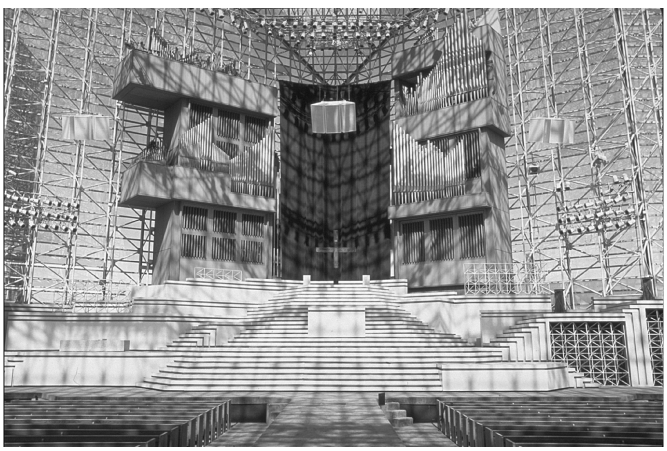
EAW Technologies



Engineering Concepts

System Design Tools

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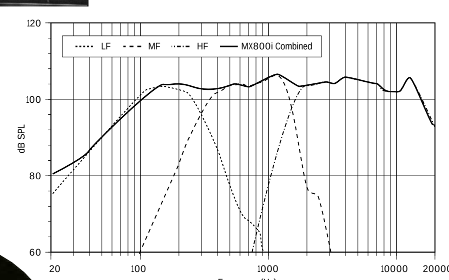

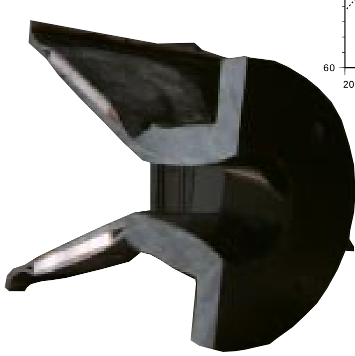

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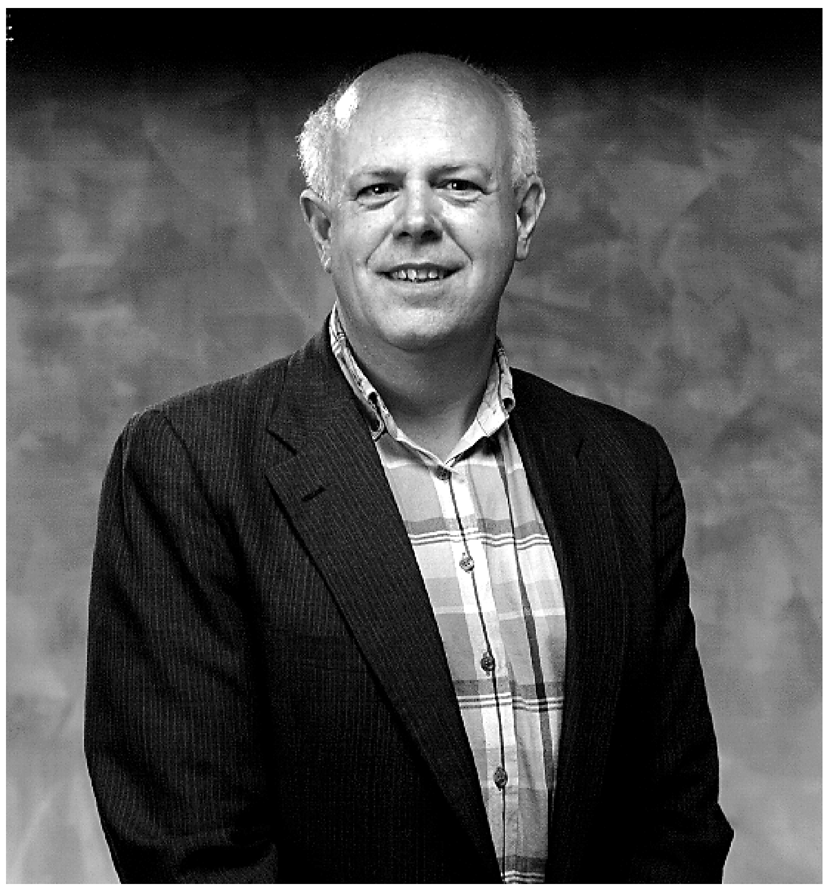
Introduction

Throughout two decades of innovation, EAW co-founder and Executive Vice President, Strategic Product Development Kenton G. Forsythe has integrated the laws of physics with the latest audio technology to design loudspeaker systems that give audio professionals the most accurate tools possible. Over the past two decades, Kenton and the team of engineers he has built at EAW have developed several new approaches to loudspeaker system design. Yet advanced technology is never more than a means to an end — loudspeaker systems that deliver unparalleled performance.

While the results are often revolutionary, EAW engineering is an evolutionary process that proceeds from the fundamentals of acoustics. Listening to customers and responding to the specialized needs of the professional audio community is a key in applying innovative technology to the development of products that lead the industry in new directions.



EAW cofounder and Vice President for Strategic Product Development Kenton G. Forsythe.

Vice President, Engineering Gary Hardesty (front) and the EAW Engineering Team.

EAW's Engineering Team

EAW's Engineering direction remains under the guidance of Kenton Forsythe, but much of the day-to-day operations of the department are now overseen by Vice President, Engineering Gary Hardesty. The experience Gary gained at JBL managing large-scale projects has served him well since joining us at EAW he has participated in such notable sound reinforcement projects as Super Bowl XXX, the 39th Grammy Awards and the 1996 Oscars.

Product development at EAW has two main branches — Core Products and Custom Products — led by industry veterans Andy Lewis and David Gunness, respectively. The Core Product Team seeks to improve our range of existing products through a process of continual evolution. The Custom Products team develops the bulk of EAW's new technology for application engineered AS series systems as well as new product ranges such as the Cinema Series.

The Senior Engineer/Team Leaders are currently supported by Design Engineers Jeff Rocha and Greg Burlingame along with a staff of documentation engineers. Manufacturing Engineer Jay Skowronski and Application Engineer Andrew Rutkin contribute to the product development cycle and also ensure that products are made with maximum efficiency and used to their best effect.

At EAW, we regard accurate, reliable engineering data as an essential element of the loudspeaker system. Without this information, it is difficult to use any sound reinforcement device properly

Our CAD Documentation and Quality Control teams are charged with making sure that our products have accurate and complete specifications.

To achieve the right balance of performance factors for each particular application, every aspect of the loudspeaker system — transducers, enclosures, horns, crossover design and manufacturing, exterior finishes, electronic signal processing — is optimized and integrated into a functional whole. By creating an engineering ethic that emphasizes total system performance rather than any one component or technology, Kenton Forsythe has redefined the standard of excellence as it applies to professional loudspeaker systems.

While pursuing overall performance, EAW engineers have developed many important design approaches and technologies: What follows are brief explanations of several of the most important design tools in use today at EAW.

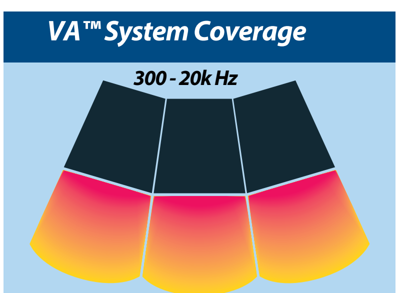
An array of KF850s, KF852s and BH852s as configured for Eric Clapton's Royal Albert Hall Concerts, 1995.

VA Technology

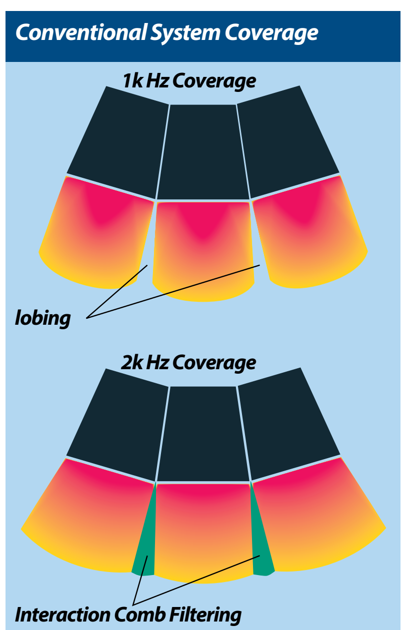
Optimizing the Loudspeaker System for Performance in Multiple Arrays

Performance Engineering: Design Focus on Applications

At the core of Virtual Array Technology is a simple realization: a single loudspeaker enclosure rarely provides adequate coverage and output for professional applications. The success with which multiple systems couple acoustically is therefore at least as important as how a single system behaves. To optimize array coverage and minimize interference between adjacent loudspeaker systems, EAW engineers have developed methods to create sound reinforcement tools that provide accurate, consistent, high-powered coverage and then roll off steeply beyond the defined coverage area.



When horizontal dispersion is consistent, each full range system covers a defined area.



