Destructive Interference

The phrase 'destructive interference' is often used in the discussion of speaker system design for large rooms, especially worship spaces. It is easy for the lay person to think of a speaker system in terms of two or more units mounted on the side walls of the room at the front, and sometimes additionally in rear areas of the room. However for a speech reinforcement and music reproduction system this is not the appropriate approach.

One of the major design goals for the worship space sound system is smooth even sound distribution throughout the room, so that the worshiper can sit in any location and hear approximately the same volume and tonal quality. To accomplish this the system designer must have an understanding of the physics of sound. I focus on the issue of multiple sound sources.

For several reasons, the ideal speaker system design would have one source for all sound dispersed into the room. Often however, due to the size and shape of the room two or more speaker locations will be required. When we have only one sound source, assuming that the source is a high quality speaker system, we will have a smooth even sound dispersion throughout the room. When room size and or shape dictate more than one source, we must ensure that each speaker is carefully selected and aimed to cover a specific area of the room with minimized overlap with the other speaker(s).

As soon as the second speaker is introduced into the system, we will have what is called destructive interference. In the area where there is overlap in the coverage, the listener will hear sound from both speakers. The sound fields of each speaker will intersect with each other, creating a series of 'crests' and 'troughs' that will alter the tonal quality of the sound. You can think of this in terms of stones and water. When you drop a stone into still water you will see rings of waves radiate out from the center. Now think of dropping two stones simultaneously into the water. You have two sets of waves. Where these waves intersect you will see a interference pattern of crests and troughs created. When two crests meet at their peak amplitude (volume) they will add together for a 3 dB increase in volume. When a crest and trough meet they will cancel each other out completely, just as adding -3 to +3 results in zero.

Because this happens throughout the entire frequency range of the speakers in use, and the phase relationships vary depending on the relative distances from listener to the speakers, an extremely complex interference pattern is created. This destructive interference is heard as a continuously changing tonal quality throughout the area in question. Literally, the sound may be good in one seat, yet in another seat only a short distance away it can be poor. This effect is easily heard when reproducing pink or white noise through the system.

Because of this phenomenon we attempt as much as possible to place speaker units such that the worst interference areas will be in aisles, however it is important to understand that even when this is possible, the negative effects of destructive interference will still be heard.

A few years ago I had the opportunity to measure a good example of destructive interference and what it looks like in a frequency response measurement. We were set to replace an aging speaker system in a small worship space. The old system consisted of two units

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mounted on the side walls just in front of the platform. We were going to install a single full range speaker up near the ceiling in the center of the room just in front of the platform. Before removing the old speakers I took a couple of measurements with our Techron TEF 20 digital analizer. Figure one shows the response of the system when the measurement microphone was at the rear of the room somewhat off center. Considering the quality of the speaker system, and the fact that there was no equalization in the system, this graph is not too terrible!. Figure two shows a dramatically different result. The only difference between these two measurements was the location of the measurement microphone; I moved it to the center of the room, literally only a few feet from the first location. Figure two is an excellent example of what we call 'comb filtering'; the destructive interference of the two speaker sound fields combined produced this graph that resembles the teeth of a comb. This is a graphic representation of destructive interference, and why it is extremely important to minimize the number of speaker units employed in the sound system, and further, why it is important to ensure the coverage areas of each speaker overlap as little as possible. One cannot simply pick their favourite brand, or choose a model that seemed to work well somewhere else. A successful system requires the knowledge and experience of a professional system designer using the appropriate design tools. Note that destructive interference will also result when discreet reflections off hard room surfaces intersect with direct sound, thus underscoring the importance of proper acoustic finishes in the room.

Figure 1

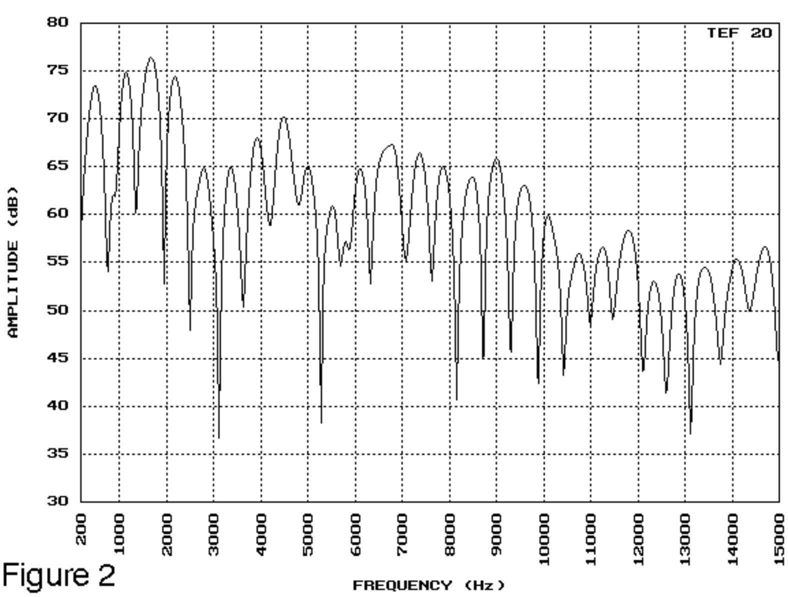

Figure 2

I also note that introducing more speaker units into a system will negatively affect other system design goals, including speech intelligibility, music clarity, and of course the budget! We have another discussion paper that addresses this issue. We at Horizon Audio have the knowledge and experience to design a high quality speaker system for your worship space. Give us a call, or visit our website at www.horizonaudio.net. Thank you!

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Date: April 2006