OPTIMIZING LOUDSPEAKER SYSTEMS WITH THE TERRASONDE AUDIO TOOLBOX

By Bill Johnson

Ideally, with installed sound reinforcement systems, there is consideration and attention given first to the design and treatment of the acoustic environment of the room. Then the loudspeaker system is designed, installed, and optimized specifically for the room. Loudspeaker optimizations are usually performed using computer-based measurement systems (such as TEF, MLSSA, SIMM, and others) that provide extensive information to the engineer. This traditionally requires a great deal of time and experimentation in order to achieve the best possible performance results, and can be rather overwhelming to the newcomer. However, touring engineers usually are required to optimize systems in less-than-ideal environments, where modifying the acoustical treatment is not an option. Also, engineers rarely have the time required to perform optimizations with these measurement systems.

There are at least three key elements to consider when optimizing loudspeakers: polarity, coverage, and amplitude response. These items should be considered the primary focus when optimizing sound systems, whether they are simple or complex. Attempts are often made to equalize the loudspeakers without giving proper attention to the polarity and coverage limits of the components. If problems with these basics are not identified and corrected first, then no amount of equalization will prove useful.

Ideally, the loudspeaker components should have the same relative polarity and adequate coverage of the audience area with smooth amplitude response throughout. As you move beyond the speaker's critical distance, the room's acoustical character becomes most evident. And as we are dealing directly with the loudspeaker components of a sound reinforcement system, we will be performing the measurements in the direct field – where the room will have the smallest possible effect of skewing the measurements.

Described below is a practical approach to using the Terrasonde Audio Toolbox (ATB) with the Contractors Software package installed to optimize loudspeaker systems. The ATB is especially useful in a touring environment, where the engineer is required to tune the system in a limited amount of time. The ATB's compact yet powerful design allows the touring engineer to test road systems without having to haul around a truckload of test gear. The ATB allows the engineer to perform optimizations efficiently and with good results. The following method is one that I have devised by using the Audio Toolbox to optimize sound systems in a wide variety of venues ranging from small rooms to arenas. By following this procedure I feel that I have been able to achieve the best possible performance from the loudspeaker system in the given environment:

Establishing Proper Polarity

The first step is to confirm proper loudspeaker polarity. To perform this procedure, do the following:

1. Go to the System Tools / Polarity Tester function window.
2. Select Speaker mode and MicL input.
3. Connect the ATB output to the loudspeaker's amplifier input. Inject the polarity pulse into the loudspeaker.
4. Place the microphone right up to the LF driver and observe the polarity.
5. Repeat for the MF and HF drivers.

You may observe opposing polarity on the HF driver; which may be intentional by the manufacturer but will need to be verified. If you observe reversed HF polarity, then use the following procedure:

1. Go to the Acoustic Analyzer / FFT Analyzer function window.
2. Select Full mode and 1/6 octave resolution.
3. Inject full bandwidth pink noise into the loudspeaker.
4. With the microphone in the nearfield (3' – 5'), observe the response at the crossover frequency between the drivers.

If a significant dip is observed, then reverse the polarity of the HF driver. Look again. You should observe an increase in response at the crossover frequency region - thus much less dip in the response. The flatter response curve shown at the crossover frequency indicates that the HF driver is now poled correctly in relation to the MF and LF drivers.

Testing Horn Coverage

Once the loudspeaker's polarity has been checked, it is now time to ensure that the loudspeaker system is providing adequate HF coverage of the audience area. NOTE: Ensure that you (and anyone else in the room) are wearing hearing protection before proceeding with the next step.

1. Go to the Acoustic Analysis / Sound Level Meter function window.
2. Set the response to Slow and select the 2kHz octave-band filter.
3. Inject 2kHz octave-band pink noise into the loudspeaker.
4. Observe the on-axis (0^o horizontal, 0^o vertical) SPL of the HF driver in the mid-field (approx. 10' – 30'). Increase the amplitude to achieve 90dB SPL at this position.

Walk away from the loudspeaker into the listening area, observing the shown SPL. Walk around and look for areas where the response drops by 6 dB from the on-axis reference SPL (approx. 84dBSPL) - this will identify the vertical coverage

limits of the loudspeaker. Walk from side to side; identifying the horizontal limits of the loudspeaker. Repeat this process for every loudspeaker and cluster of loudspeakers. Make physical adjustments, as necessary, to the loudspeaker(s) to obtain adequate coverage of the listening area. The loudspeakers should then be adjusted so that their respective 6dB downpoints intersect at the same spot to minimize comb filtering.

To establish a more defined listening area, repeat the above steps with 4kHz octave-band pink noise using the SPL meter set to Slow response and the 4kHz octave-band filter selected.

Optimizing Loudspeaker Response

Now that you've checked the polarity and coverage of the loudspeakers, you can proceed to equalize the system. The method described below should provide good, consistent and repeatable results.

LF Response-

1. Go to the Acoustic Analysis / FFT Analyzer function window. Set the resolution to 1/6 octave mode and 1s decay time.
2. Place the microphone in the seating (listening) area. It needs to be placed so that it is in the direct field of the loudspeaker system (on-axis and 10 to 30 feet from the loudspeaker) and off center in relation to the room dimensions. Be sure that it is placed at listening height (4 to 6 feet off the floor).
3. Inject full bandwidth pink noise into the loudspeaker system to achieve a level of 90-95dBSPL at the microphone position.
4. Adjust the FFT Analyzer display window to the 35dB scale to show as much energy as possible, with the peaks just reaching to the top of the window.
5. Quickly mute the pink noise and observe the decay of the bars on the display.

You should look for one frequency that is the last to decay from the display. Repeat step 5, looking for a pattern in the energy decay (i.e., 160Hz is always the last to decay). Once this frequency is identified, then cut it by 6dB on the system equalizer. Doing this will increase the apparent intelligibility of the system, by removing some of the "mud" from the low end.

HF Response-

1. Inject full bandwidth pink noise into the system.
2. Observe the response curve from 2kHz to 8kHz. Look for 1 or 2 frequencies that are significantly higher in level than the surrounding frequencies. Adjust the system equalizer as needed to bring these frequencies under control. Take care not to cut more than 4dB - any more than this, you will severely affect the clarity of the system.

MF Response-

1. Inject full-bandwidth pink noise into the system.
2. Observe the response curve from 400Hz to 2kHz. Look for 1 or 2 frequencies that are significantly higher in level than the surrounding frequencies. Adjust the system equalizer as needed to bring these frequencies under control. Take care not to cut more then 6dB - any more than this, the system may lack "punch".

By following this straightforward procedure which covers the basics of speaker polarity and coverage before the equalizer is touched, I have found that you can get good, consistent results from any loudspeaker system in a performance venue in a relatively short amount of time.

About the Author:
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