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SIA-Smaart® Pro Real Time and Analysis Module Case Study #3: Two Way, Bi-Amplified Loudspeaker In A Critical Listening Room

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For this case study, I wanted to look at a 2-way speaker system that I really like in a good-sounding room, so I picked the critical listening room in our office. Our office is the home of SIA Software Company, Inc. and the NY office of the Walter-Storyk Design Group. The room was designed by the team consisting of John Storyk, Dennis Janssen, and myself. This room serves as a conference room, video teleconference center, and critical listening room. I wanted to look at the both the room and the speaker system.

At approximately 15’ x 20,’ this room is relatively small. I started by placing my microphone about 4 feet in front of one loudspeaker, geometrically centered between the two drivers. I then used the Smaart delay locator to measure the impulse response of the system (i.e. the loudspeaker and the room. The result of this measurement is shown in Figure #1 below.

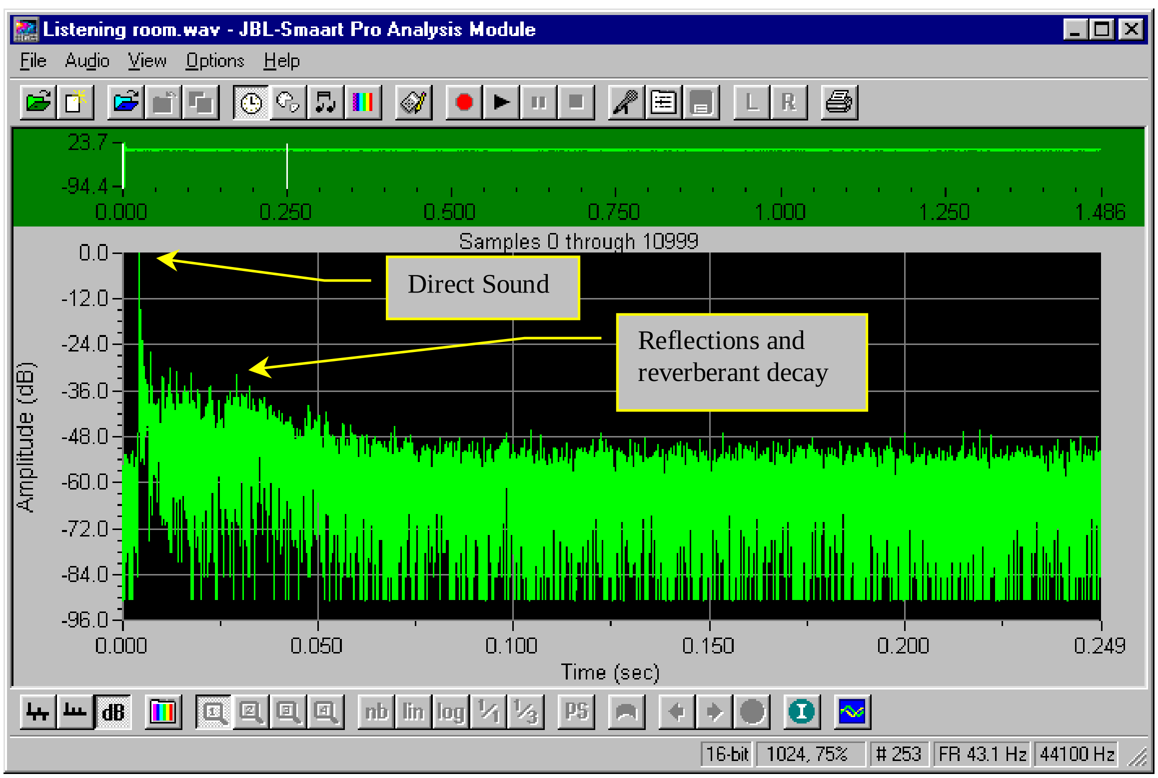

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Figure #1: The impulse response of a single 2-way loudspeaker measured about 4’ from the loudspeaker, using a 44100 Hz sampling rate, 65536 point FFT, and 4 averages (frames).

