ISSUE
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BRYSTON
A Lifetime of Music

This Issue

Reflections on Comb Filtering

So, you have built the sound room based on the "Golden Dimensions" to reduce standing wave problems, positioned the speakers to best avoid the dreaded "boundary effects" and somehow the presentation just does not seem to be providing that "holographic" image you lust after.

Accurate sound staging depends on the direction and timing of sound coming from the loudspeakers. Interfering reflections will upset the stereo auditory image that is presented by the system. For this reason it is advantageous to remove these harmful reflections. A warning though; excessive use of absorption can lead to a loss of ambience leading to a very "dry" sounding environment. For this reason, only specific reflections should be absorbed.

Reflections that reach the listener soon after the direct sound cause a phenomenon known as comb-filtering. The appearance of a single reflection in a frequency response looks similar to the teeth in a hair comb. Comb filtering due to a single 2 ms reflection is illustrated below.

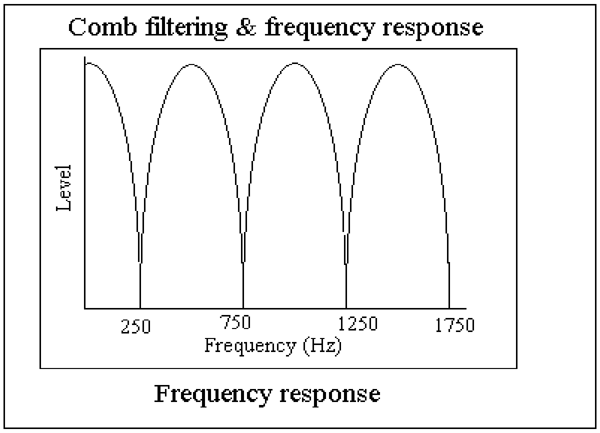

Figure 1

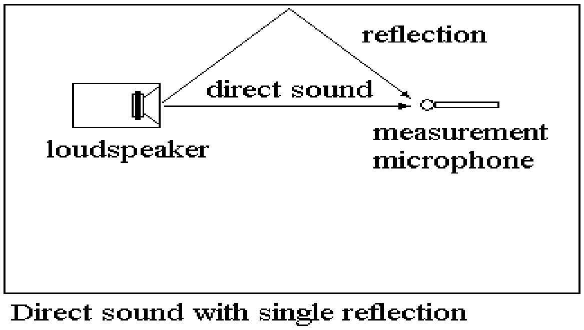

Figure 2

It is the difference in time between the direct sound coming from the loudspeaker and the extra time it takes for the sound to bounce off a boundary and reach your ear which creates these nulls in the frequency response. The result is a lack of image specificity and the sound is very "soupy" with no exact placement of instruments in the sound stage. Figure 3 is an example of comb-filtering at 1 meter from a good quality speaker. Figure 4 shows comb-filtering at a typical listening location, and figure 5 shows what happens when you have glass at the first reflection point. When looking at the graphs the point to remember is that the more "jagged and numerous" the lines from left to right on the graph the more comb-filtering and therefore frequency nulls it indicates. So how do we deal with this problem? Sound behaves as rays and sound rays reflect from room surfaces similar to the way in which billiard balls reflect from the sides of a billiard table during a billiards game. We can use a trick known as the mirror trick to find the reflecting regions of walls, ceilings and floors to determine where energy is reflected from loudspeakers to the listening location.