When coverage is inconsistent, no array format will provide true acoustic coupling

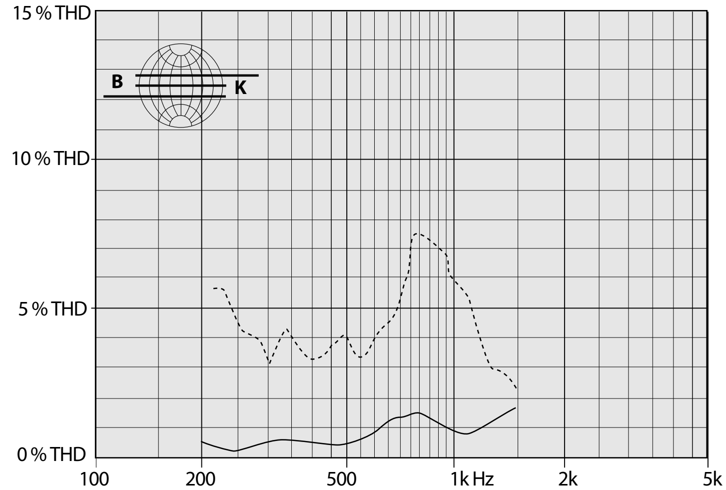
To reach this goal, they employed a design process we call Virtual Array Technology. They examined every aspect of the multi-system array to determine exactly what was required and where existing approaches fell short. Then they applied the laws of physics to create systems that work in arrays as well as singly.

The Three-Way System Solution

At the core of VA Technology is the horn-loaded, three-way system design built around Kenton Forsythe's midbass horn and displacement plug. Early in his career, Kenton realized that a minimum of three subsystems was required to achieve realistic reproduction of either speech or music. He was most concerned with the frequency range 250 Hz to 3 kHz—the human vocal range —where the ear is most sensitive to acoustical anomalies of any kind.

Typical two-way systems inevitably place the crossover point somewhere in the middle of this region, creating audibly noticeable power response peaks and dips, phase anomalies and excessive distortion in the crossover transition. Adding a subwoofer or supertweeter does nothing to eliminate these problems, nor can they be equalized out of the system.

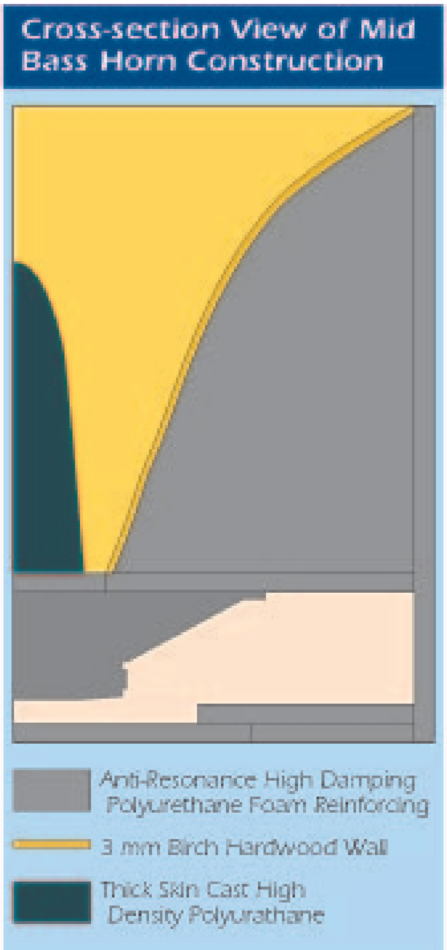
Total Harmonic Distortion Mid Band Comparative Data At 10% of Max Input Power



EAW's attention to detail maximizes the potential of true horn-loaded three-way designs. Similar designs from other manufacturers do not provide EAW's high level of performance.

Efficiency, Directivity, Coherency

This led Kenton to develop true three-way systems centered around the midbass horn. By dedicating a hornloaded



Proprietary horn construction methods produce large-format horns with complex, mathematically correct flares.

subsystem to cover the midband, power response problems in the crossover area are minimized. The large horn throat allows the wavefront to develop without distortion yet be efficiently directed to the defined coverage area. In addition, the horn serves as an impedance-matching device, increasing the driver's efficiency by an order of magnitude.

To fine tune the design of these large horn flares, a displacement/phasing plug was developed. The displacement plug, centered directly over the driver, creates the proper exponential volume expansion within the horn flare. The phase plug equalizes the various routes from the driver into the horn in order to produce a coherent wavefront at the throat.

Unique Construction Techniques

To achieve truly flat response and consistent directivity across a horn's passband, the flare of the horn must conform precisely to an exponential curve. The curvature must be directly proportional to distance from the driver; the farther from the driver, the greater the rate of expansion.

Modern manufacturing technology allows such designs to be fabricated relatively easily using molded plastics or fiberglass, materials EAW uses to make high frequency waveguides. But those materials are resonant within the bass and midbass horns' passbands and are therefore unacceptable for this purpose. The 3/4-in Baltic birch ply used by EAW for cabinet construction is acoustically "dead" but very difficult to shape into the complex curves required for an accurate horn. Conversely, a thinner, more bendable birch ply would be acoustically transparent at low frequencies and could not function as a waveguide.

The solution EAW has developed is to use a 3-mm sheet of birch ply fitted into a track cut by a computer-numerically-controlled router. This allows the horn flare to conform precisely to the mathematical formula. To create an acoustical barrier, the space behind the flare is filled with a high density polyurethane foam. After the foam hardens, it, in effect, becomes the horn flare and the thin birch ply sheet is merely a mold which defines its shape.

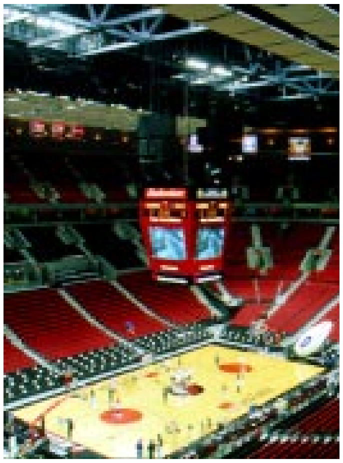
Today, Virtual Array loudspeaker systems set the world standard for arrayability, intelligibility and consistent, accurate, predictable performance. The ongoing Performance Engineering process has produced a variety of systems, each designed for a specific range of applications.

The MH Series

The Purest Expression of VA Technology

EAW's MH Series of mid/high frequency VA modules is engineered solely for optimized performance in permanent installations. Portability played no part in its design. Despite the fact that the systems need only cover midbass and high frequencies (no lower than 120 Hz), both the midbass and high frequency horn flares have been allowed to expand in both the vertical and horizontal planes. With these large horn flares,

MH and BV systems create a large format array in Trinity Pentacostal Church, Lubbock, TX.



MH systems provide accurate, broadband pattern control for large installations like Key Arena, Seattle,WA.

directivity and smooth power response are controlled to a lower frequency. LF and sub-bass output is provided by SB, BH, BV or TD Series systems. Sound system designers use these systems to create precision arrays for arenas, stadiums, theme parks or any large space where oratory or musical performance is given.

In the AS Series, horn flares developed for MH or KF Series systems are combined with vented LF systems. EAW's proprietary Application/Engineering process develops loudspeaker systems that are tailored to the requirements of specific projects such as Coors Field in Denver or Anaheim Stadium in southern California.

MH Series:A Pure Expression of VA Technology

The architectural and acoustical requirements of large scale applications demand loudspeaker systems that produce consistent dispersion across a wide operating band. EAW's MH se-ries of Virtual Array mid/high systems provide the predictable directivity sound system designers need to fill large spaces with high-im-pact, high-definition sound and successfully deal with challenging acoustical environments. For ex-ample, the notoriously hostile Crystal Cathe-dral in Walnut Grove, CA (which has proven more than one sound system inadequate) was tamed by a system incorporating Virtual Array Technology in the form of MH and BV products as well as KF systems.

The MH series embodies the purest expres-sion of VA Technology. Issues of portability and, to an extent, enclosure size are secondary to each system's performance alone and in combination. 10- or 12-in cones loaded with our signature midbass horn and 2-in exit compression drivers loaded in constant directivity horns provide high power handling and efficient transfer of acoustical energy in a variety of coverage patterns. Appropriate BV, BH, SB or TD Series low frequency or sub bass systems extend frequency response to the lowest musical octaves.

EAW Technologies Applied in the MH Series

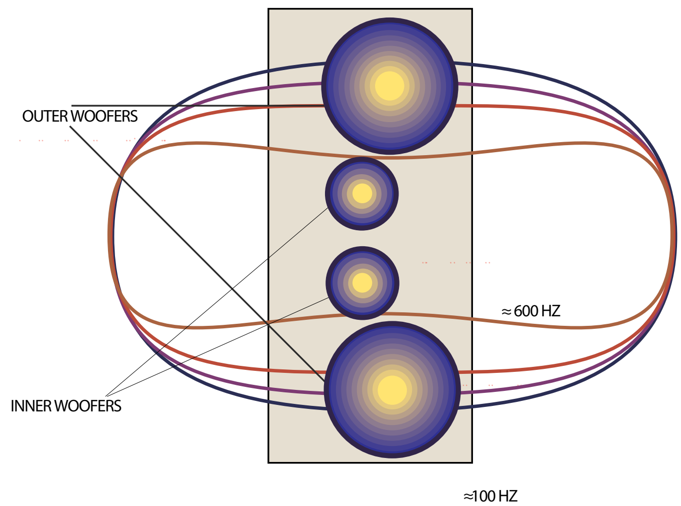
- Midbass Horn
- Undercut Throat
- Asymmetrical Crossover/Filter Network
- CCEP/CCNP

TD Series

Dedicated Low Freqeuny Pattern Control

Low frequencies are difficult to control due to the long wave-lengths involved. But inventor Craig Janssen has found a solution in the Tuned Dipolar Array (TDA). Janssen, a consultant with Acoustic Dimensions, has applied for a patent on the technology, and licensed it exclusively to Eastern Acoustic Works. In keeping with Kenton Forsythe's saying, "No one can repeal the laws of physics. The challenge is to make them work for you," the Tuned Dpolar Array uses well known interference principles to create a directional low frequency source.

