Ben Boeshans
FA4740

Final Report

"To a casual observer, a moving coil loudspeaker seems to be a simple enough device. "[1] When I first read this quotation from Philip Newell I knew loudspeaker were more complex than I realized, but not the extent of how much more complex they really are. I have learned a great deal about speakers during the construction process and have also built a pair of speakers with which I am very satisfied. After design, construction and tuning, the speakers achieved their design goals.

The primary design goal of the speaker is all-purpose music speaker for everyday listening. The speakers require good low-end extension, good clarity, and low fatigue. The crisp highs were obtained through crossover points calculated to be 900 Hz for the woofer and 1.2 kHz for the tweeter. The goal was met, as exhibited by the several peer reviews some of which commented, "extremely clear," very accurate," and "sounded really clean." I really like the sound of the plucked guitar played on the speakers. If one closes their eyes they can believe the guitar is being played in the same room. Part of that effect is also attributed to the reverberation in the cabinets. After experimenting with a few different types and amounts of damping materials a balance was found between the openness of the speaker and eliminating resonances.

The goal for f_3 of the speakers was set at 50 Hz. This would allow the speakers to be used on their own, or with a subwoofer. The modeling with WinSpeakerz predicted that the speaker would have an f_3 of 38 Hz in the 4^{th}-order vented box. The

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[1] Newell, Philip, and Keith Holland. *Loudspeakers for Music Recording and Reproduction*. (1 ed. Burlington, MA: Focal Press, 2007.) p. 2

measurements show the f_3 at 40 Hz. This exceeds the design goal and is consistent with the model. I am happy with the low-end response of the speakers – it is a really tight bass that can still punch.

A major concern I had during the design process was the affect the low crossover point would have on power handling. A design goal of K-14 was set, 83 dB capability with a 14 dB crest factor, bringing the total required SPL to 97 dB SPL at 1m.[2] Though a measurement has not been taken, the speakers did not experience any distortion problems when played much louder than normal listening levels.

The one goal that is arguable as to whether or not it was met is portability. In terms of physical size the speakers fall into the large studio monitor category. However, they are very heavy. One person can carry them, but lifting them up on stands takes effort and coordination. The heavier speaker does not bother me any because I don't think I could have gotten the low-end response out of a small cabinet and the reinforced walls were free from any major cabinet resonances.

Overall, the off-axis response is satisfactory. Response doesn't noticeably change until past 60 degrees off-axis. The front baffle was designed to be very narrow to help with the response. The only comment made on the peer reviews about off-axis response was that there is a slight shift in the mids. I agree, a shift does exist, but it is within tolerance.

The construction process was pretty straightforward. The only major problem I ran into was not being able to construct the front baffle out of a solid piece of hardwood.

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[2] Katz, Bob. "Level Practices (Part 2)." http://www.digido.com/media/articles-and-demos/13-bob-katz/21-level-practices-part-2-includes-the-k-system.html (accessed 19 Feb 2009).

This was the case because a board nominally 12" across in actuality is only 11¼". My front baffle needed to be 11½" across. In the end using another sheet of plywood worked out to my advantage. First, it was much cheaper than buying a hardwood that when stained would likely look a lot like the fake grain of the plywood anyway. The one area of concern was that the layers of the plywood showing would ruin the look of the rounded corners. I did some experimenting with cutting rounded edges on several different types of plywood and found that the 13 layers of the birch plywood looked really cool when rounded off. The finish became the second benefit of using the plywood as the front face. The layers of the plywood also made it so the putty I used to smooth the gaps where the front face met the sides blended well with the grain, appearing as another ply rather than looking like putty. The one disappointment from the construction phase is the location of the ports. It wasn't even noticed until after construction was complete that one port is slightly closer to the drive than the other. From the graph comparing the differences between the right and left speaker, it doesn't appear that it affects the sound, but aesthetically it drives me crazy every time I look at the ports.

Several qualms existed after first listening to the speakers. There didn't seem to be a great deal of bass response, not near the f_3 of 38 Hz. Thankfully, once the speakers were used the woofer broke in and response improved. The Before and After response curves are shown in Figure 1.

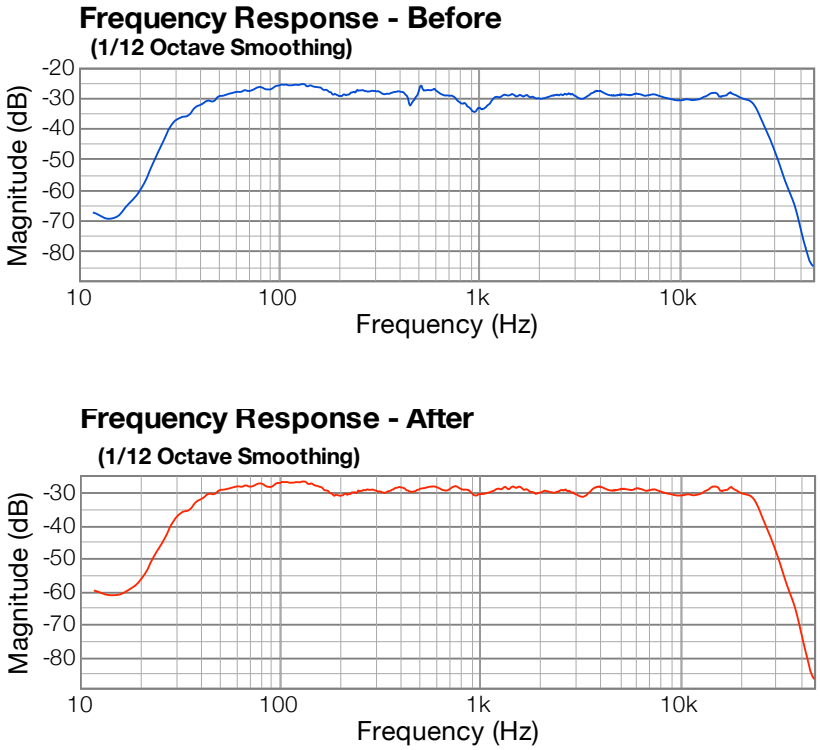

Figure 1

The speakers exhibit the desired qualities to meet the goals of the speaker design and construction project. The design, construction, and tuning process combined to create a speaker with which I am very happy. It has become clear that a loudspeaker is only a simple device to the causal observer. The speaker design project was challenging, rewarding, and ultimately "a wicked amount of fun."