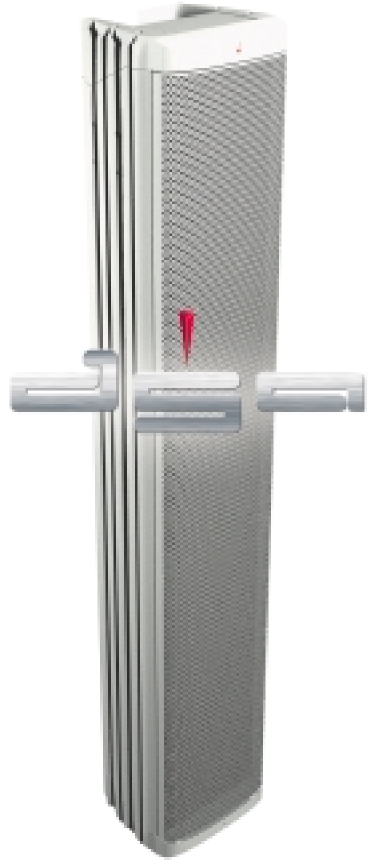


d i g i t a l l y   s t e e r a b l e   a r r a y

t e c h n o l o g y   o v e r v i e w

EAW's new Digitally Steerable Array, or DSA™ Series, represents a radical step forward for small to mid-sized permanent installation applications. In essence, the DSA Series simplifies the KF900/PPST technology that permits digital steering and aiming of an array's output and adapts it to applications where column loudspeakers would typically be specified.

Like a KF900 array, *(see figure 1)* each driver in a DSA Series loudspeaker enjoys its own individual amplification and digital signal processing (DSP). Using EAW's free DSA Pilot software program, users can vary the vertical coverage pattern from 15° to 120° as well as aim the coverage ±30°.

Unlike the KF900 system, however, all this power is housed in a compact, column speaker-type enclosure that requires no external amplification or processing. Users only need to connect AC power, audio signal, and network communications cables. DSA Pilot recognizes each loudspeaker connected to the network and allows users to control all of them from a single interface.

This complex, powerful technology has been years in the making, so a review of the engineering goals and design concepts will help the reader better understand the genesis of these amazing loudspeaker systems.

Project Background and Engineering Goals

In 1997, the KF900 Series proved that high-resolution measurements of each individual driver in an array could serve as the basis for an advanced modeling program that accurately predicts total array performance at a variety of locations. Furthermore, by manipulating various DSP parameters, this modeling program could optimize performance and even steer the array's overall output.

The next year, preliminary work began on a highly compact, single-enclosure array capable of this same control. Over the next few years, experimental prototypes proved the concept to be a valid one, and, in 2001, work began in earnest on what would become the DSA Series.*(see figure 2)*

It may sound redundant to say so, but the primary engineering goal of the project was to ensure that the DSA Series loudspeakers sounded like EAW loudspeakers. Like all EAW loudspeakers, the DSA systems would need to deliver high output, high definition performance within the constraints of its given application. The given application, in this case, was defined as the small to mid-sized installation in spaces with problematic acoustics such as houses of worship, transportation terminals, and museums.

Thus, the DSA Series would need to meet a variety of professional performance standards. Peak output should be in the neighborhood of 120 dB SPL to provide adequate coverage. Since speech intelligibility is a critical issue for these facilities, the system should provide maximum clarity through the vocal range. Broadband frequency response would also be needed to deliver full range music reproduction. Finally, the system would need to deliver outstanding fidelity, an enduring EAW engineering goal.

Often, especially in house of worship applications, aesthetic requirements demand that loudspeakers virtually disappear into the overall architecture. Thus the DSA Series systems should be housed in compact enclosures with a minimal profile. Almost from the beginning, EAW engineers decided to model the DSA enclosures on the traditional column speaker. In addition to minimizing visual impact, this configuration would enable the creation of a line array that was central to steering output in the vertical plane.

