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Loudspeaker Profile

Danley Sound Labs SH-50

By Pat Brown

Loudspeaker arrays have always intrigued audio people. It seems perfectly logical to build a cluster of devices to cover an area based on the assumption that loudspeakers interact in the same way as light fixtures, and all one needs to do is point each loudspeaker at a different area to achieve optimal coverage. It should come as no surprise that it is not that easy, and that designing a good array is significantly more difficult than designing a good standalone loudspeaker.

The Danley Sound Labs SH-50.

THE DEVICE UNDER TEST

The loudspeaker profiled this month is the Danley SH-50. The SH-50 is a relatively compact three-way horn loaded loudspeaker that works well for stand-alone applications requiring a tight (50-degree x 50-degree) pattern. It is also touted to work as an array element for achieving wide horizontal coverage. I will examine both applications in this profile. As is my usual practice, the measured data referred to in this article is available in CLF format from www.danleysoundlabs.com. Interested readers are encouraged to download this data and view it with the free CLF Viewer available from www.clfgroup.org. EASE 4.x data is also available from the same source. There is insufficient space to publish all of the plots here, but with the data file and viewer you have it all. Each of the plots mentioned in this article can be seen in the viewer.

SENSITIVITY

The average sensitivity of the SH-50 is 99 dB ref. 20uPa with 2.83 Vrms applied across the loudspeaker's terminals (**Figure 1**). Due to the large high frequency radiating area of the SH-50, it was measured at eight meters and normalized to one meter. This is relatively high sensitivity, as would be expected from a device with a tight radiation pattern and multiple transducers. One reason for the higher than usual sensitivity at lower frequencies is that two LF radiators are incorporated into the design, and the loudspeaker is physically large enough to provide some horn loading in the lower octave bands.

POWER HANDLING

The 'Bad Sound Guy' power test (www.etcinc.us) revealed that about 30 Vrms can be applied to the loudspeaker for ten minutes before a significant change occurs in its response. This represents about 20log(E/2.83) = 20 dB of gain over the sensitivity rating. This is the gain applied to each

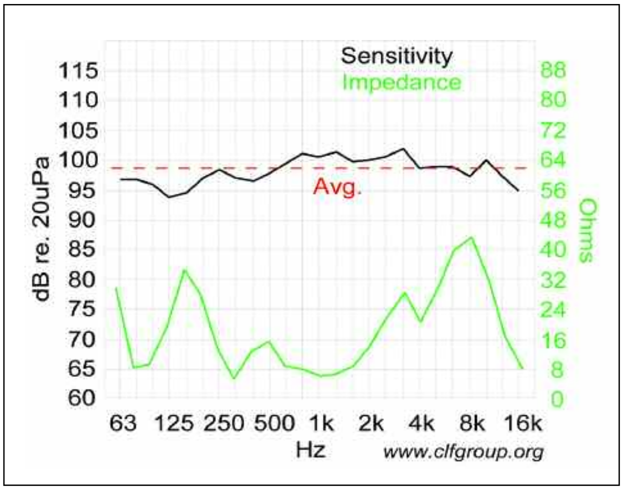


Figure 1

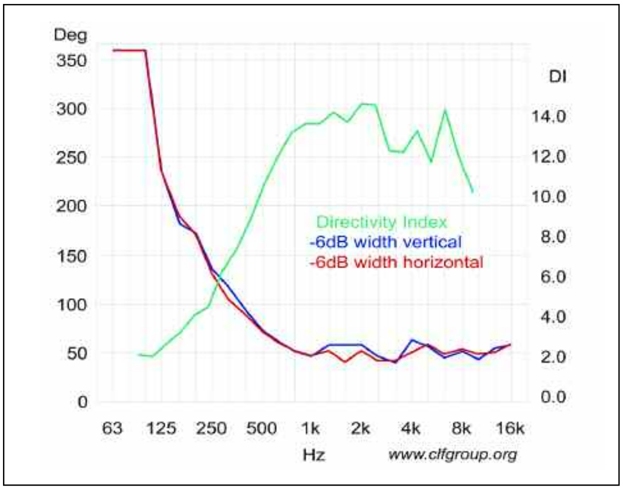


Figure 2

cabinet to produce the room coverage maps presented later in this article. If the user wishes to drive the loudspeaker to its limits, an amplifier with an eight ohm rating of at least +40 dBV should be used. This corresponds to a sine wave power rating of about 800 watts continuous into eight ohms. As usual, we need a very large amplifier in order to get the required Vrms across the loudspeaker, assuming that the goal is the maximum achievable SPL. This unfortunately opens the door to thermal loudspeaker damage from a careless system operator who is not monitoring RMS levels during operation of the system. Since many of today's mixers have peak or quasi-peak meters as opposed to volume indicators, an outboard meter that displays both peak and RMS levels is advisable (visit http://www.dorrough.com and http://www.rane.com for examples).