The mirror trick works as follows: The listener is seated in the

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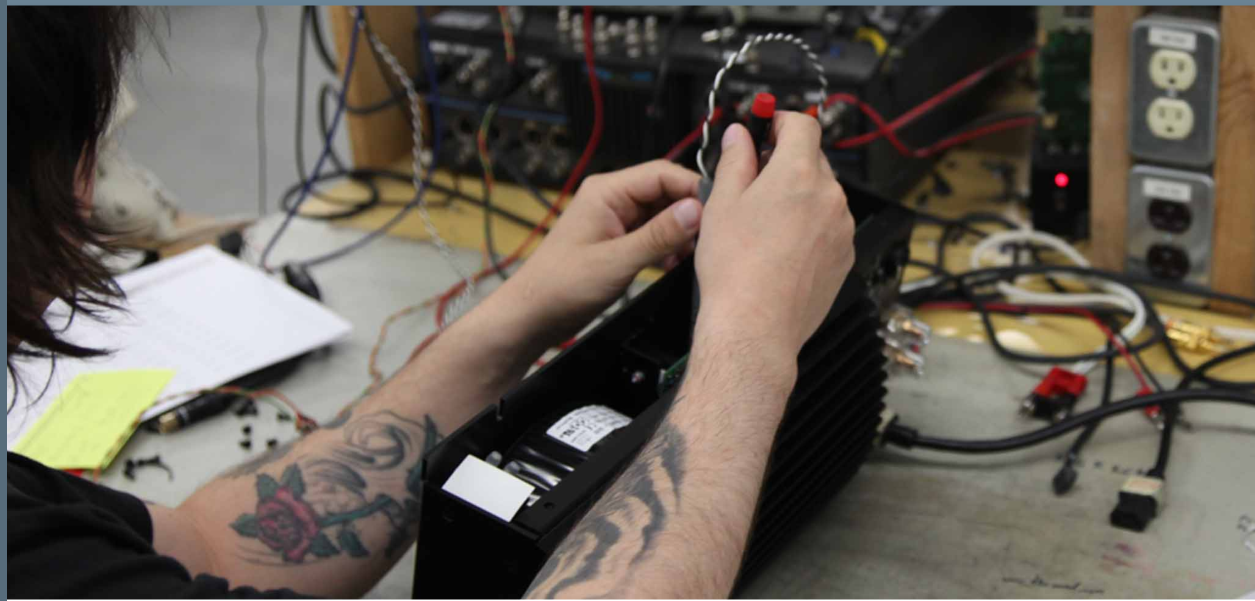