In EAW's TD Series systems, two pairs of woofers are used. The distance between each pair is calculated to produce a figure eight polar pattern, with cancellation on the axis between centers, at a certain frequency. Below this frequency, which occurs when the distance between the woofers is equal to 1/2 wavelength, the pattern gradually changes to omnidirectional: when the distance between cones equals 1/4 wave-length, they combine acoustically and act as a single point source. Crossover filters allow each woofer pair to operate only in the transition region between omni-directional radiation and the fig-ure-eight pattern. For the outside pair, this occurs at lower frequen-cies than the inside pair, which are closer together. The overall effect of this design is approximately 10 dB of attenuation along the axis between cone centers, occurring over a broad 2 1/2 octave range. Additional woofer pairs can be used to further extend the TDA's effective operating band. Multiple TDA's can provide pattern control in two dimensions at once.



This graphic illustrates how a TDA's vertical coverage pattern narrows as frequency increases.The signal crosses over from the outer to the inner pair of drivers as the directivity becomes too pronounced.

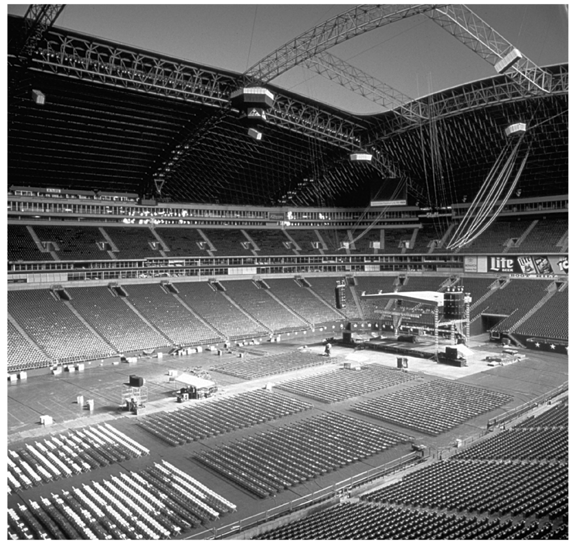
Stadium Array Series

Built to Withstand the Hardships of Life on the Road

Stadium Array systems are not just for touring. Mayday used several KF and SB Series systems (including 100 SB528s) for one of this rave held in a German sports arena.

The breeding ground for VA Technology is the highly competitive, rapidly evolving business of touring sound reinforcement. The worldwide acceptance of EAW's Stadium Array Series is proof of the superior ability of Virtual Array design techniques to meet the specific needs of touring sound companies. For this application, road-worthy construction and efficient truck packing are critical design criteria. Making the systems easy to work with means ergonomically engineering the placement of handles and casters; making them safe means creating load-rated, all metal flying systems.

The Stadium Array Series is continuously evolving to ensure that audio professionals have the most up-to-date tools for creating precision arrays for any audience configuration. The three-way, full-range KF850 is the basic building block of sound systems for audiences up to 8,000. KF853/BH853 mid/high and low frequency systems provide true long throw coverage for au-diences of 100,000 or more (as at Pocahontas: The Premiere in the Park in June 1995). Their tight pattern control can also help tame acoustically difficult venues. SB850 and SB1000 subwoofers are designed to integrate with these full frequency systems,extending output into the lowest musical octaves.



KF853s at the 1995 Promise Keeper's Gathering,Irving,TX. Long-throw capabilities reached the back of the stadium.

KF853:ATrue LongThrow System

The KF853/BH853 system — the newest addition to EAW's Stadium Array Series — is a true long-throw loudspeaker. The KF853's 40° x 30° dispersion pattern is consistent to 700 Hz, allowing for accurate dispersion and flat response at distances of 200 feet or more. The BH853 dedicated bass system loads dual 15-in drivers in large horns constructed using EAW's proprietary technique for exceptionally "tight" bass response at "long-throw" distance, not just an indistinct LF fog.

Front-of-House engineers for world class touring acts have reported that with this system, the sound is "right there" or "in your face" at the back of the biggest arenas like Texas Stadium (above). With this level of consistent directivity, they are capable of taming such hostile environments such as the Royal Albert Hall.

To control the complex interaction between the mid/high and bass systems, passive filters are required in addition to MX series processors which have been custom configured to integrate the KF and BH systems.

KF853/BH853 AppliedTechnologies:

- Midbass Horn
- UndercutThroat Horn
- CCEP/CCNP
- Asymmetrical Crossover/Filter Network

Thanks toVirutal Line Array Technology, spill from the sound reinforcement system into the televised feed was not an issue at the 1996 Grammy Awards,a first for that event.

Virtual Line Array Technology

The KF860 embodies a new approach to sound reinforcement that extends Virtual Array Technology in a new direction. Virtual Line Array Technology solves the acoustical problems of events which have both live and broadcast audiences. The conflicting requirements of these events include high SPLs and full bandwidth reproduction for the live audience; minimal "spill" onto the stage and into micro-phones; and unrestricted sightlines for television cameras.

This complex technology requires a high level of expertise in order to adapt and use it properly. EAW works actively with application partners to develop the required knowledge base and complementary technology.

A Virtual Line Array is designed as a single functional and acoustical unit composed of multiple "building blocks," the KF860 and KF861 Virtual Line Array Modules. The minimum operational Virtual Line Array consists of three KF860/ KF861s. The recomended minimum configuration is four.

The KF860 provides fixed horizontal pattern control of 60° and the KF861, optimized for nearfield coverage, 90°. Dispersion is consistent down to 300 Hz, due to the horizontal spacing of the midbass cone drivers. The vertical pattern is variable and can be controlled by changing the number of elements within the array as well as the angular relationship and physical spacing between the array elements. Digital Signal Processing (DSP) is an integral part of Virtual Line Array Technology: the techniques used to create consistent wideband vertical pattern control depend on the proper integration of DSP units.

Wideband Directivity

The goal of Virtual Line Array Technology is one that sound system designers have pursued for years without success: to extend consistent directivity downward into the bass region. The lengths of low frequency sound waves (around 22.6 feet at 50 Hz) make horns impractical for this purpose even in permanent installations. Line or ring arrays have proved difficult to control and optimize.

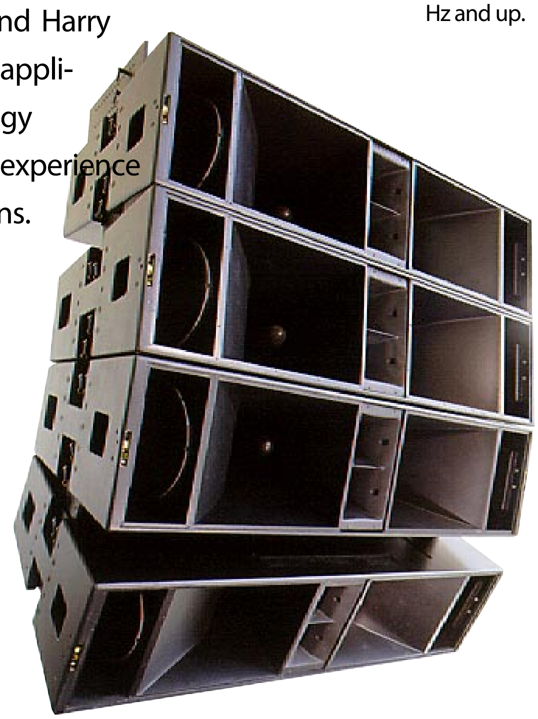
Applying the Tuned Dipolar Array concept (see page 12, above), EAW engineers realized that the low and mid frequency bands in a three-way system could be further subdivided at critical points and distributed to separate drivers. If these drivers were phase and time aligned, then the size of the entire array would define the maximum wavelength that can be effectively controlled. Signal processing of this complexity can only be implemented in the digital domain.

In order to achieve precise, repeatable results, the spatial relationship between the drivers, waveguides and enclosures must also be precise and repeatable: thus a new type of rigging hardware would become an integral compo-nent of the design solution.

Tailoring a Virtual Line Array to a given venue and/or application requires a knowledgeable designer to select the number of array modules and their angular relationships. These in turn determine the selection of crossover points within the low and mid frequency bands.

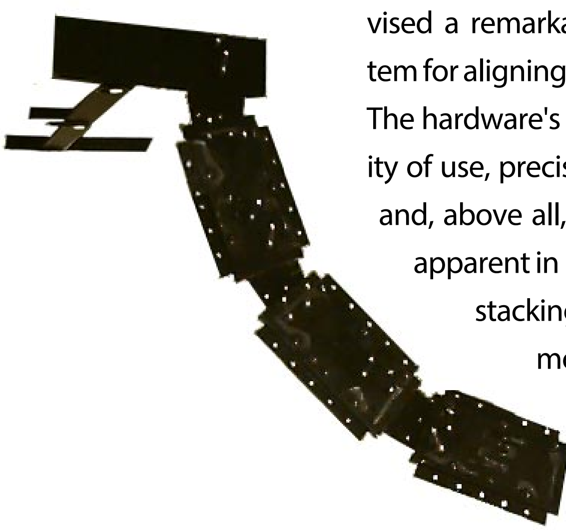
The theory is well understood, since it is based on acoustical phenomena identified by pioneers such as Leo Beranek and Harry Olsen. However, reliable application of VLA Technology requires considerable experience in real world applications.