IMPEDANCE

The Impedance vs. Frequency plot of the SH-50 is also included in **Figure 1**. A single SH-50 should prove to be an easy load for most professional amplifiers, allowing the amplifier to operate as a constant voltage source to the loudspeaker. The typical allowable wire resistance is five percent of the minimum value of the impedance curve (within the passband of the loudspeaker). Using this criteria cable lengths of less than 30 meters (100 feet) should be no problem with AWG12 (3.3 mm) or larger copper wire. If two SH-50s are driven from a single amplifier channel, the cable should be kept much shorter (at least one-half), and the amplifier ideally placed pretty close to the loudspeakers. Many amplifiers can drive two ohm loads, but this fact alone does not solve the problems of cable loss and damping factor. Control of these always requires either a heavier cable, a shorter cable, or both. I suggest following the 'one-amplifier-per-loudspeaker' rule when designing systems with the SH-50. This is good practice for any high-output box, but especially so for loudspeakers with significant portions of their impedance curve below eight ohms.

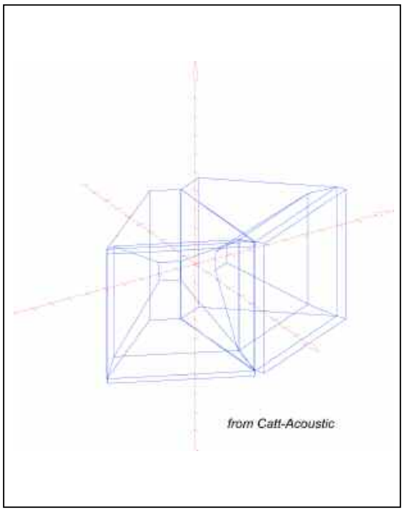


Figure 3

ARRAYABILITY

The SH-50 is a well behaved stand-alone box. Rather than dwell on that here, I will address something that is even more noteworthy. The SH-50 is also a worthy array element because it holds its pattern control over a wide frequency range. Here we have an opportunity to tread on new ground. There are relatively few acoustically arrayable loudspeakers in the professional audio marketplace, and very little measured data on arrays in general. Let's look closer at this aspect of the loudspeaker as it makes a good tutorial for array design in general.

Logic says "If you point it in that direction, then that's where the sound goes." In reality, this is only true at frequencies for which the loudspeaker provides pattern control. This is why we are interested in the Directivity vs. Frequency plot and the Beamwidth vs. Frequency plot, both derived from the 3D loudspeaker balloons. These two-dimensional graphs present the three-dimensional balloon data in a way that directly relates to coverage and arrayability.

The directivity (radiation pattern control) of any loudspeaker diminishes with decreasing frequency, approaching omni-directivity in the low frequency decade. The 'holy grail' of loudspeakers is the one whose beamwidth vs. frequency plot is a flat horizontal line. It doesn't exist, but it is still the goal of loudspeaker designers, who strive to make it flat over as many octave bands as possible. Loudspeakers that can maintain a tight pattern through the speech range produce systems with high speech intelligibility and music 'punch.'

