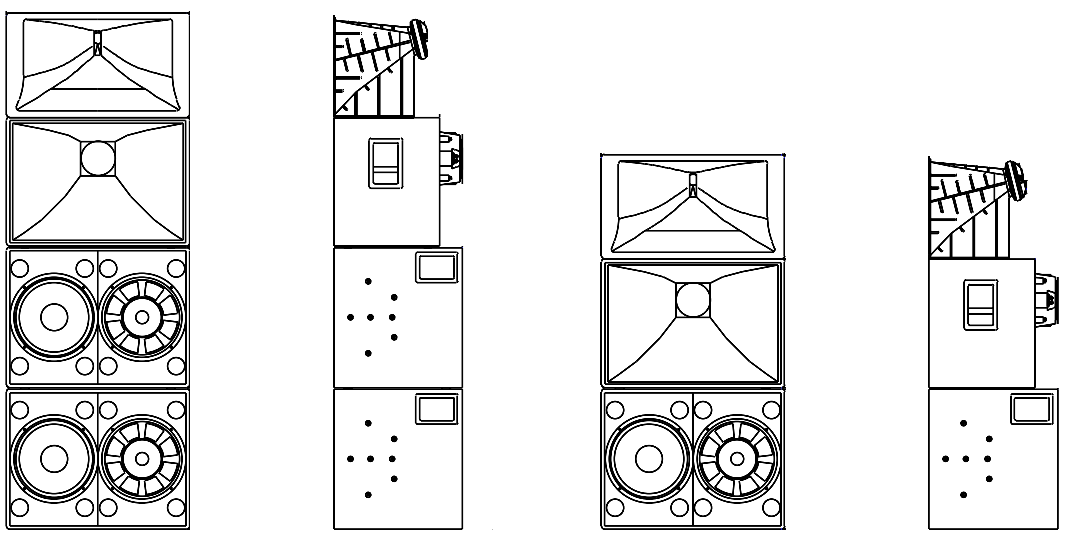
EAW's CSC Series Screen Channel Systems

A Technical Overview



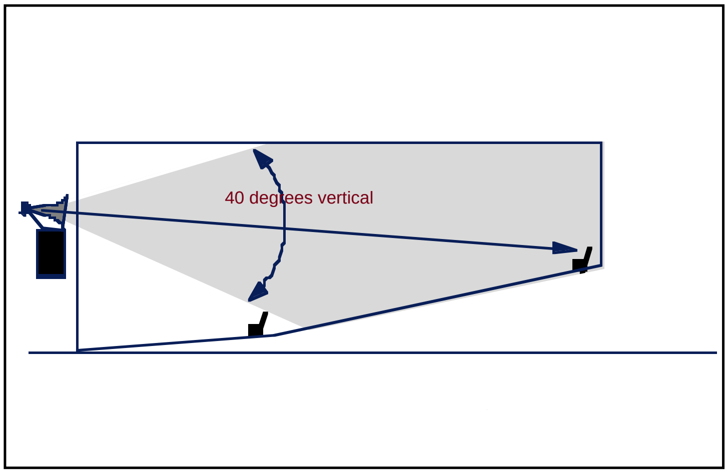
System Overview

The CSC Series three-way screen channel loudspeaker systems from EAW address many issues raised by the changing design trends of modern cinemas. The features and benefits of this product design are manifested in two models at the present time: the CSC923 (and its biamplified version, CSC923X), and the CSC723 (and its biamplified version, CSC723X).

The CSC923 is intended for screen channel use in very large cinemas exceeding 90 feet (27.4 meters) in length from screen to last row. The CSC723 is intended for screen channel use in cinemas up to 90 feet (27.4 meters) in length from screen to last row.