To this point, balancing enclosure size against driver placement represented the first substantial obstacle in DSA Series development. While longer lines extend line array benefits to lower frequencies, the applications demanded minimal enclosure size. Therefore, engineers decided to create two different enclosures – a primary full range system (DSA250) and a secondary LF-only system that would extend pattern control when needed (DSA230).

With the basic concepts of the physical design in place, EAW engineers turned their attention to the problems of developing DSP parameters and a control surface that could shape and aim the arrays output in the vertical plane. While the KF900 Series provided some background, the smaller format presented new challenges. Beyond that, any success in steering output above 2 kHz would require even greater precision.

Ultimately, however, it was the goal of creating a total package that delivered easy installation and simple operation that provided the greatest challenge of all. Yet, like all EAW engineering goals, this, too, was met.

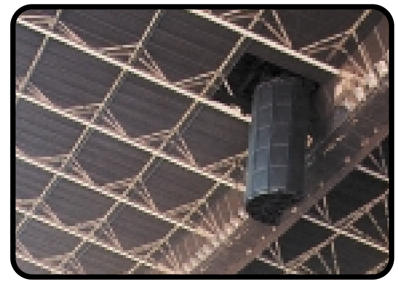


figure 1

figure 2

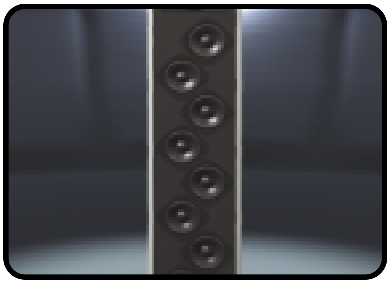


figure 3

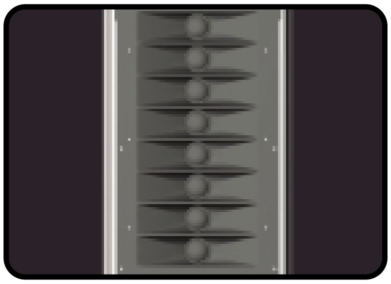


figure 4

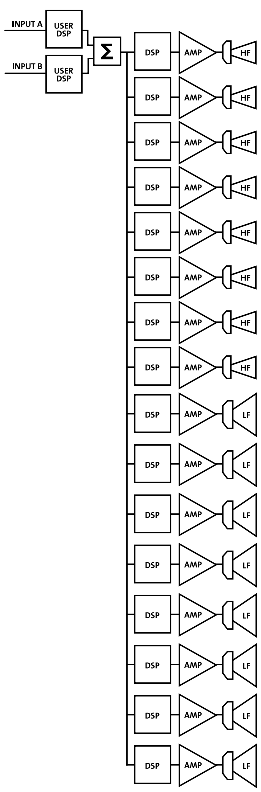


figure 5

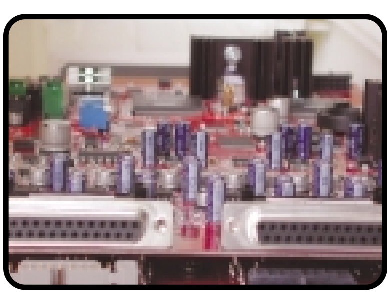
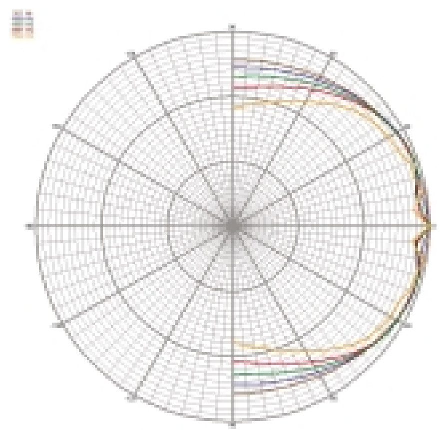