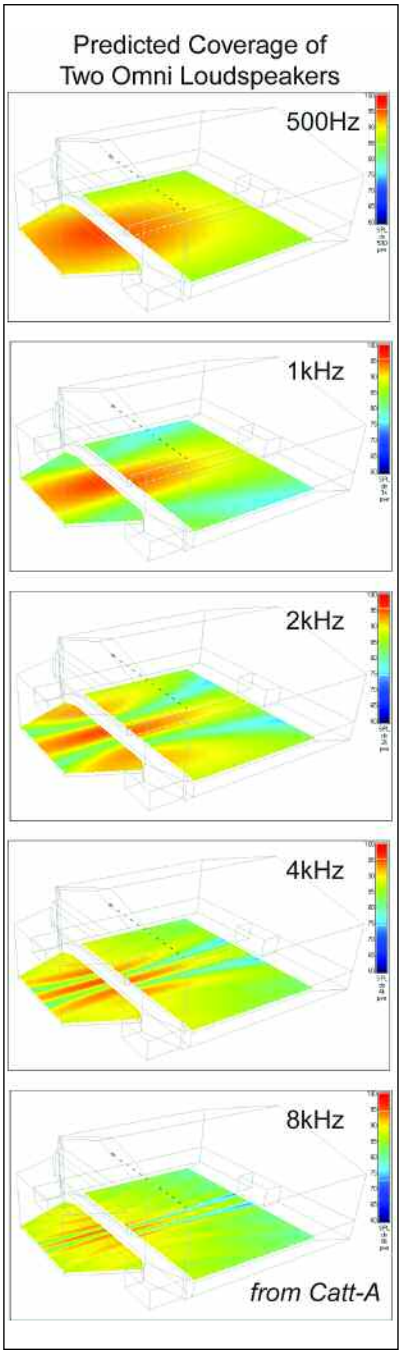


Figure 4

A quick comparison of the horizontal and vertical beamwidths of the SH-50 shows them to be essentially identical (**Figure 2**). This plot also shows the directivity index (DI). The model number aptly describes the beamwidth of the loudspeaker – approximately 50 degrees for the high frequency decade and much of the mid frequency decade, eventually becoming omni at low frequencies. The SH-50 holds its pattern for nearly five octaves. Neither crossover frequency is apparent from the radiation balloons or polars – a noteworthy accomplishment for a three-way system. The crossover network is passive, so this box requires very little signal processing for its direct field response to be flat.

ARRAY COVERAGE

For loudspeakers to array physically, the boxes must simply fit together. That's the easy part, and examples abound in the audio marketplace. For loudspeakers to array acoustically, the designer must use aggressive pattern control so that adjacent loudspeakers don't overlap much in coverage. It's also important for the acoustic centers of two adjacent devices to be as close as possible. Arrayable loudspeakers have their acoustic centers toward the rear of the enclosure to accomplish this.

ARRAY DESIGNS

There are two ways to approach the problem of predicting the coverage of an array. One is easy, the other is not. Let's look at the easy way first.

Since we have accurate balloon data for the SH-50, a modeling program can be used to predict how an array of them will behave. I used Bricscad (an AutoCAD work-a-like) to place two SH-50s in a tight-pack configuration. This gives the coordinates for spacing and aiming the devices. Next, these coordinates were used to create an array of SH-50s within a room model. CATT-Acoustic (www.catt.se) was used for the simulations. **Figure 3** shows the configuration of an array of two SH-50's for a general purpose auditorium that is too wide to cover with a single loudspeaker. The DXF for the auditorium used in this study is available from www.etcinc.us/lsi/ncc.dxf and can be imported into CATT-Acoustic or EASE for experimentation. I chose to model the floor as a flat plane for clarity, but in real life we would elevate the floor to ear height, box it in and apply frequency-dependent scattering to simulate an audience.

ARE ARRAY PREDICTIONS ACCURATE?

While modeling an array configuration using individual loudspeaker data is relatively fast and simple, one can never be completely sure that the actual response will match the predicted response. It is a fact that if you place a loudspeaker near an object (like another loudspeaker) that its response will change. The only questions are "How much?" and "Is it significant?" Array modeling programs do not account for this interaction. The only way to find out is to actually measure an array of devices in the same way that a single device was measured. This allows the predicted and measured coverage to be compared. That is exactly what I did with the SH-50 by measuring a full radiation balloon for a tight-packed array of two. Both CLF and EASE data of the array are available from the source indicated earlier.

THE RESULTS

Loudspeaker arrays are not judged by whether or not there is interference in the pattern – there always will be for physically realizable arrays. The questions again are "How much?" and "Is it significant?" The performance of a loudspeaker array can be judged by comparing it to an array of devices that have no pattern control at all. **Figure 4** shows the coverage pattern of spaced omni loudspeakers for five octave bands. **Figure 5** shows the predicted coverage of an array of SH-50s. An omni array will have very large deviations in the radiation pattern. Arrayable loudspeakers can reduce these deviations to a tolerable amount of ripple (i.e. ±3 dB) over the array's useful coverage angle, which the SH-50 array accomplishes.

While direct field coverage is important, an equally important attribute of a good array its ability to maintain low SPL on stage. Note that the array of omni devices saturates the stage at every octave band – a recipe for disaster regarding gain-before-feedback. The SH-50 array produces very low level on stage. This allows significant increases in acoustic gain and the minimum talker-to-microphone distance.