I then checked the overall response of the loudspeaker. From Smaart's delay locator, holding down the CONTROL key while pressing F6, F7, F8, F9 or F10, will set the measured delay and exit Delay mode. The specified delay time will also be stored in the Delay Preset register corresponding to the function key you pressed. A handy little shortcut.

Having measured and set my delay time, I made a transfer function measurement using the Fixed-Point Per Octave (FPPO) transfer function. I also applied a very gentle smoothing to the curve. The result of this measurement is displayed in Figure #2.

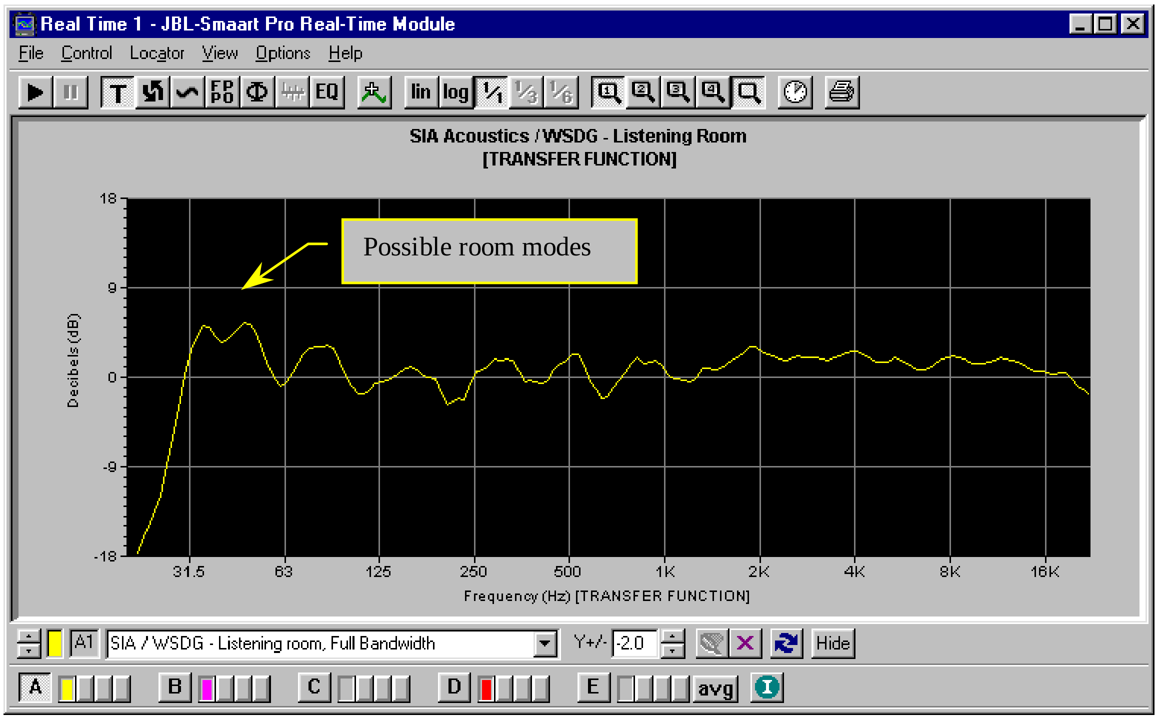

Figure #2: The transfer function of a single two-way loudspeaker measured in a listening room. Notice that the speaker seems extremely well behaved above 125 Hz. Below 125 Hz., interaction with the room dominates the measurement.