figure 6

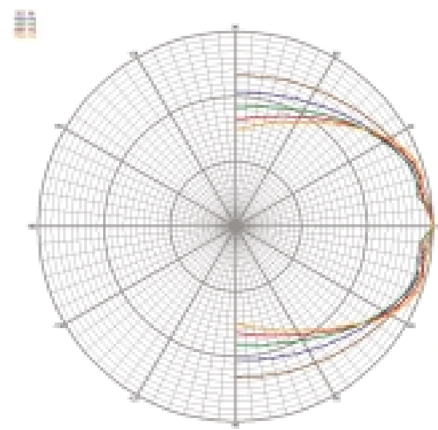
DSA250 Design

The design engineering phase of the DSA project began with the assumption that a single DSA250 loudspeaker would meet the minimum performance requirements. To achieve the necessary broadband pattern control, the LF section's line length was specified to provide meaningful pattern control to around 300 Hz. EAW engineers created a line comprising 8x 4 in LF cones, slightly offset to help minimize enclosure height. This closer vertical spacing creates a higher resolution that optimizes DSP control.*(see figure 3)*

Output and driver spacing drove the HF section design where EAW engineers loaded 8x 1 inch soft dome tweeters with a single, very shallow, multi-cell horn. *(see figure 4)* The goal was to keep the drivers' acoustic centers as close as possible. Again, this high-resolution design optimized DSP control to substantially higher frequency than previously achieved. Indeed, actual performance exceeded the engineer's expectations with steerability to 16 kHz.



Single DSA250 with 120° beam showing octave band polars, 500 Hz to 8 kHz



Single DSA250 with 75° beam showing octave band polars, 500 Hz to 8 kHz

Each DSA250 loudspeaker delivers a fixed 120° horizontal coverage pattern. This wide-angled coverage allows for fairly wide horizontal spacing between DSA250 modules in an installation with the systems vertical steerability virtually eliminating the dead spots in between.

To simplify installation, set up, and long term use, engineers designed all signal processing and amplification as internal components of the loudspeaker system. Each DSA250 loudspeaker delivers 480 Watts of power (8x 40 W LF, 8x 20 W HF) *(see figure 5)* as well as 16 channels of complex DSP that includes conventional HPF and LPF, delay, PEQ and limiting as well as proprietary filters developed specifically to facilitate steering. The internal power and DSP modules also incorporate a robust driver and electronic protection system.*(see figure 6)*

DSA loudspeakers use standard EIA-485 (RS-485) network communications cable/connectors with an optional CobraNet interface available. When connected, all DSA Series loudspeakers in an installation comprise a network in which DSA Pilot recognizes each individual loudspeaker as well as arrays of loudspeakers acting as a single unit.

In the physical design of the DSA250 loudspeakers, engineers broke new ground for EAW in specifying an extruded aluminum enclosure. Several factors made aluminum an excellent choice. In addition to its exceptional strength and rigidity, the use of aluminum allowed the entire enclosure to act as a heat sink, an important consideration for the sixteen internal amplifiers. Heat sink ribs on the rear of the enclosure also act as wire channels for a clean, elegant installation.

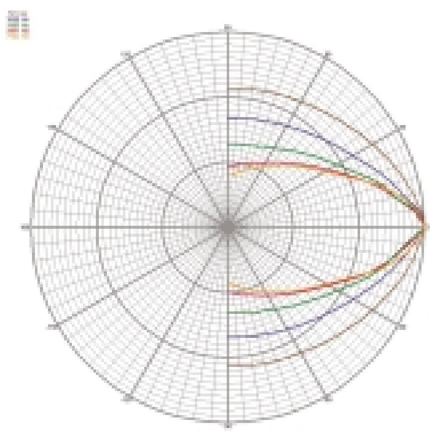
Molded plastic end caps house all connectors with AC power on one end and audio signal and network communications on the other.*(see figure 7)* The intelligently designed enclosure allows easy access

[1] *Within 50% of nominal coverage, in this case, an 80° vertical beam at 300 Hz based on a nominal 40° coverage pattern.*

during installation while cables and connectors remain virtually hidden.