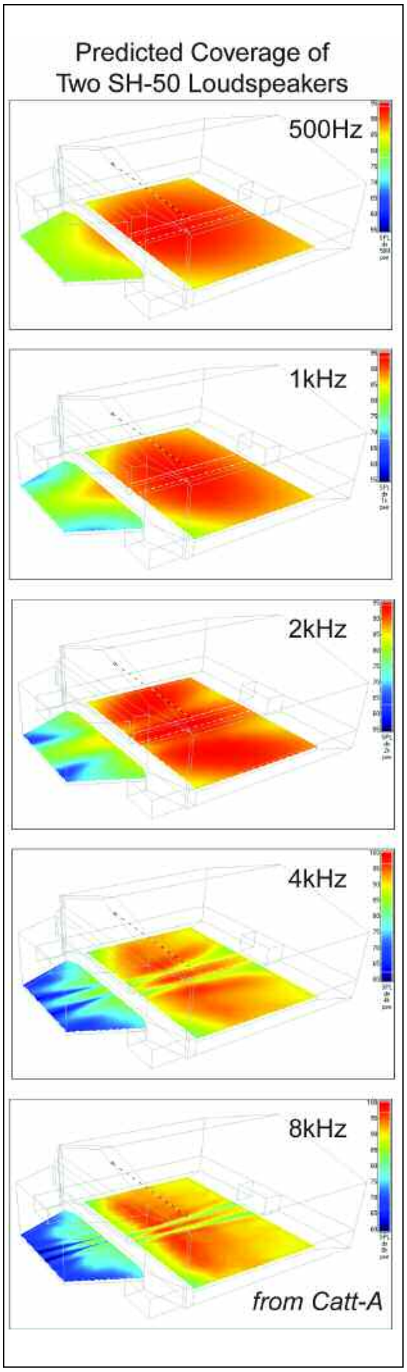


Figure 5

BUT IS IT REAL?

Figure 6 shows the measured array data for the same octave bands. This correlates well with the predicted data for most octave bands, bolstering confidence in array predictions in general as implemented by the software. There are a number of factors that can cause differences between predicted and measured array data, none of which I will go into here, other than to say that any differences between **Figure 5** and **Figure 6** can be attributed to them. Once we know that we can predict array performance with acceptable accuracy, we can save ourselves the time and effort of array measurements and look to the modeling programs to determine array behavior.

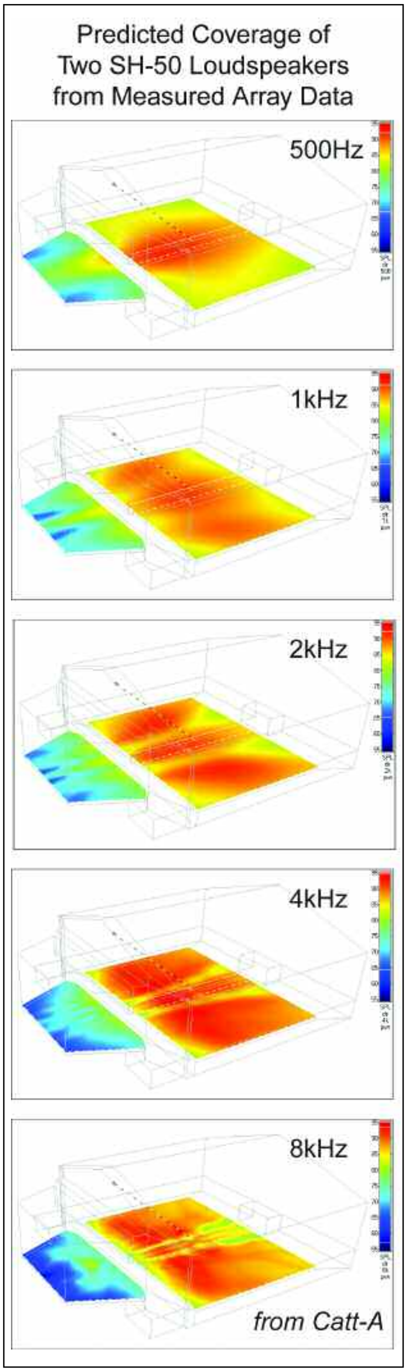


Figure 6

The deviations in sound level through the coverage pattern of the SH-50 array would not likely be audible for speech or music program. The reader is encouraged to experiment with larger configurations.