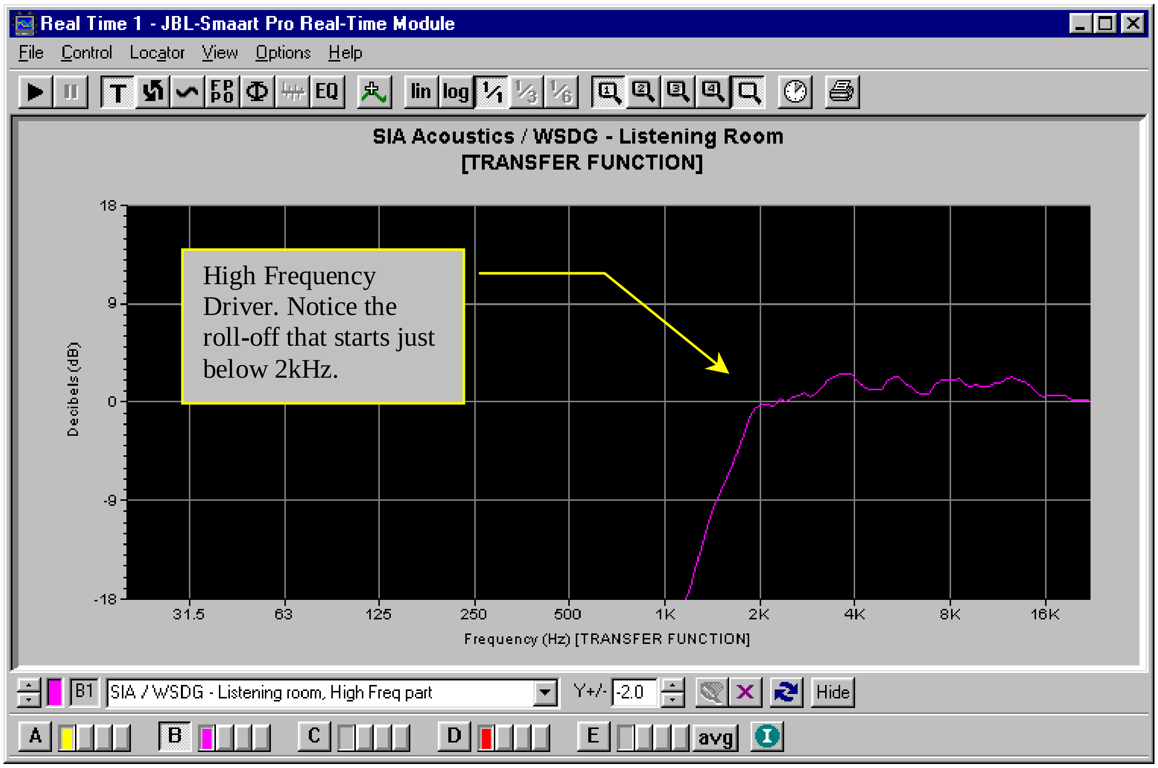

Figure #3: The high Frequency driver response. Notice the steep decay of the driver/cross-over. By looking at the two points on the decay I was able to see that a 18 dB/octave filter was used.

To further explore the loudspeaker's performance, I muted the low frequency driver (at the amplifier) and measured the high frequency driver only, as shown in Figure #3. I then muted the higher frequency driver and measured just the low frequency driver. I used the Delay Locator in both cases so I was able to look at delay locator plot on a linear amplitude scale and determine the *polarity* of each driver as well.

