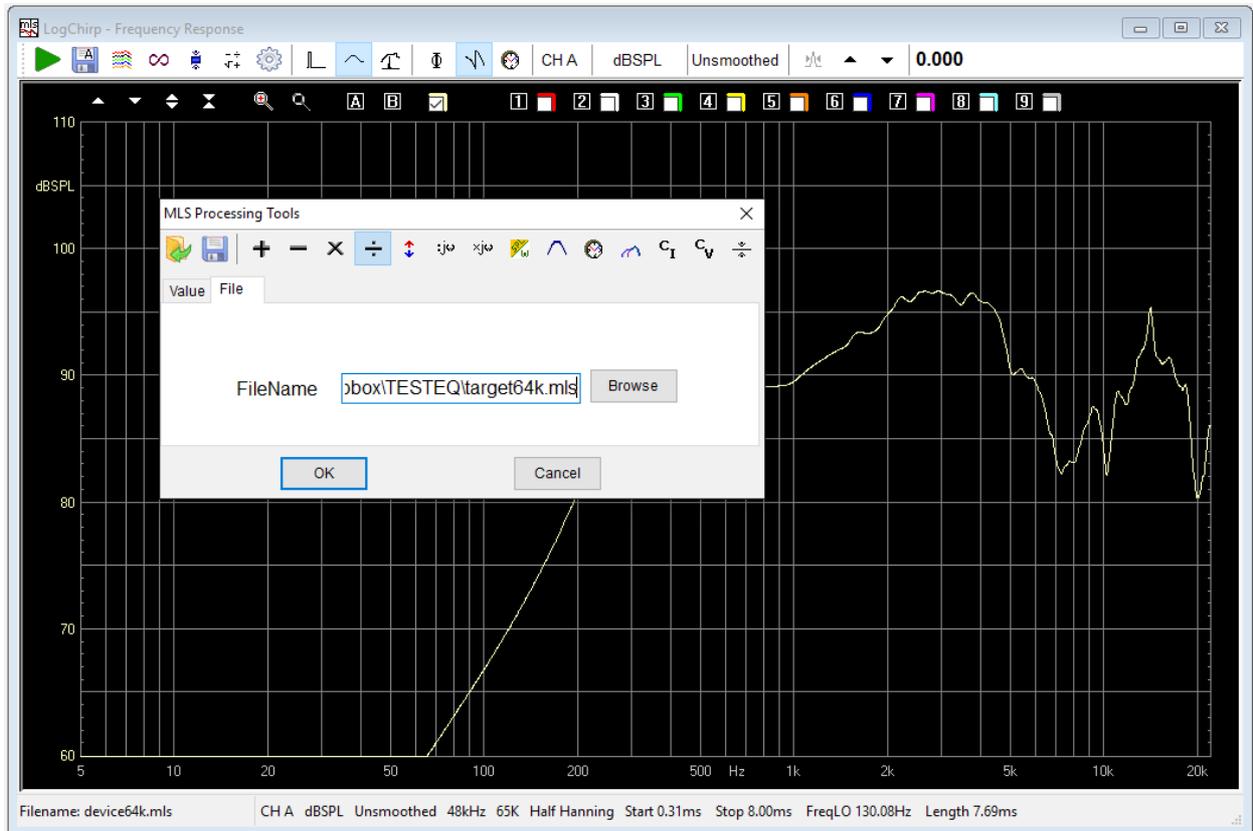
By applying the octave filter processing we will get our target response, the resulting file can be saved with a name like target.mls, since we will need this response in the next step.