Complex digital signal processing integrates Virtual Line Array modules into a single acoustical unit. By optimizing Tuned Dipolar Array effects, an array of four modules exhibits off-axis rejection of 10 dB down at 90° off-axis, 100 Hz and up.



Unique Rigging Hardware

Flat steel tubing built into the VLA module enclosures provides the precise, repeatable rigging required by VLAs. Steel plates attach the enclosures together and to the specially designed fly bar. The added strength of steel allows arrays as large as 12 modules to be safely flown.



Precise alignment of VLA modules being critical to the successful application of the technology, EAW engineer Andrew Rutkin has devised a remarkable hardware system for aligning Virtual Line Arrays. The hardware's speed and simplicity of use, precision, repeatability and, above all, safety are equally apparent in hanging or ground stacking arrays of VLA modules.

The VLA hardware system supports the array using a structure of flat 3/16-in steel tubing. The tubes are linked to form a continuous steel-to-steel structure via 1/2-in thick steel plates and quick-release stainless-steel pins. The system allows array modules to be configured in six different spatial relationaships.

For an array of twelve enclosures (a truly massive beast), the the safety rating of VLA hardware is greater than 10:1, or double the industry minimum. For arrays of four, the rating is greater than 25:1. These ratings are achieved despite the 355 lb. weight of the speaker systems because the enclosures bear none of the weight of the hung array. Instead, the rigging system creates an unseen steel frame from which the enclosures themselves hang. In fact, one could hang an array and then completely remove the enclosures (destroying them in the process); the steel skeleton would remain intact.

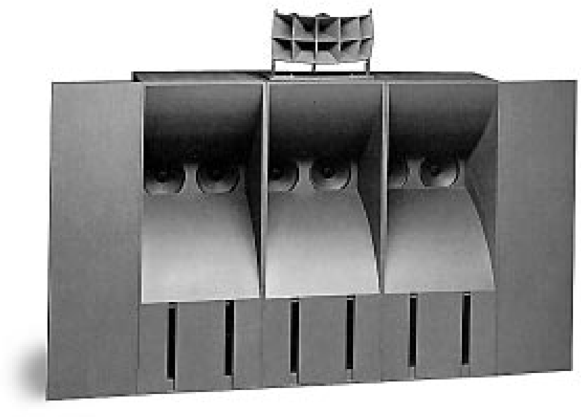
Horns and Waveguides

A Very Brief Primer

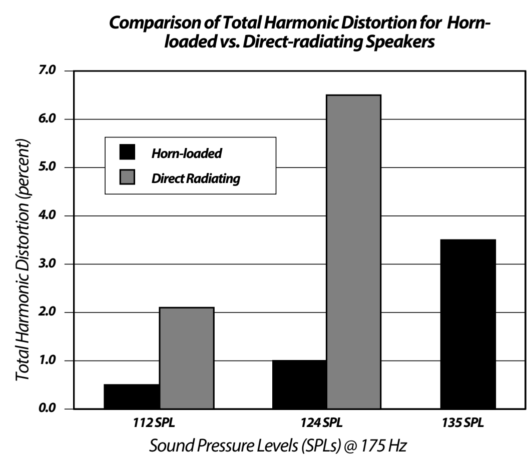
The efficiency of any transducer can be improved when it is coupled to the air with a horn as opposed to being allowed to radiate directly. In the 1930s, horns were used as impedance matching devices (acoustical transformers) because they could increase the amount of air a driver and amplifier could move, often by several orders of magnitude. Because the power amplifiers of the day were weak by modern standards, increasing the driver's efficiency was absolutely mandatory.

As amplifiers became significantly more powerful in the 1960s, the efficiency-improving benefits of horn loading became less important than a horn's ability to direct the driver's output to a given area. It was at this time that the distinction between horns (impedance matchers) and waveguides (sound directors) was first made. The distinction, which depends on the primary function of the item, is more semantic than practical; either will, to a certain extent, achieve both aims.

A "classic" design circa 1940. Multiple cells are employed to maximize driver efficiency.



This graph shows the comparison of Total Harmonic Distortion for horn-loaded as compared to direct-radiating loudspeaker systems.



The compact KF300 employs both midbass and constant directivity horn technologies.

Bass Horn Technology

A horn will be effective in any given frequency range depending on the size of its aperture and the rate of its flare. Because wavelengths in the lower octaves are so large (about 22.6 ft at 50 Hz), the construction of practical, portable bass horns is a challenge that has gone largely unmet by the acoustical community.

Why Folded Horns Fail

One solution that was developed to cut the LF horn down to a manageable size was to fold the horn in on itself. The idea was that by collapsing the horn while maintaining the overall length of the path, the size of a functional LF horn could be cut in half.

While this did, in fact, decrease the size of the enclosure, it created two other problems. First, fabricating a folded horn with a curved flare proved economically and logistically impractical. The solution employed by many manufacturers — straight-line, angled horns — failed to provide the mathematical accuracy and resulting flat response which Kenton Forsythe demanded from his bass horn. Secondly, sound waves above a certain frequency don't "corner" well. The acute angles in the folded horn blocked the coherent expansion of these frequencies, creating audible distortion and limiting the horn's effective range. Furthermore, some waves would simply reflect back into the driver, producing phase anomalies and de-grading the power response.

The Bent Horn Succeeds

Like virtually all of his innovations, Kenton Forsythe's bent bass horn was the result of approaching the problem without preconceptions. Instead of folding the horn, Kenton bent it into an exponential arc. This maximized the efficient use of space yet presented no impediment to the free expansion of the wavefront. Because he mated a three dimensional horn throat to a completely open horn mouth, the impedance-matching ratio was maximized, therefore maximizing driver efficiency across the system's entire effective range.

Constant Directivity Horns

As dispersion and directivity became the waveguide's primary function, new issues came to light. Most notable was that frequencies in the upper third of a waveguide's intended range of effectiveness "never saw the sides of the horn" and did not expand to fill the flare's dispersion characteristics. Instead, these higher frequencies beamed straight ahead, creating uneven frequency response within the intended coverage area.

The first constant directivity horns featured a narrow aperture (usually around 1 in) and straight sides angled at the horn's intended pattern. They succeeded in dispers-ing the high end, but instead beamed the low end. In response, John Gilliam and Don Keele de-veloped the constant directivity flare which smoothed the direc-tivity across the waveguide's en-tire range.

But their design only affected the vertical plane. For a constant directivity horn to pro-duce separate coverage patterns

EAW systems installed at the Garden State Arts Center, Homedale, NJ.

in the vertical and horizontal planes, the flare for the narrower of the two angles must start farther back, creating a throat section where the wider-angled plane's walls are straight for some period before flaring out rapidly. This is the design Cliff Henrickson and Mark Ureda developed.

As is so often the case, the solution created a new problem. Here, the long throat was resonant at lower frequencies, creating an acoustical anomaly commonly referred to as a "honk." For the typical high frequency horn, this honk appears in the 600 - 800 Hz range where the ear

Renewing Cinema Exhibition's Leadership in Audio Technology

Today's digital sound tracks have a wider dynamic range and require higher fidelity than their analog predecessors. EAW's new Cinema Series offers a flexible line of full-range main systems, full-range surround systems and subwoofers for cinemas of every size and configuration. Every system provides flat, full-range frequency response and consistent, high-impact sound coverage for today's cinema construction and renovation.

Flat, neutral, uncolored response through-out the audible spectrum is the most impor-tant criterion for any loudspeaker, regardless of application. For cinemas, flat response means that low frequency rumbles and explosions will sound massive and ominous, not wimpy or anemic. They'll actually shake the room if that's what they're supposed to do. High frequency effects like gunfire will sound detailed and realistic, never flat, tinny or harsh.

Where once they were only used to produce "ambient" effects, today's surround tracks carry as much program material as the main left, right and center channels. Again, EAW's full-range sur-round systems have the wide frequency response and high power-handling capabilities to meet the challenge.

With EAW systems, sound designers, editors and mixers can create the film's acoustic environment with greater realism than ever. Audio imag-ing technology uses digital sound tracks to pro-vide subtle cues that indicate a sound's direction and distance. But creative audio production is only effective when matched by accurate, natural reproduction. With astonishing accuracy, EAW loudspeakers create a 360° aural arena that gives the audience every bit of the magic the director set out to create.

is most sensitive to acoustical anomalies of any kind. The result is speech which sounds as if it is coming through a megaphone, which in a sense it is. Radical equalization using both passive filters and active filters proved ineffective in solving the problem, which is caused by cancellations in the throat section of the horn.