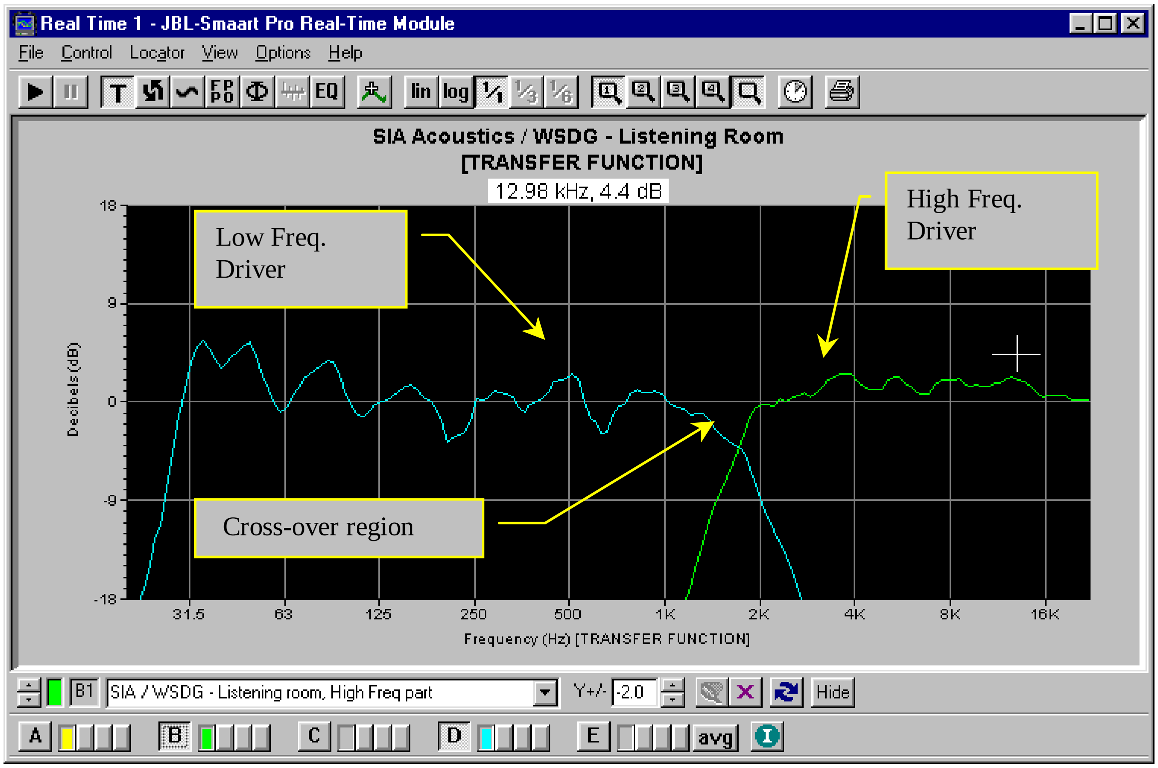

Figure #3: The high and low frequency drivers measured independently. By measuring each driver independently and overlaying their response curves, it is easy to see how the crossover filters are set to provide optimum overlap and response. This approach is particularly useful for setting crossovers and relative amplifier levels.

The standard room mode calculations (see case study #2), led me to expect modes in our room at both 35Hz and 48 Hz. But after carefully listening to the room I concluded that, while small resonances might indeed exist at those frequencies, they do not cause a problem in this room. I was more concerned about the resonance I found at 86 Hz. I decided to insert a filter in the signal chain to try and eliminate this resonance. Using a parametric equalizer, I set up a filter, by overlying the EQ response on top of the measurement results shown above. However, after more careful listening I decided that the filter was really not required after all.

Understanding the results in Figures #2 and #3 is extremely important, as it can help to explain the FPPO transfer function. At high frequencies the FPPO transfer function uses very short time windows, that essentially reject the effect of the room. As a result, the high frequency result obtained is extremely close to the loudspeaker manufacturer's published test results. At lower frequencies, a much longer time window is required to achieve the 16-point per octave resolution,. This longer time window allows reverberant (and reflected) energy to be included in the measurement. In fact it is *extremely* difficult to make high resolution low frequency time windowed measurements with *any* measurement system in all but the largest rooms.

The low frequency results in Figures #2 and #3 clearly show the speaker exciting modal response of the room — a very common problem in smaller rooms. Fortunately, this interaction can be greatly reduced with properly selected parametric filters when necessary.

By the way, you may have noticed that in figure #3, I changed the display colors for the reference traces. I did this by using the Options> Colors feature. I can easily restore the default colors or choose a different color for almost any part of the display. The reason I changed colors was simply that the default (dark red and purple) colors for reference banks B and D do not stand out very well on a printed page.

I Hope you find this case study useful!