Actual measured performance of prototype and pilot run systems meet expectations and prove out the concepts of vertical beamwidth variability and steerability. Peak output varies between 120 to 130 dB SPL depending on the DSP-controlled vertical beamwidth and steering angle. As a rule, a narrow beam focused straight ahead delivers maximum output with wide beams and sharp coverage angles slightly attenuating peak SPL. Frequency range response is admirably flat from 100 Hz to 16 kHz.

Of course, most of the testing efforts were focused on the variability



Single DSA250 with 30° beam showing octave band polars, 500 Hz to 8kHz

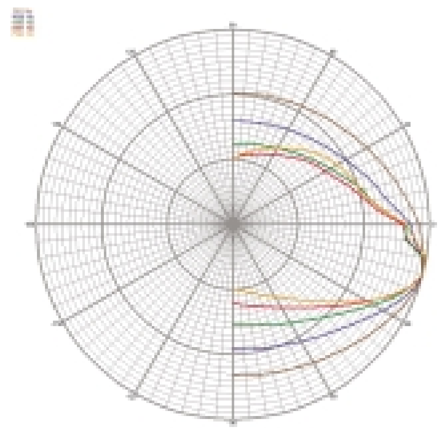
and steerability of the vertical beamwidth. Indeed, properly configured DSP can vary a DSA250 loudspeaker's vertical beamwidth anywhere from 15° to 120°. Furthermore, the beam can be steered ±30° while maintaining even frequency response up to 16 kHz. *(see figure 8)* Beyond those angles, a complex set of variables comes into play. With proper thought and, occasionally, a modest performance compromise, radical steering angles and even intentional nulls can be achieved. In particular, band-limiting the signal to around 8 kHz allows for radical shaping with smooth frequency response across a large area. Interested parties should check the Discussion section of the EAW website where, no doubt, many questions about the exciting, new technology will be asked and, hopefully, answered.

DSA230 Design

A DSA230 loudspeaker is simply the low frequency section of a DSA250 housed in a separate enclosure. It includes 8x 4 in LF cones as well as 8 channels of power and processing. The addition of a DSA230 effectively doubles the line length of the overall LF section, providing effective directivity to 150 Hz with nominal pattern control maintained to 300 Hz.

DSA Pilot

DSA Pilot was created on a separate development path from the DSA Series loudspeakers, with DSA Pilot's roots lying in the KF900 project's optimization program, FChart. FChart used high-resolu-



Single DSA250 with 30° beam and 15° steering showing octave band polars, 500 Hz to 8kHz

tion measurements of each individual driver in an array to predict and optimize total array performance. *(see figure 9)* DSA Pilot uses this same approach to control multiple loudspeakers in a total installation environment.

DSA Pilot assists in both the design and the installation of a complex sound reinforcement system, yet it requires no advanced acoustical knowledge. *(see figure 10)* Once DSA Pilot knows the dimensions of the room and the location of the DSA Series loudspeakers, DSA Pilot controls the DSP settings to form a vertical beam matched to the space. While the control computer can be disconnected after installation, many users will prefer to leave it connected for monitoring purposes and rely on DSA Pilot's multi-level password protection to prevent tampering.