EAW's Curved-Faced Waveguide

EAW Senior Engineer David Gunness, one of the industry's leading experts on the mathematics of horn flares, has developed a workable solution to the problem of throat resonance in constant directivity horns. Rather than have the two different flares start at different points and terminate together, he simply let them start at the same point (at the driver) and terminate where they would. Because the wider flare (typically for the horizontal plane) expands more rapidly, it ends sooner. To smooth the edges between the sides and the top and bottom, Dave curved the face, cre-ating an entire new class of constant directivity horns. Because the wider flare does not "wait" to develop, the throat section is cut by nearly half. This moves any resonance out of the problem frequency range, dramatically im-proving the naturalness of speech. To date, this new technol-ogy is only available in EAW's large-format CB2590 cinema stage sys-tem, for which it was originally de-veloped. Under the guidance of Dave Gunness and Kenton Forsythe, EAW engineers are ex-amining the new horn's applicabil-ity to other system.

The large format curved-face horn designed by EAW Senior Engineer David Gunness, one of the leading experts on the mathematics of horn flares, resolved many of the problems of previous constant directivity horn designs. The book (12 inches tall) provides scale.

Undercut Horn Throat/Collapsible Mold

The Henrickson/Ureda constant directivity horn design has another limitation: the size of the driver that can be loaded is limited by the size of the horn throat. Since the typical throat was 1 inch, only 1-in compression drivers could be loaded. Larger horns with larger throat apertures only reintroduced the uneven pattern control problems which the constant directivity horn sought to resolve. To enable the loading of larger drivers, the undercut horn throat was developed. Here, one of the planes is allowed to open slowly while the other, usually the vertical plane, actually decreases in size

JF560: Maximum Power from a Compact Enclosure

An excellent example of appropriate use of an undercut throat horn can be found in EAW's JF560 full-range loudspeaker system. Among the defining requirements of the JF two-way series are high power handling and compact size. In addition, the JF560 required a tightly controlled 60° x 45° dispersion pattern.

To create a system that can handle the substantial amplifier power typical of professional ap-plications without sacrificing smooth power re-sponse to the two-way design, it was determined that the optimum HF subsystem was a 2-in exit compression driver loaded in a constant direc-tivity waveguide. The CD5001 was selected for its wide range frequency response and excellent characteristics when driven at high volume.

The optimum throat aperture (or slot) for the given dispersion pattern in the HF bandwidth was 1 inch. To load a 2-in exit driver with a 1-in aperture CD horn, the flare of one of the planes (in this case the vertical) must decrease from 2 inches to one before the flare again expands. This is the definition of an undercut throat horn. It permits the loading of large diaphragm compression driv-ers with a CD horn flare. This permits systems that are more efficient, more sensitive, can handle more power and are less prone to distortion.

JF560 applied technologies:

- Undercut throat horn
- Passive crossover/ network
- CCEP

down to the aperture. The decreasing flare is referred to as the undercut or reverse draft portion of the horn. The undercut throat horn allows a horn with a 1-in aperture to load a 2-in compression driver. The larger driver enjoys the same impedance-matching effects of the horn, and thus efficiency is greatly increased.

This cutaway view illustrates the "reverse draft" or "undercut" portion of the horn throat.

The Acoustical Solution Presents Manufacturing Problems

While this solution presented no major acoustical dilemas, it did prove difficult to manufacture. Because horns are molded, a mold had to be developed that was able to release from the undercut throat section. This proved difficult because no matter which end the mold was drawn out through (front or back), one of the flares was decreasing and preventing the mold from being withdrawn.

One solution was to cast the throat section of the horn in two parts which join longitudinally, and then mold the flare around them. In addition to being far more costly, this process leaves a seam down the middle of the throat. The seam can cause imperfect interaction between the halves and produce driver loading problems.

The EAW solution was to develop a fully collapsible mold that would enable the efficient, cost effective manufacture of a one piece, undercut throat horn. This mold collapses in both the horizontal and vertical planes to a size small enough that it is easily withdrawn from the molded horn.

The FL103 began as an Application/Engineering project for l'Opera de Lyon.The application --"lifting" the soloist over the orchestra -- required absolute fidelity, low "Q" and very high output.

FL103: High Definition/High Output/Low "Q"

The first prototype that evolved into the FL103 was originally designed to "lift" soloists over the orchestra and chorus at l'Opera De Lyon in France. While the system would need enough power to fill the expanded hall, the Opéra's musical director was adamant that it sound completely natural. To create a low "Q" system that would reliably handle large amounts of amplifier power, EAW engineers loaded a powerful 2-in diaphragm compression driver with the "wide by wide" Wave Guide Plate™. This allowed for wide dispersion of HF energy and smooth power response.

Another important innovation in the FL103 is its vented midrange subsystem. The port func-tions like any port - its resonance acts instead of the cone at certain frequencies. The FL103's port is tuned just above the LF/MF crossover point. Frequencies in this range place strain on the MF driver, producing distortion and limiting power handling. But since the port is tuned at these frequencies, it does most of the work instead of the driver. The crossover frequency can be lowered, allowing better integration of the midrange and woofer. Ultimately, this creates a system that handles more power while producing less distortion.

Like other EAW enclosures, the FL103 is built from 18-ply-to-the-inch, cross grain laminated Bal-tic birch. It has the same heavy duty handles, vinyl coated steel grill and Speakon connectors as our other systems. The crossover is switchable: bi-amp/passive. MX200i and MX300i configurations are available for the FL103 bi-amped or tri-amped with subwoofers. Hang points and a stand mount are standard, allowing the FL103 to be used for portable applications as well as installations.

FL103 Applied Technologies:

- WGP
- Asymmetrical Crossover/Network Filter
- CCEP/CCNP

Shallow Waveguides

EAW loudspeakers optimized for use in single unit configurations require wide dispersion of high frequencies. To satisfy these needs, EAW developed specialized waveguides to effectively disperse HF sounds over wide areas. For an aperture/flare type HF horn to achieve the particularly wide dispersion patterns required, it must grow to an unmanageable size. EAW engineers removed the throat section entirely, placing the

LA325: The Next Step in Performance Audio

Until recently, the choice for band PA was limited to professional equipment that was too big and too expensive or PAs that didn't perform. Almost anybody who's ever been in a band or heard a friend's band perform is familiar with the result of the latter: live sound that seems to suck the life out of the performance.

For the vast majority of bands that work every weekend in nightclubs around the world, smooth power response and consistent dispersion are as important as high power handling. To produce the LA325 full-range system's exceptionally smooth power response, EAW engineers loaded a 2-in compression driver with the new Elliptic Conical Waveguide. The ECW's 70 x 90° dispersion pattern covers a wide audience area with high-impact, high-definition sound. Because the ECW loads a large diaphragm compression driver, HF distortion is minimized, even at live performance volume.

Another chronic problem working bands have had to contend with is vocals rendered unintelligble by the PA system. Much of the fault for this can be laid on 2-way loudspeaker designs which ask both the HF and LF subsystems to reproduce a wider range of frequencies than they should. The result is distortion in the crossover transition range. And since the crossover for 2-way systems inevitably falls in the human vocal range, the vocalist pays the price. The LA325 is a 3-way system with a dedicated midrange subsystem covering the entire vocal range. Dual 6.5-in cone drivers are mounted in a separate subenclosure for optimized midband fidelity.

Finally, the LA325's internal passive network is more massive and complex than an ordinary PA's simple crossover. Precise equalization is tailored to the acoustical repsonse of the drivers and enclosure in order to achieve flat on-axis response and optimized power response.

LA325 Applied Technologies:

- Elliptic Conical Waveguide
- Asymmetrical Crossover/Filter Network
- CCEP

WGP™ technology provides wide-by-wide dispersion of high frequency energy. Some versions load mighty 2-in compression drivers.WGP is specified on many EAW systems optimized for nearfield coverage.

driver right at the mouth. Waveguides with "wide by wide" dispersion characteristics could then effectively handle frequencies up to and above 15 kHz.

Wave Guide Plate

The WGP (Wave Guide Plate) is a very shallow waveguide which employs an axis-symmetrical, constant directivity flare to achieve a 100 x 100° dispersion pattern. EAW currently specifies the WGP for use on a wide variety of nearfield systems such as the MM and JF series.

While other manufacturers have loaded dome tweeters with shallow waveguides, EAW is the first to load a high power 2-in compression driver with such a device.

Elliptic Conical Waveguide

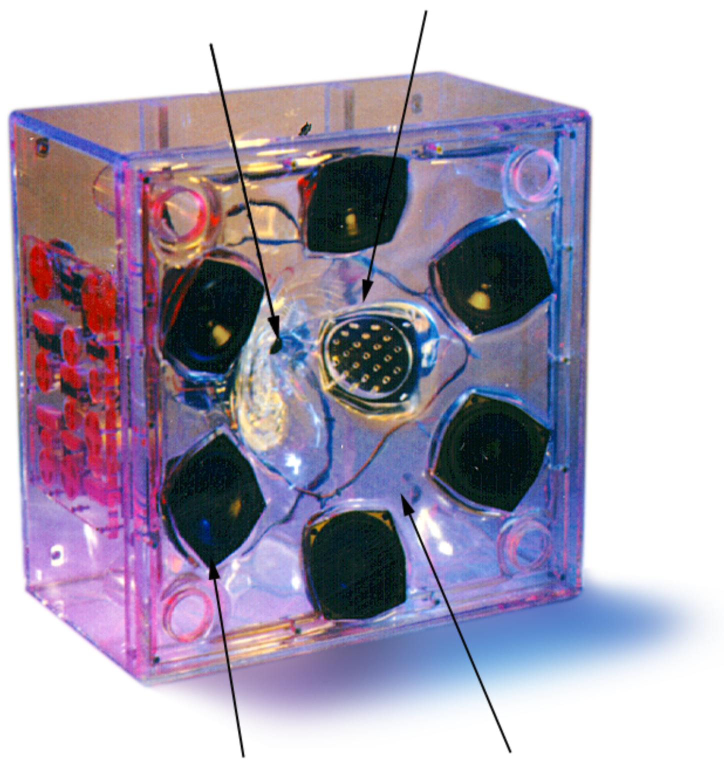
For applications that require a wide asymmetrical dispersion pattern, such as small venue live performance, the Elliptic Conical Waveguide offers an optimized solution. Like its cousin, the WGP, the ECW is exceptionally shallow. It produces a 70° x 90° disper-sion pattern. The ECW is cur-rently used on the LA325 Perfor-mance Audio full-range system.