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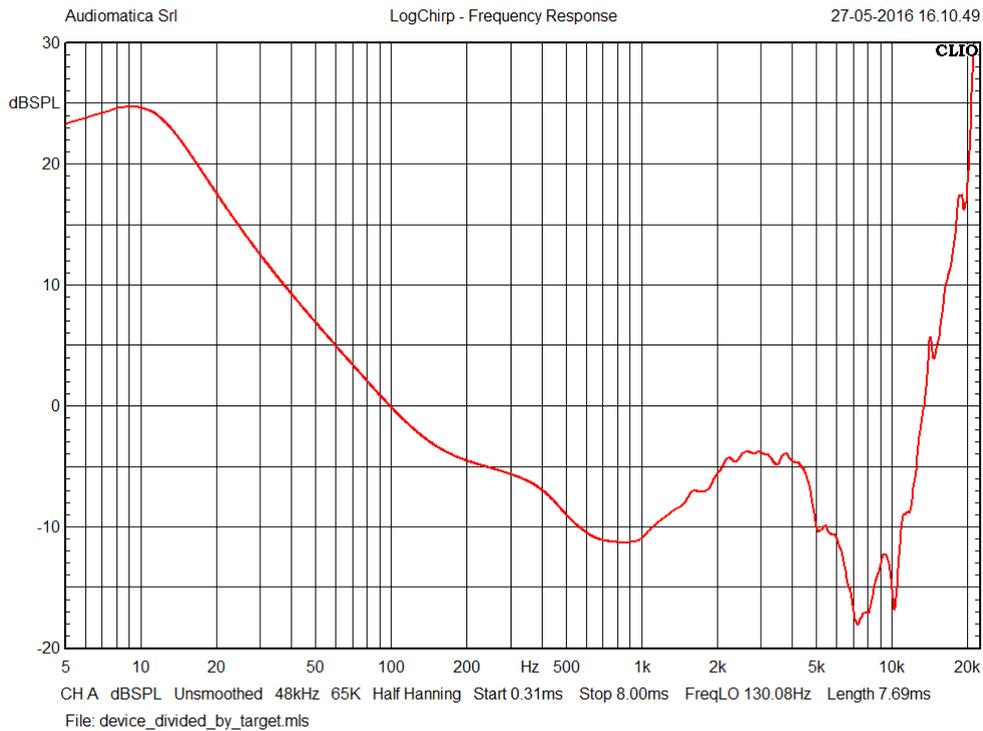
Now that the target function is ready, we can apply this to our device response.

To do this the device response has to be reopened and then the divide by file post-processing, selecting the target function as file, shall be applied.



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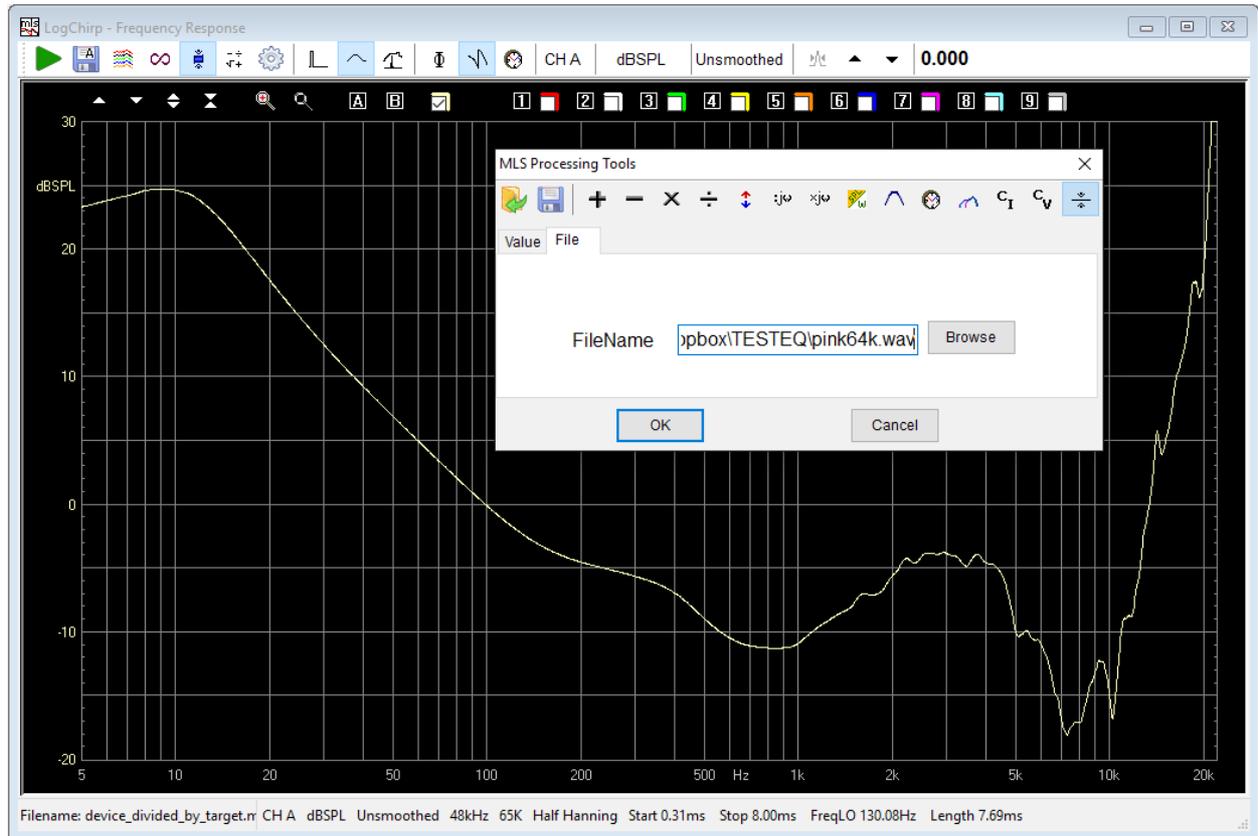
The resulting response should look like this:



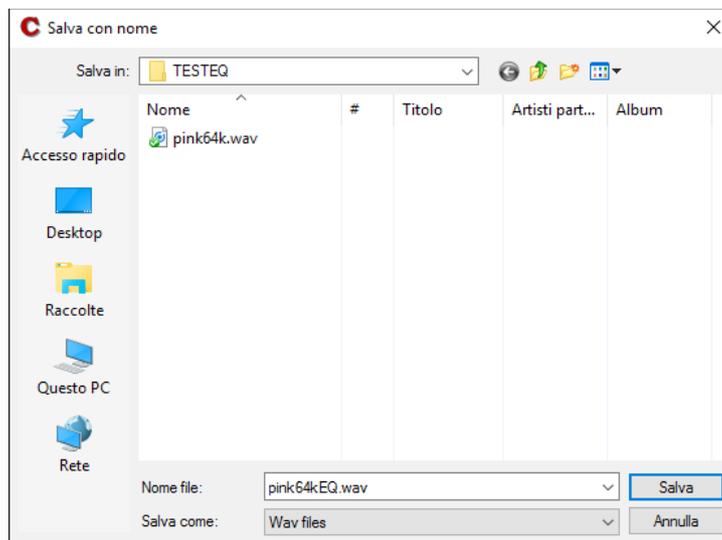
where the response of the device can be visible in the pass-band range of the target response, while outside the response is increasing. This will result of an attenuation of the convolved wav outside the pass-band, which in turn solves the saturation problem previously described.

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Finally the wav file equalizer post-processing can be applied. Select the post-processing tools and select the wav file equalizer, choose the wav file to be convolved using the browse button. In our case we select a 64k size pink noise wave file which we have previously saved from the CLIO signal generator.



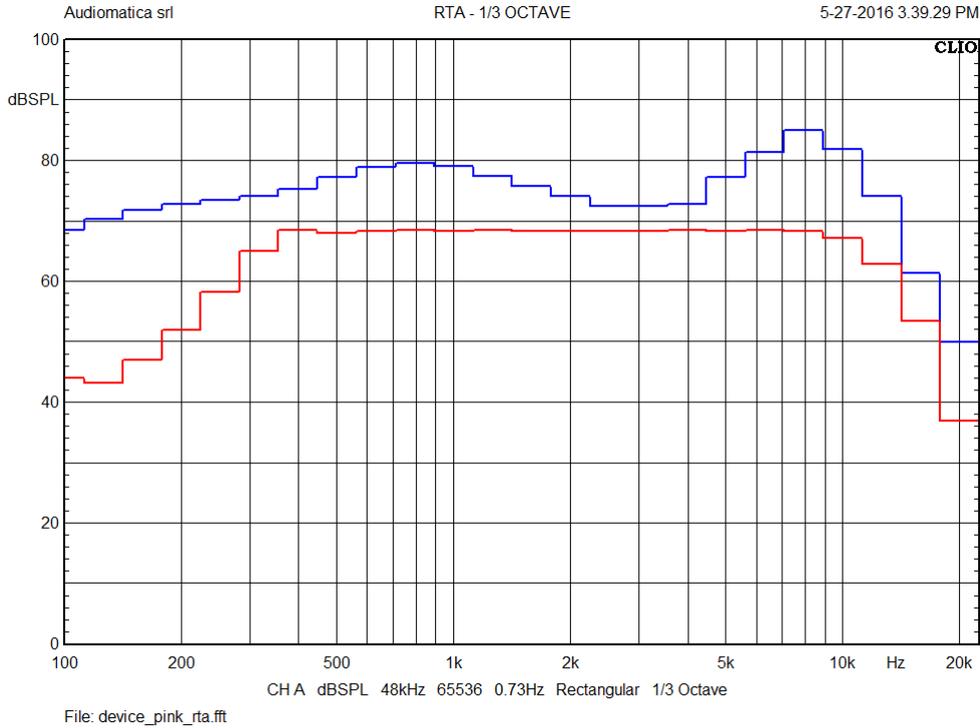
By pressing the OK button the software will prompt for a file name of the equalized wav file to be saved.