The challenge of coverage in steeply-raked seating areas

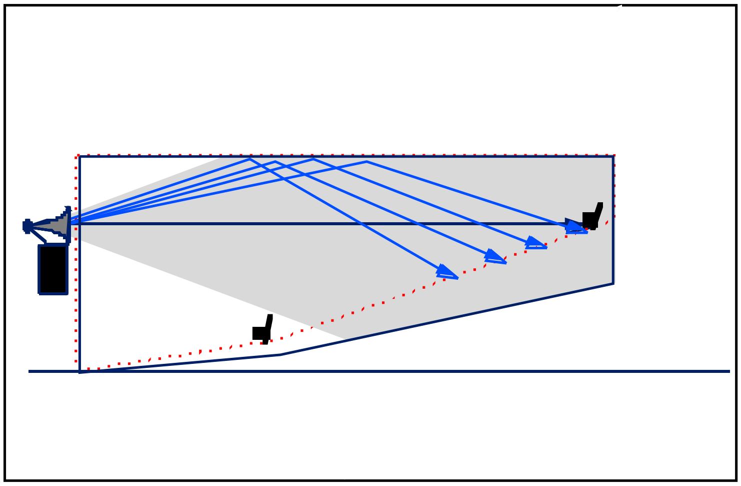
The primary design feature of the CSC Series is its remarkable asymmetrical mid and high frequency horn designs. While the predominant theatre design of new construction sites includes “stadium style” seating plans, loudspeaker manufacturers have only begun to actually adapt speaker designs which attempt to address this room geometry. Although the concept of asymmetrical pattern horns has been in existence for some time, it has only recently surfaced as a viable approach for the specific requirements of cinema sound. The application of this horn design for cinema makes particular sense because we have a known “standard” room dimension proportion (length x width); the most significant variable is scale and floor slope. But, as any loudspeaker designer knows, any change to room geometry changes the coverage you can expect from a given horn design.



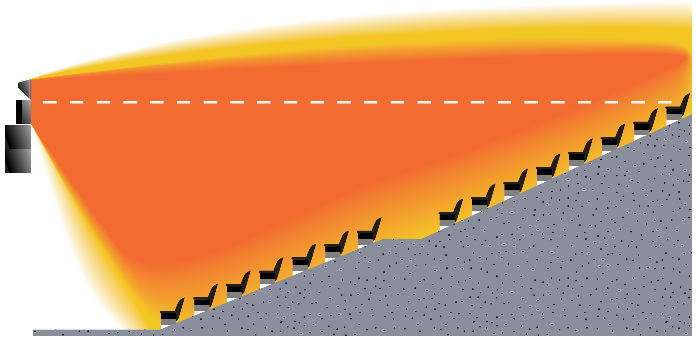
Conventional 90º x 40º constant directivity horns do a good job of providing even coverage for traditional moderate-slope cinemas. The trade-off of on-axis positioning against seating in or out of the horn’s defined coverage pattern results in a fairly even SPL throughout most seating areas.

Once the floor slope is increased, this trade-off becomes off-balance; now the closest seats in front are brought into the coverage pattern. Attempting to aim the horn for even coverage results in making a new trade-off between providing good HF to either the farthest rows or the nearest rows. If the conventional horn is aimed to reach the last rows, HF coverage in the front rows will suffer, and vice versa. Another issue is the energy directed toward the ceiling, now that the conventional horn is aimed upward for the back rows. This is not only wasted energy, but also potentially reflects energy from the ceiling back into the seating area, which could interfere with dialogue intelligibility.

A horn designed to provide an asymmetrical coverage pattern will produce a pattern which projects energy directly on-axis and downward, instead of equal angles above and below its center axis. Thus much of its energy reaches the back rows, while the seating area in front is also still well within the horn’s defined coverage pattern.



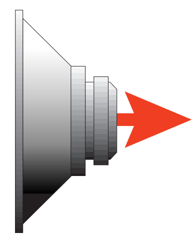
Both the HF and MF horns in the CSC Series feature an asymmetrical shape which produces a coverage pattern which can be described as 80 to 90 degrees horizontally by 50 degrees vertically. The range (80-90 degrees) of the horizontal pattern produces even coverage on the seating area because, to the horn, the seating area appears trapezoidally-shaped. This helps minimize energy directed to the walls of the theatre, and focuses coverage to the audience.