For this full range monitoring application, Hootie and the Blowfish drummer Jim Sonefeld turns his LA325's Elliptic Conical Waveguide to disperse vertically.

Concentric Phase Aligned Array

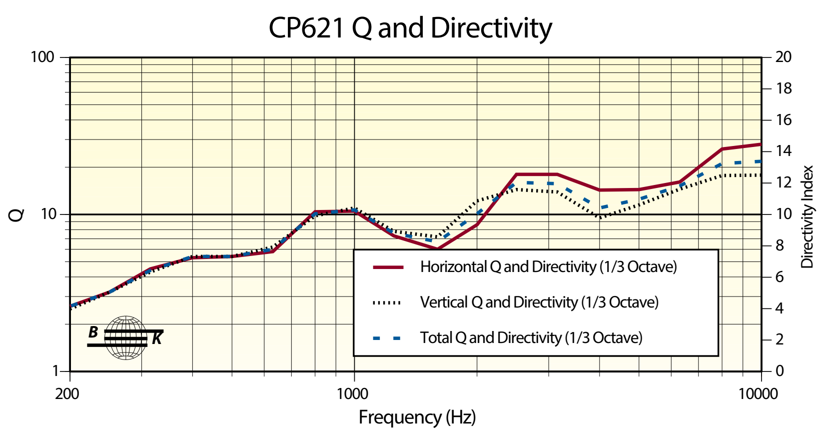
Developed in cooperation with Stephen Siegel of Acentech, the CP621 is purpose-engineered for large public spaces. Initial exploratory work on some of the approaches used in CPAA Technology was done in the 1970's by David W. Robb, Director of Electro-Acoustic Design with Jaffe, Holden, Scarbrough Acoustics, Inc. But it was Siegel, a Cambridge, Massachusetts-based acoustical consultant, who defined the problem and the parameters of the solution: a symmetrical coverage device with consistent, wideband pattern control that could be installed easily in standard 24-inch or 600 mm ceiling grids.

To develop the solution, EAW Engineering turned the conventional coaxial concept inside out. Typical coaxial systems consist of a large cone woofer surrounding a compression driver and a small horn flare. The CPAA takes the opposite approach: a large axis-symmetrical horn flare surrounds the low frequency section, which consists of a number of smaller cone



CP621s installed at the new Baltimore Convention Center.

This Q and Directivity chart illustrates the CP621's superior performance. Directivity and power response (not shown) are consistent across the frequency spectrum.



transducers mounted within the flare.

The advantages of this design are many: the larger horn mouth opening extends the range of consistent pattern control downward by an octave compared to ordinary coaxial horns. Meanwhile, the multiple woofers mounted around the circumference couple acoustically and provide the effective radiating surface of a 21" woofer. This large effective diameter enhances directivity in the lower octaves. To smooth response in the crossover region, two additional woofers are mounted within the horn throat. They are phase aligned with the circumferential drivers to cancel reflections from the horn throat. Because their output is coupled to the horn, they have enhanced directivity and also serve to alleviate lobing near the crossover frequency.

The results as measured in EAW's automated test facility are clearly superior to conventional coaxial designs in consistent directivity over a wide bandwidth. The symmetrical 60° x 60° dispersion provides consistent coverage when installed in square ceiling grids. The system is designed for easy installation above these grids: grills can be customized to provide an attractive finished installation.

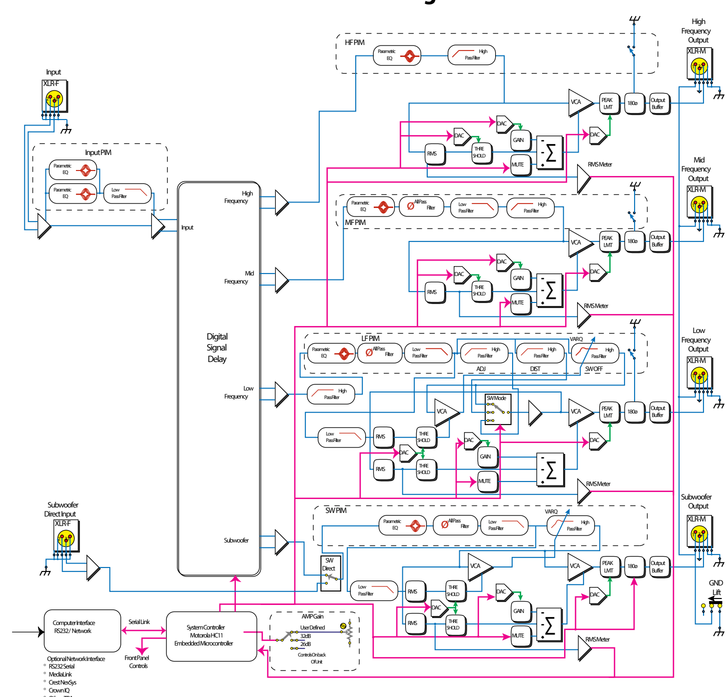
Cross Platform Technologies

Close Coupled™ Processing

Ultimately, the degree to which critical signal parameters can be controlled defines how well a given system or array performs. To optimize total system performance, EAW has developed Close Coupled Electronic Processors™, Close Coupled Network Processors™ and digital interface software that offers a prototype of the audio control surface of the future. Close Coupling is a process by which the processors are custom configured for specific loudspeaker systems or combinations. The long range goal of R&D in Close Coupled Processing is to create signal processors that integrate systems into arrays with the same degree of precision that today's crossovers integrate the separate subsystems within a multi-way loudspeaker system.

The EAW engineering team began the development process that yielded the MX Series of Close Coupled Processors with the recognition that the total loud

MX8000 Block Diagram



Signal processing block diagram for an MX800i Close Coupled Electronic Processor.

speaker system encompasses internal passive electrical networks and acoustical filters in addition to transducers, waveguides and enclo-sure. They integrated external active electronics into this com-plete system to optimize its acous-tic transfer function. Since MX se-ries processors do not rely on dynamic effects to disguise the limitations inherent in a given loud-speaker system's electro-mechanical design, they do not change the loudspeaker's tonal bal-ance or power response at high volumes.

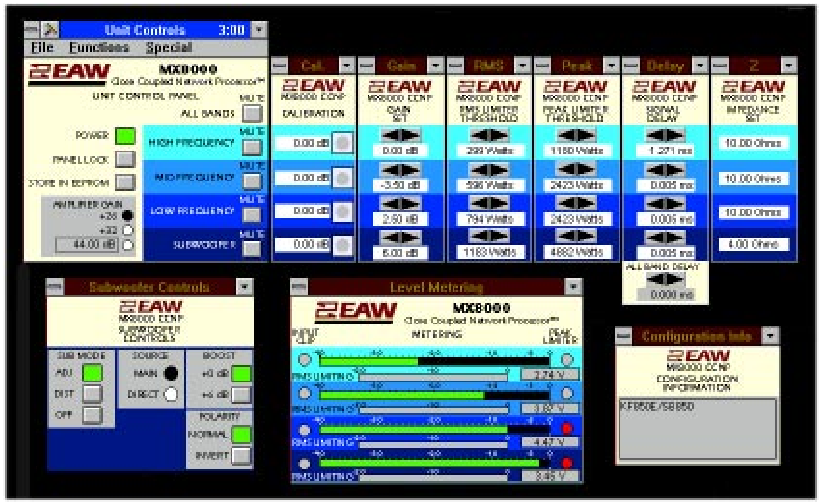
By incorporating active electronic processing into the loudspeaker system, the MX Series offers end users a higher degree of performance than was heretofore available. Close Coupled Electronic Processors™ (CCEP™) control a range of critical parameters including low frequency driver excursion, amplifier clipping protection limiting, phase compensation and individual asymmetrical filters for each frequency band. The line of CCEPs include the two-way, two-channel MX100 dedicated subwoofer crossover, the MX200i (two-way, two-channel) the MX300i (three-way, two-channel) and the four-way, two channel MX800i processor.

The MX Series of Close Coupled Processors. (from top) MX100, MX200i, MX300i, MX800i and MX8000.