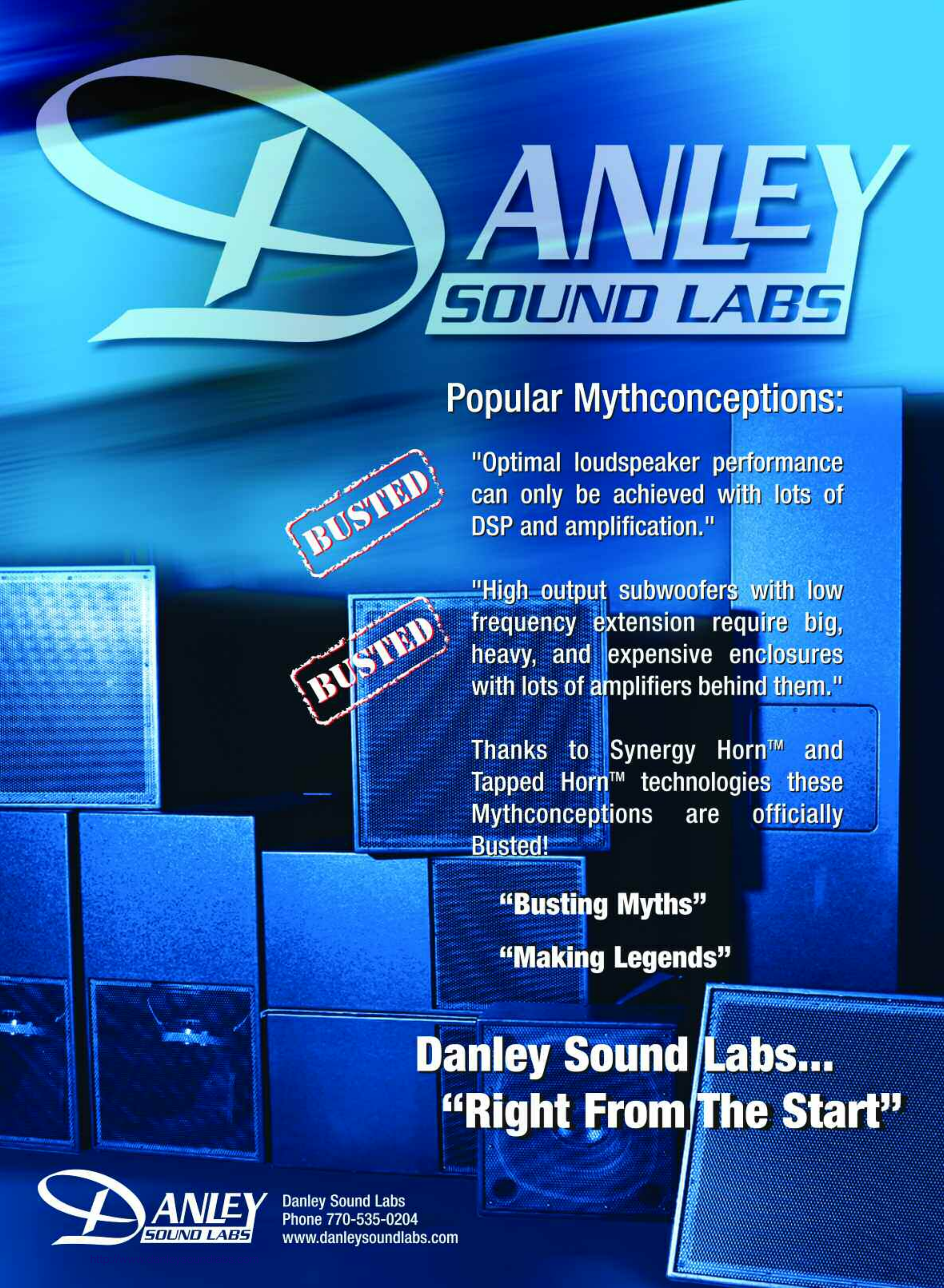
Kudos to Danley Sound Labs for actually allowing an array of SH-50s to be measured and the data published without cosmetic surgery. There are many tricks to make array responses look perfect, and you can bet that if you see array data without interference effects that one or more of these tricks has been used. No smoothing beyond the 1/3-octave smoothing used in the CLF2 and EASE data specifications has been used on the data.

CONCLUSION

Most loudspeakers are suitable for either stand-alone use or for use in an array, but not both. The SH-50 is a rare bird because it is suitable for either application. Designers and installers will love this box because it's essentially plug-and-play, requiring no external crossover networks, alignment delays or multi-pair cables and connectors. Arrays can be quickly configured by simply bolting the boxes together and driving each with a unique amplifier channel.

And, by the way, it sounds good too. ■

Pat and Brenda Brown *own and operate Syn-Aud-Con, conducting training seminars around the world. For more information, go to www.synaudcon.com. This article is also available in an extended format on-line at www.prosoundweb.com.*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Popular Mythconceptions:
BUSTED
"Optimal loudspeaker performance can only be achieved with lots of DSP and amplification."
BUSTED
"High output subwoofers with low frequency extension require big, heavy, and expensive enclosures with lots of amplifiers behind them."
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