Since the vertical coverage pattern tilts downward, we recommend little or no downward horn aiming. Instead the system is aimed by elevation; the HF horn should be elevated to a height where it is directly in line with the last row of seats. This has been found to provide the best coverage front to back, and significantly simplifies setup and installation by removing the "guesswork" traditionally associated with horn-aiming behind the screen.

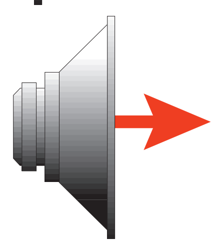
Screen compensating HF horn design

Another feature of the HF and MF horn design of the CSC Series addresses the so-called "screen effect" of the perforation of standard perf screens. Several phenomena contribute to create a dispersion "widening effect". First, sound that is reflected off the rear of the screen, back into the mouth of the horn is then passed through the screen at random angles. Also, when short wavelength frequencies pass through the perfs, the holes themselves tend to widen dispersion, increasing with frequency beginning at frequencies above about 5 kHz. The higher the frequency, the wider the pattern effectively becomes. However, it has long been known the most high frequency devices tend to naturally narrow in dispersion. This "beaming effect" has traditionally created a challenge for horn designers trying to achieve even coverage. During R&D efforts for the CSC Series, the beaming effects of the HF driver and the widening effects created by the cinema screen were measured with great precision by EAW engineers. As a result, the HF horn in the CSC Series addresses this phenomenon by subtle shaping of the critical throat section of the horn, which allows the horn to "beam" at a frequency where the effect of the screen will broaden the coverage. The result is a more controlled high frequency dispersion pattern after the screen.



Push-Pull LF Driver Configuration

The LF section of the CSC Series uses "push-pull" driver mounting which significantly lowers mechanically induced distortion. Any driver will produce a certain degree of distortion simply as a result of the motor action of the piston (voice coil/cone assembly). When the array includes pair of identical drivers, simply inverting the mounting orientation of one driver will cause the mechanical distortion produced by one driver to "cancel" the same distortion produced by the other. With the CSC Series, each push-pull driver pair is loaded into its own modular enclosure, to make moving and installing the speaker easier and less cumbersome.



EAW's VA⁴ Technology

In addition to optimized coverage, the CSC Series also features proprietary EAW design technology which significantly improves dialogue clarity. VA⁴ Technology is a breakthrough EAW design philosophy which has been used successfully in several popular EAW professional sound systems. The main focus of VA⁴ design is how it addresses time alignment in the critical mid-band frequencies. The CSC Series' patented phase plug design solves problems of early arrivals in the upper mid frequency range by developing a more logical cone geometry.

With this design, all paths from the source (voice coil) through the cone assembly (cone, dustcap and surround) and into the horn throat are virtually identical. This subtle yet important breakthrough gives the CSC Series its remarkably clear sound.

Cinema screen channel loudspeaker systems strive to optimize performance in four areas:

- spectral (frequency range, sound quality)
- spatial (pattern control, SPL distribution)
- temporal (unified arrivals from various subsystems)
- utilitarian (size and weight, ease of installation)

Unfortunately, optimization in one area usually results in trade-offs elsewhere. For example, spatial performance (pattern control) can be optimized by very large horns, but the resulting enclosure's utility will be severely degraded.

The goal of the CSC Series was to optimize performance attributes in all areas without compromising others. Specifically, the main goals were:

- unifying arrival times within and among the subsystems
- achieving broadband pattern control in the both the vertical and horizontal planes
- creating a modular system that's easy to move, install, and aim
- setting a new standard in audio fidelity

Optimized Mid-Frequency Sub-System: Achieving temporal coherence and spatial consistency

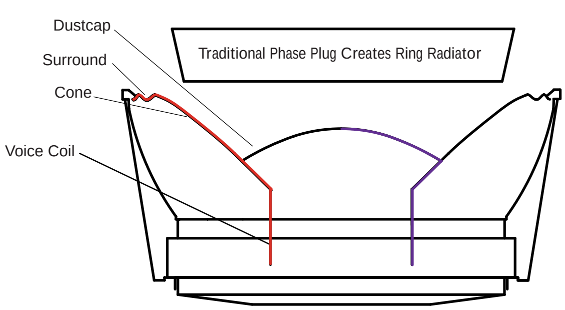
EAW has historically created true three-way cinema loudspeaker systems that use cone transducers to reproduce the majority of the vocal region. This approach significantly reduces distortion resulting in more natural sounding dialogue. But the additional LF section has typically created compromises in the temporal and spatial domains.