The Future of Signal Processing

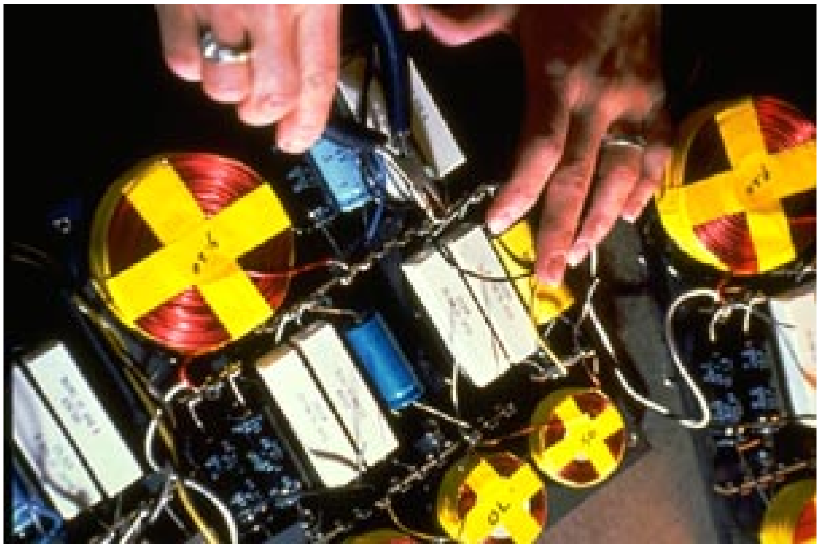
The MX8000 Close Coupled Network Processor™ (CCNP™) is the first device that extends the emerging audio control network to the end of the signal chain: the loudspeaker system. In addition to the parameters controlled by CCEPs, the MX8000 offers extremely fine resolution digital delay for each of the four frequency bands to achieve coherent signal arrival time (within a fraction of an inch) from variously placed speaker systems in an array. The delay lines can also be adjusted as a group to synchronize arrival times from remotely located speaker systems.

In addition, the MX8000 and associated user interface software offers designers and operators a prototype of the integrated audio control surface of the future. Multi-level password security protection allows any level of access from zero (front panel rendered inoperative) through full adjustment of all remotely addressable parameters.



The MX8000's digital interface offers a prototype of the audio control surface of the future.

Unlike digital signal processors, the MX8000 does not permit adjustment of crossover points. EAW engineers have designed complex, system-specific internal passive networks to control the interaction of the drivers within a single loudspeaker system. Any additional external processing which would alter this delicate balance is more likely to degrade than enhance sound quality by creating phase anomalies and uneven acoustical summation in the transition area. To achieve positive results from "on the fly" adjustments to crossover points, sophisticated system response testing equipment would be required.



To minimize distortion, our crossover/filter networks are built up from top-quality components, hand-soldered and epoxy-mounted to the same Baltic birch that makes up our enclosures.

Asymmetrical Crossover/Filter Design

Crossover design is critical to loudspeaker performance. But many loudspeaker manufacturers design crossovers within narrow guidelines of price or performance and expect the end user to equalize the system to compensate for the its built-in failures. This is not the EAW way. We don't expect system operators to make our speakers sound great; we design them to sound great right out of the box.

The Iterative Process

To do this, EAW has invested substantially in the human and technological resources necessary to create passive crossover networks that optimize total system performance. Kenton Forsythe insists that his team of engineers use the time consuming, but superior, iterative process of development.

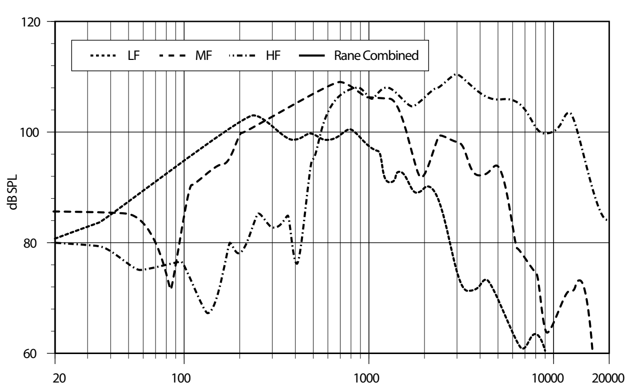
An iterative processes repeats a cycle of operations, beginning each new cycle with the results of the previous cycle. With each cycle (iteration) the actual result is brought closer and closer to the "ideal" or "model" result. In the case of an EAW loudspeaker system, the ideal result is perfectly flat on-axis response and perfectly linear power response. Of course, perfection cannot be achieved, only approached.

Accurate Data Yield a Superior Filter Network

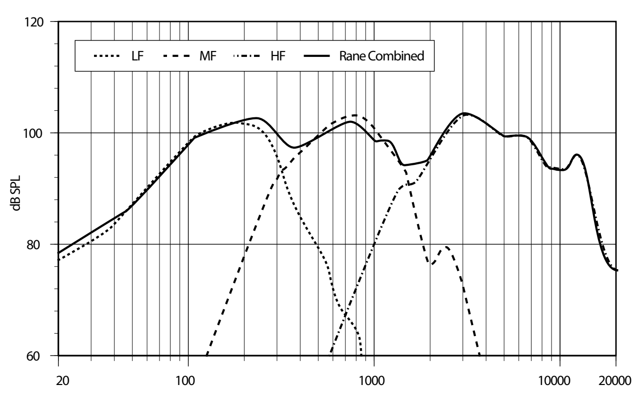
To properly use the iterative method to design crossovers, absolutely accurate data on raw system response must be obtained because all future decisions are based on this starting point.

Unfortunately, manufacturers who cut corners simply use a mathematical abstractions to design "electrically correct" filter networks. Those designs may look fine on paper, but power response in the real world will inevitably be uneven. This is because actual transducers do not behave like mathematical abstractions and each enclosure design has its own unique "hot spot" resonances.

To optimize power response, a system-specific crossover network must be designed around the actual performance of the raw components and enclosure. Because these networks are not only far more effective than equation-derived designs but far more complex as well, we use proprietary computer software called Filter Designer to help manage the design process. First, the acoustical and electrical response of the raw drivers and enclosure is measured with a multichannel digital FFT analyzer, and the data are fed into Filter Designer's computer model.

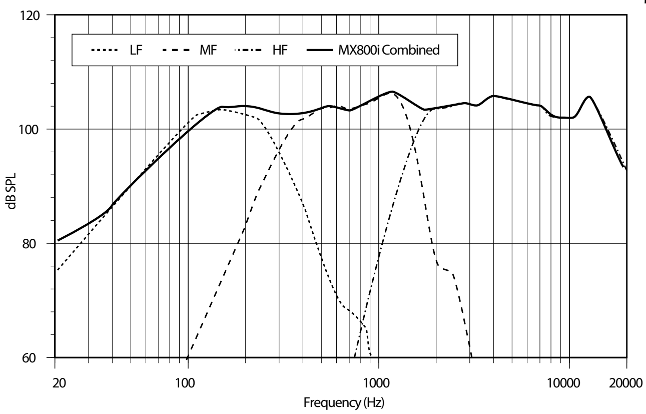


The EAW crossover/filter design process starts with the actual response of the raw drivers and enclosure to ensure total system optimization.



Data from the initial test are fed into proprietary computer software and an "optimal" network is built up.

Based on the data obtained, EAW engineers build an "optimal" network. The system is measured again and the new data are fed back into Filter Designer. The network is refined, iteration after iteration, until total system performance is optimized. The result of this process is a highly complex network of electrical components which can include passive filters and equalization. In almost all cases these passive networks exceed the function of merely dividing the output signal as a simple crossover would.



The system is measured again and the new data help refine the network, iteration after iteration, until total system response is optimized.

It should be noted that not only do we design around actual drivers, but we also take into account variations which occur during component production and use the iterative process to set limits on the variances we will accept. The result are loudspeaker sys-tems that are consistent across production runs.

Optimizing Crossover Points to Suit the Driver

A poorly designed crossover will create audible power response anomalies. But even the best crossover cannot eliminate distortion caused by a driver operating at the extremes of its range. EAW's engineering methods solve both problems by selecting drivers and crossover points that work together to optimize total system performance.

As noted earlier, Kenton Forsythe has focused considerable attention on the 250 Hz - 3 kHz range — the human vocal range where the ear is most sensitive. In the case of two-way systems with crossovers points in this region, the power response anomalies that result from poorly designed crossovers inevitably occur in this frequency range where the ear is most sensitive.

Designing Around the Human Voice

While much of the acoustical energy that creates articulate speech occurs above 1.5 kHz, the vowel sounds that define the timbral quality of a voice occur in the 300 -600Hz range. Designing speaker systems that merely reproduce articulate speech is not acceptable at EAW, where the goal is totally natural reproduction. To achieve this objective, EAW engineers employ true three-way design wherever possible. By providing a separate midrange cone driver to handle nearly the entire vocal range, true three-way systems eliminate the power response anomalies that occur at crossover and reproduce all the subtle characteristics of each individual human voice. An added benefits of three-way systems is that each driver covers a narrower range. This way, distortion, which typically occurs at the extremes of any driver's range, is dramatically reduced. Letting the drivers operate in their respective "comfort zones" also permits higher power handling capabilities.