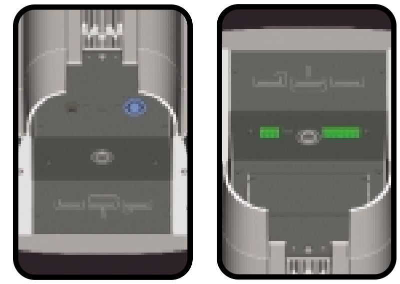


figure 7

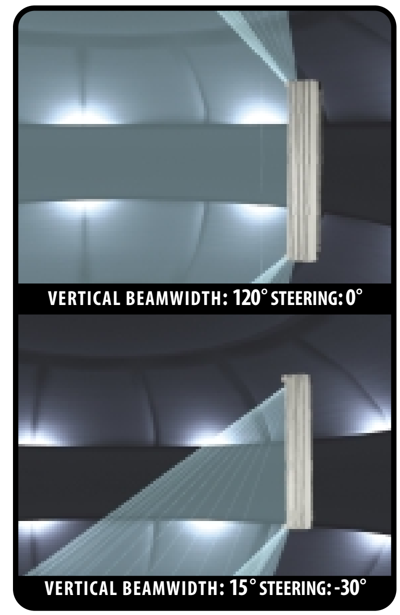


figure 8

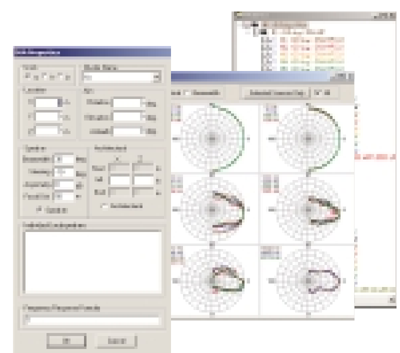


figure 9

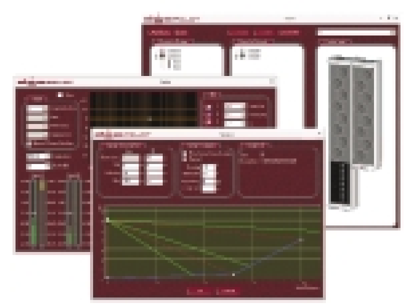


figure 10

[2] *DSA Pilot strives to reach this ideal when it optimizes DSP settings. Users can choose:*
- *even SPL across the entire listening area*
- *even frequency response across the entire listening area*
- *some compromise between the two extremes*

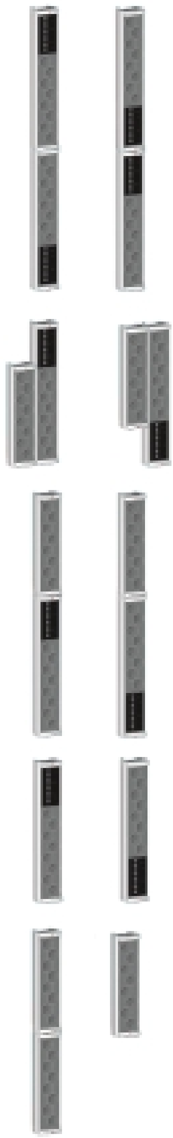


figure 11

Ultimately, DSA Pilot allows users to create multiple DSP configurations to meet a variety of needs such as multiple zones or voice-only/music options. DSA Pilot is a user-friendly software program that assists designers and installers through the process of overall sound system design and installation.

DSA Pilot does not attempt to replace the designer. Indeed, it is helpful to develop a detailed sketch showing loudspeaker placement and horizontal coverage before working with the software.

When the basic design is set, start work in DSA Pilot by building the total system in the Network screen. Select pre-configured clusters ranging from one to several DSA Series modules to suit the cluster's output and control requirements. Name each cluster and module appropriately to speed the installation process.

Now, create a coverage area profile for each cluster. Define the size and slope of the vertical coverage area's floor and input the cluster's mounting height. DSA Pilot will display the ideal vertical coverage beam as well as the cluster's current vertical beam. The user can adjust the cluster's beam manually or DSA Pilot can optimize the beam to match the ideal. Results can be exported to EASE 4.0 for display or further study.

Finally, the user can address settings for the clusters as a whole such as parametric EQ or gain and delay settings for secondary clusters in a larger system.

Once the system is installed and connected, DSA Pilot then seeks out and identifies all clusters and loudspeaker modules on the network. The user selects an identified loudspeaker, activating an LED on the enclosure. Each DSA Series module is identified and associated with its mate in the design, confirming that the system is properly installed. The DSA Pilot then determines if any groups in the system should be treated as clusters or individual modules.

In a matter of seconds, DSA Pilot adjusts each module's DSP setting in conformity to the design and the system is ready for use. A listening test should prove satisfactory and the user is left to adjust front-end equalization to taste.