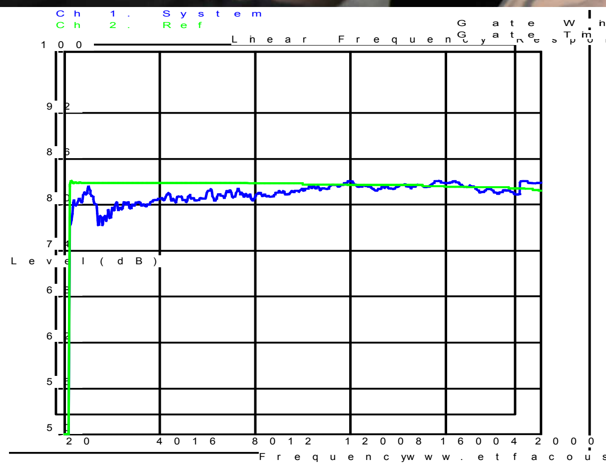


Figure 3

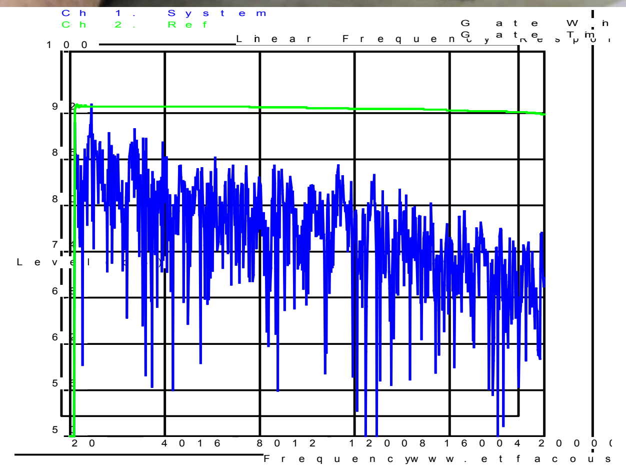


Figure 5

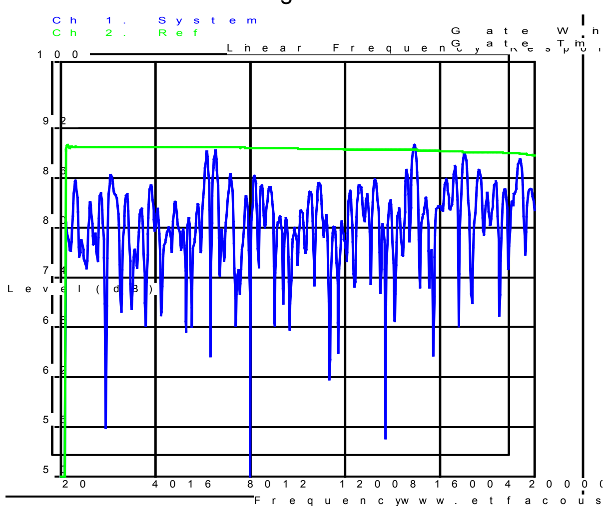


Figure 4

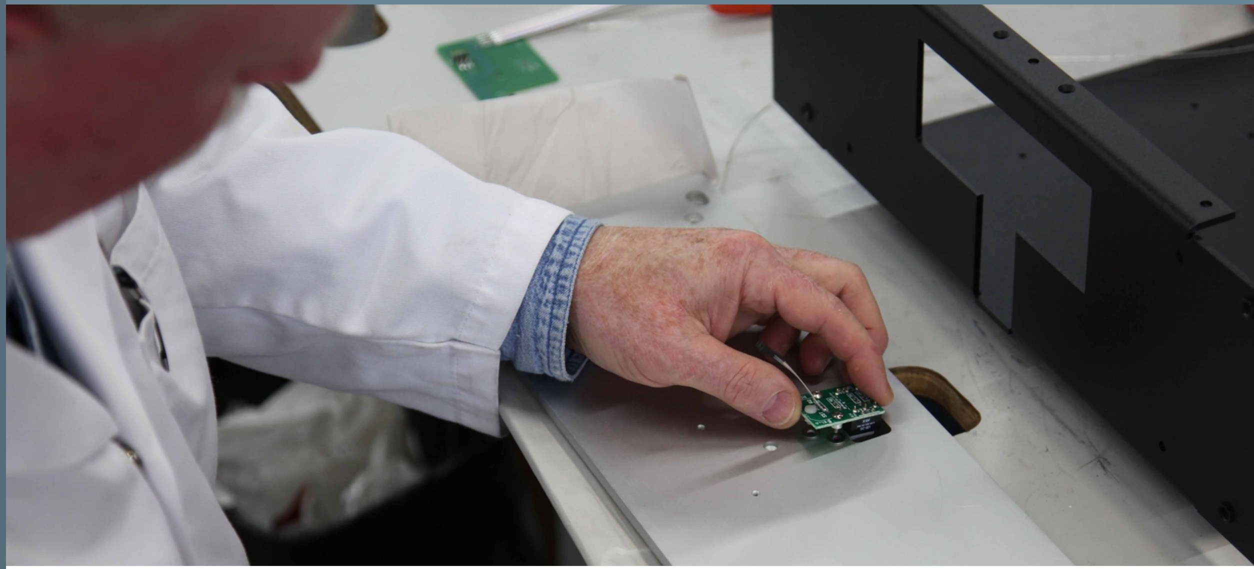
listening location of the room and another crazed audiophile moves a mirror along the surfaces (in most rooms the side walls, rear wall and ceiling are the leading culprits) of the room. When the loudspeaker can be seen in the mirror, the mirror is in a spot where sound waves can reflect from the surface to the listening position. These locations require absorption.

So, how do we better determine where and what intensity of early reflections we are dealing with? There are specialized programs available and the one I used for these tests is called ETF. Check the program out at etfacoustic.com.