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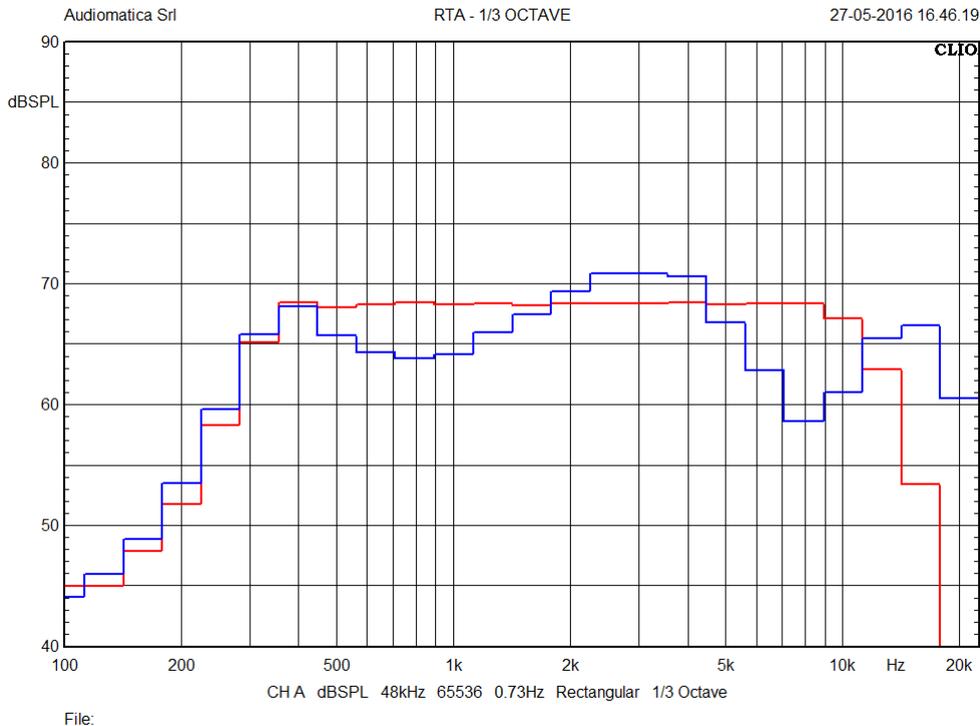
The following figure finally illustrates the effects of the whole procedure.

The red curve is the RTA of the box being driven by the equalized pink noise, blue curve the spectra of the same noise:



It can be seen that the response of the device has been modified to fit the target function.

In the next figure we can see a comparison of the response of the loudspeaker to a pink noise (blue curve) against the response to the equalized pink noise (red).



CONCLUSIONS

The equalization of an electro-acoustic device by pre-equalization of a wave file can be an handy tool in several measurement scenarios.

We have shown that using CLIO post-processing features it is possible to equalize a wav file to a given target response.

It shall not be forgotten that the equalization from a single measurement point in space is usually valid only at that point.

REFERENCES

[1] Audiomatca, "*Application Note 13 - Speech Intelligibility Assessment Using CLIO 11*", http://www.audiomatica.com/wp/wp-content/uploads/APPNOTE_013.pdf