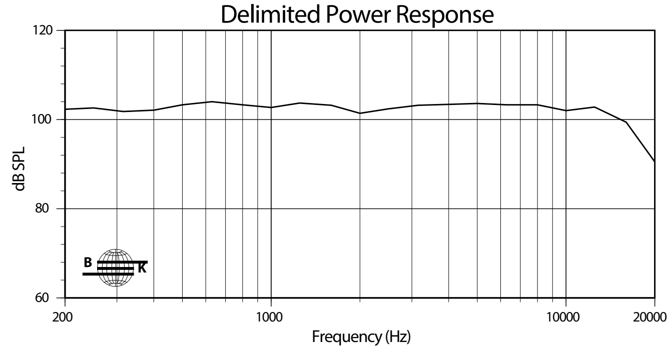
Power Response and How it is Measured

Some speaker systems have outstanding on-axis response, but sound considerably worse from almost any other angle. This is due to uneven power response. Power response is an average of the system's response measured at incremental locations across the entire listening area. EAW engineers Jeff Rocha and Greg Burlingame have developed a com-plex and highly accurate method for determining a speaker's power response, called Beamwidth De-limited Power Response.

Previously, power response was measured by manually moving the measurement microphone across a system's coverage area. Using an RTA in "Forever Averag

Smooth power response indicates that the system provides full frequency response across its entire defined beamwidth.

KF650is with MX300i-653 Beamwidth Delimited Power Response



ing" mode, the power response measurement was partly a function of the length of time the microphone spent in each sector of the coverage area.If the microphone was in one sector longer than another, data from the former would influence the average more than that from the latter.

Another method, more time consuming but more accurate, is to place the system on a turntable and measure response in 5° increments. After one horizontal circle is completed (72 measurements) the system is vertically rotated 5° and 72 more measurements taken in the horizontal plane. This entire cycle is then repeated in 5° vertical increments until a complete

KF650is: Optimized Power Response

While the on-axis response of a particular loudspeaker system may be impressively flat, if that is only the parameter around which the system was designed, its performance in the real world is unlikely to be as impressive. EAW feels that power response, which measures the response of a sys-tem over the full frequency spectrum across the entire coverage area is a more effective param-eter around which to design.

Case in point: the KF650is. This system applies VA design principles to a more compact enclosure designed for portable or permanent applications where maximum output from minium enclosure volume is critical. Like other fullrange KF Series systems, consistent sound qual-ity across the entire coverage area is a critical system parameter. Consistancy must also be maintained across the output range from mini-mum to maximum.

The KF650is integrates advanced horn-loading and waveguide technology with an internal passive filter/equalization network to smooth power response, as the graph at left illustrates. This allows the system to be driven at high levels without creating hot and cold pockets within the listening area.

Should you wish, you may obtain the under-lying measurement data from the APP section of our World Wide Web site and construct the graph yourself.

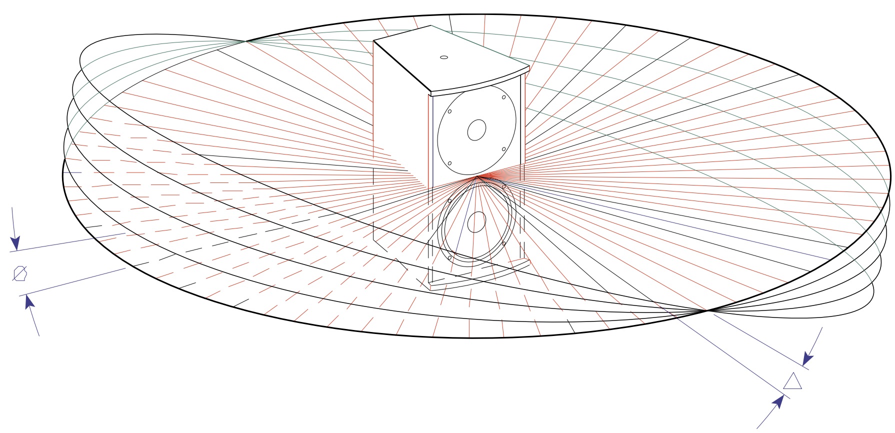
KF650is applied technologies:

- VA technology
- Midbass Horn
- Undercut Throat
- Asymmetrical Crossover/Filter Network
- ARC

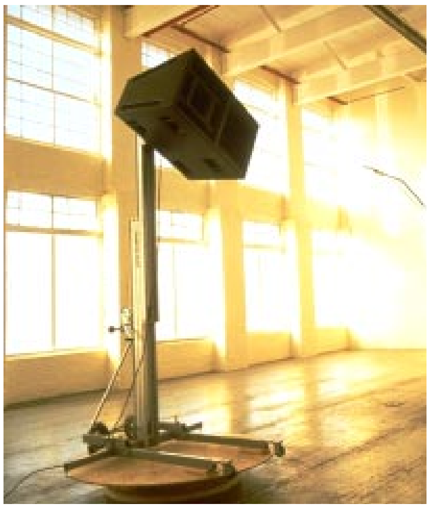
sphere of measurement points is created. The responses are then averaged to produce a power response chart.

While this method produces accurate data at each measurement point, Jeff and Greg were dissatisfied with the method of averaging the data. Like the sectors defined by the longitudes and latitudes of the earth, the sectors near the "equator" of the measurement sphere were much larger than those at the "poles." Thus, there are more measurement points near the poles, and since the poles represented the on-axis position (or 180° opposite on axis), on-axis response carried more weight than the off-axis response which power response is supposed to measure. Their solution was to create a mathematical formula to "weight" each measurement point depending on the size of the sector it represents. This equalized the measurements, returning a more accurate power response measurement. But Jeff and Greg were still dissatisfied. They had devised a method for producing accurate power response information. But they questioned its usefulness in the real world because the system's response outside the intended coverage area carried more weight than the re-sponse inside the coverage area. Again, they created a formula to weight proportionately the measurement points inside the defined coverage area. Finally, they created a system for measuring power response which they felt was both accurate and useful.

To produce a Beamwidth Delimited Power Response curve, a total of 5,184 measurements must be taken. The system is measured on the 0° plane in 5° horizontal increments, then rotated vertically 5° and measured again.



Exhaustive testing in our automated facility led to the development of Acoustic Refraction Control.



ARC ™Acoustic Refraction Control Technology

To create a true three-way system like the KF695 that was manageable in size, efficient use of space was critical. Since the woofer need only handle frequencies up to 250 Hz, we were able to mount the high frequency subsystem within the woofer horn.

Testing in our automated measurement facility revealed that small amounts of energy at the bottom of the HF range were refracting or "wrapping around" the HF waveguide and radiating back down the LF horn. This energy would then reflect off the woofer cone and arrive in the listening area significantly later than the original HF sound, blurring staccato sounds like percussion.

KF850:The World Touring Standard

EAW's KF850 Stadium Array System is the world standard for touring performers. It is accepted in more technical riders than any other loudspeaker on the planet. And for good reason.

Front of House engineers, pressed for time between load-in and sound check or sound check and showtime, appreciate the fact that EAW engineers have created a system that sounds great "out of the box." From complex internal passive filters and ARC™ technology to the unique midbass horn and enclosure construction, every aspect of the system has been optimized.

Other systems can require substantial equalization despite flat on-axis response, because their power response is not equally smooth. Time spent attempting to compensate for uneven power response is time that is unavailable for dealing with the characteristics of the room itself. And it is this fine tuning that can make the difference between a good and a bad night.

With the KF850, flat on axis response and power response are built in, so the engineer can spend his time making a good system sound great, rather than making an average system sound good.

KF850 Applied Technologies:

- Midbass Horn
- ARC
- Asymmetrical Filter/Crossover Network
- CCEP/CCNP

To alleviate this problem, the Acoustic Refraction Control (ARC) device was developed us-ing a proprietary material that would be transparent to low fre-quencies yet absorb high frequen-cies. The ARC is mounted in the woofer cavity directly behind the HF horn. It absorbs the reflected HF sound waves while allowing LF energy to pass through unob-structed. While testing this new system, a fringe benefit to using ARC was discovered. Not only does it absorb refracted HF energy, it also acoustically filters harmonic distortion from the woofer which cannot be eliminated by active or passive crossovers. Again, since all ARC filtering occurs above the LF subsystem crossover, the woofer's intended response is unaffected.

Acoustic Refraction Control is part of the KF850's "E" upgrade.

Ordinarily, wood veneer horns are formed buy using simple circular-section formers.To produce accurate realizations of Kenton Forsythe's unique compound midbass horn flare, EAW uses numerically controlled routers to cut the exponential side flare into the top and bottom of the horn. Wood formers and reinforcing foam complete the structure.

CAD/CAM Agile Manufacturing

Rapid Response to Customer Needs

It is our ability to meet customer needs with specialized designs that has redefined standards of performance in permanently installed systems. EAW employs the latest computer technology not only to design superior loudspeaker systems, but also to fabricate the enclosures with astounding speed, accuracy and repeatability.

Once a custom order is accepted, an EAW engineer's cabinet drawing becomes a prototype that is used as a 'golden reference' piece for product testing, typically in a matter of days, through the use of Computer-Aided-Design/ Computer-Aided-Manufacturing (CAD/CAM). Because we use computer-numerically-controlled (CNC) saws and routers as part of our CAM operations, critical information from our CAD drawings (i.e. dimensions, hole patterns and locations, etc.) is programmed directly into the CNC machines to create the components with maximum efficiency and minimum scrap. Once a prototype is approved for production, the information needed to create as many exact copies as necessary is already stored in digital form.

EAW is looking into the future of automated machining to keep our manufacturing processes as well as our loudspeakers on the cutting edge of technology. By continuously improving every aspect of our operations, EAW can meet the needs and exceed the expectations of an increasingly sophisticated and demanding market, today and tomorrow.