APPLICATION

The DSA Series is appropriate to a wide range of venue types including theaters, theme parks, retail spaces, and government facilities. Its unique capabilities, however, make it particularly well suited to applications that present a challenging acoustical, physical, or aesthetic environment.

Highly reverberant spaces, such as houses of worship, museums, and transportation terminals, will benefit from coverage closely tailored to each specific situation. The DSA Series provides wide horizontal coverage in applications where few mounting locations exist and the narrow profile enclosures offer a minimum impact solution where aesthetic considerations are paramount.

For voice-only applications, single DSA250 loudspeakers placed to provide adequate output and horizontal coverage should solve the problem. In these cases, designers enjoy complete control of the vertical pattern throughout the vocal range. For broadband music reproduction, the addition of a DSA230 to each DSA250 will extend pattern control well into the LF range and provide additional LF output.

Designers can use DSA Series modules in a variety of combinations to meet specific output or directivity needs, and work is ongoing to create a set of factory-supported configurations. In general, EAW engineers have found some of the following guidelines to be helpful.

With 120° horizontal coverage, only back-to-back arrays of DSA modules would be feasible in the horizontal plane.

DSA250 loudspeakers are designed to "lead with the highs," so the HF section should be closest to the listeners whenever possible, typically putting the HF on the bottom. However, if the loudspeaker were covering a balcony at or above its level, then the HF should on the top.

In cases where two DSA250's would be used to create a vertical array recognized by DSA Pilot as a single unit, they should

[3] Indicates DSA250. DSA230 is 37 inches/75 lbs.

always be placed HF-to-HF. With the two LF lines now over 8 feet apart, that separation allows DSA Pilot to control the vertical pattern throughout the operating band.

Users can add as many DSA230's as they wish to a single DSA250. DSA Pilot will recognize and control as many modules as needed to reach the desired output or directivity goal.

When desired, directly adjacent DSA modules can be treated separately so the lower one can, for example, cover a main listening area while the upper covers a balcony. *(see figure 11)*

Installation

Since DSA Pilot controls the vertical pattern, standard installation is remarkably fast and easy. Each DSA250 and DSA230 includes a standard mounting kit with two 2-part brackets and a mounting template. *(see figure 12)* One part of each bracket mounts to the wall and the other part to the DSA module. Installers simply lift the 51 in/100 lb modules and set them in place – they never support the weight while attaching the bracket.

The loudspeaker is now securely mounted but can swivel up to ±55°, allowing easy access to connectors. After being aimed in the horizontal plane, tightening the connecting bolts then secures the module in position.

In situations where installers must suspend DSA Series loudspeakers, an optional suspension bracket is available. This permits the physical angling of DSA enclosures to provide maximum output at a down angle. DSA Pilot does support applications in which loudspeakers are not flush mounted.

Conclusion

In the professional audio industry, the phrase "breakthrough technology" has been used to describe innovations that fall considerably short. In this case, EAW engineers feel justified in the use. The DSA Series represent an important step forward in the quest for smaller, smarter systems that offer designers truly customizable tools to solve difficult application problems.

dsa digitally steerable array

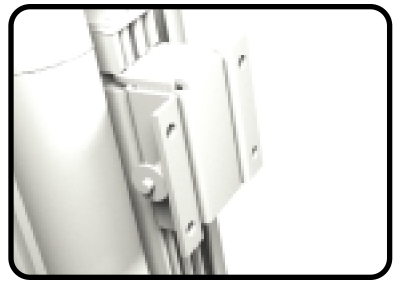
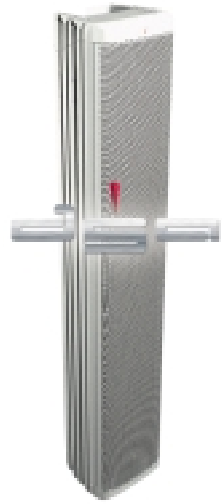


figure 12



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