As stated above, side walls, rear walls and ceilings are the major concerns when dealing with these early reflection problems. Absorbers should be very thick, in the order of 6 inches or greater. The absorber should be at least 8 times its thickness in width and height. Do not be fooled by people promoting 2 inch thick absorbers as having great effectiveness at low frequencies. The methods used to derive this specification are in no way similar to this application. The lowest frequency of absorption is dependent upon absorber thickness rather than "exotic high end technologies". A 6 inch thick absorber can be very effective down to approximately 600/800 Hz; a 3 inch thick absorber can only be effective to frequencies as low as 1200/1600 Hz.

One of the tests ETF allows you to perform is an "impulse response" of the speaker. In the impulse measurement below you will notice a major spike at 2 ms (see Figure 6).

As shown in Figure 1 (above) the comb-filter effects of this hard 2 ms reflection create severe nulls in the frequency



response. The comb filtering nulls in the frequency response due to a 2 ms reflection will be spaced 1/0.002 = 500 Hz. The

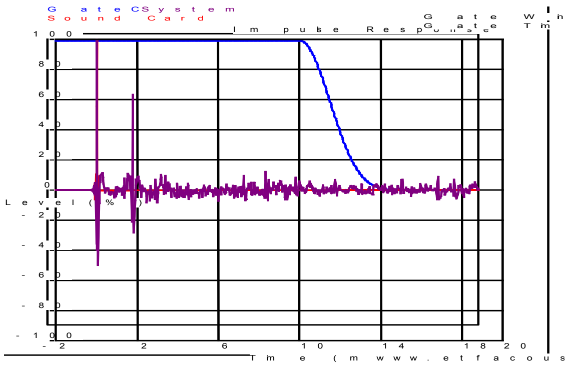


Figure 6

first null will appear at 500/2 = 250 Hz then 750 Hz then 1250 Hz then 1750 Hz etc. An ideal absorber will eliminate the comb filtering nulls above its frequency of operation.

An example of before and after measurements for an open cell foam absorber placed on the side walls and rear walls in my listening room (microphone at the listening location) are shown below. As you can see, an excellent improvement in reducing the comb-filtering at the listening position as a result of the early reflections and therefore a much better stereo image is obtainable. Hey, but your work has just begun. You've solved the stereo problem but now you have to deal with the same reflection problems with the center, side and rear channels in a typical home theatre surround setup - have fun.

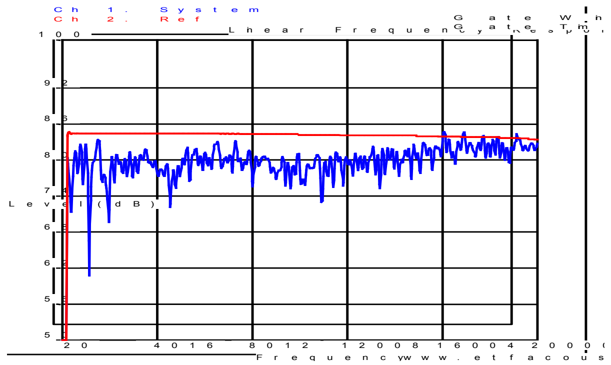


Figure 7

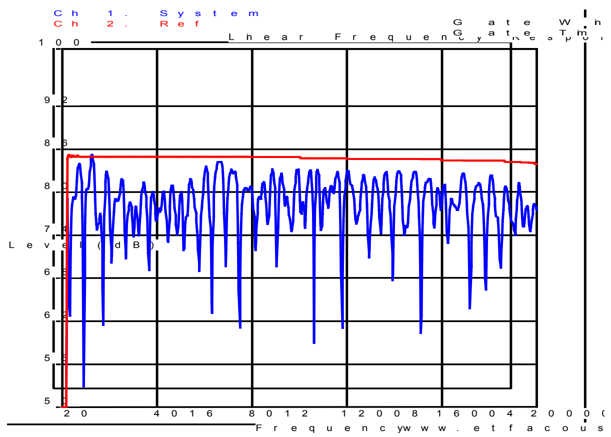


Figure 8

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