In addition to the sonic difficulties associated with transitioning between subsystems in the heart of the vocal band, two-way systems suffer from higher distortion in the lower portion of the compression driver's range. In the temporal domain, however, two-way systems excel where typical three-way systems falter.

Unlike the relatively simple geometry of a compression driver's diaphragm, there is a slight but noticeable difference in the point of origin of a cone driver's dustcap, cone, and surround. Particularly in the upper midrange, these differences create a "smearing" of arrival times at the listener that degrades the clarity and impact of mid-frequency sonic events: most notably voice reproduction. Because they are what the ear hears first, early arrivals out of the passband can affect overall fidelity even though they are substantially lower in level.

Traditionally, most manufacturers (including EAW) have asked the mid-frequency phase plug to fix the arrival smear. But because this approach treated the symptom (inconsistent arrivals at the horn throat) instead of attacking the disease (bad cone geometry), it fails. In contrast, the CSC Series' entire mid frequency cone and phase plug assembly was designed to solve this problem at the source.

Traditional Mid Cone with Phase Plug, Side View Cutaway



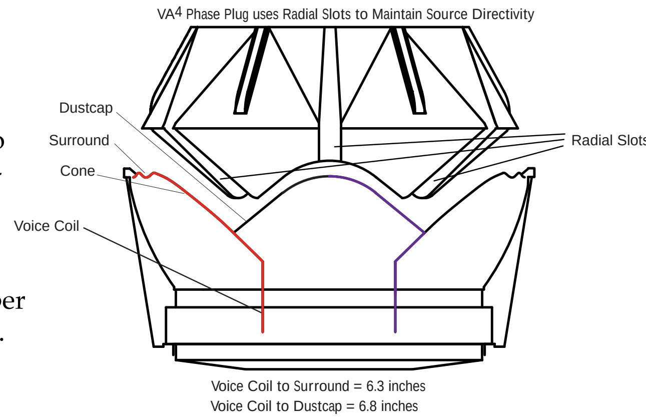
Voice Coil to Surround = 6.3 inches
Voice Coil to Dustcap = 4.5 inches

The distance from a cone driver's voice coil to its dustcap is shorter than the distance from the voice coil to either the cone or surround. Therefore, the energy radiating from the dustcap most often leads the energy from the rest of the system. Traditional phase plug designs have isolated this energy and routed it through a longer path than that which faces the energy from the cone or surround. In so doing, the phase plug attempts to equalize the arrival smear.

Conventional phase plug designs achieve this result by using a circular entrance and exit to the phase plug – they simply convert the output from a point source into a ring radiator. This approach has proven effective with high frequency compression drivers mostly because the simpler compression driver diaphragm geometry and shorter high frequency wavelengths create significantly smaller arrival differences that are less problematic to resolve. But because the wavelengths in the mid frequency passband are so much greater, this ring radiator solution actually creates another more serious problem.

A ring radiator exhibits a more dramatic narrowing of beamwidth with increasing frequency than a cone transducer. When the mid frequency device becomes a ring radiator, its directivity narrows too greatly with increasing frequency to the point where it no longer fills the bell of the horn. This is a problem that virtually all horn-loaded mid or midbass systems suffer from, including systems that are highly regarded in the professional audio and cinema sound communities. As a result all of these systems exhibit acceptable low/mid coupling, but the mid/high energy does not cover from box to box, leaving upper mid holes in the frequency response on the seams of an array.

The CSC Series mid/phase plug assembly approaches the problem in a different way. It attacks the



Traditional Mid Cone with Phase Plug, Side View Cutaway

problem at the source. The cone transducer's temporal smear is corrected by precisely aligning the cone/dustcap/surround geometry to maintain temporal unity. The distance to the dustcap is slightly longer to compensate for differences in material density.

The phase plug, whose geometry is matched to the cone, then serves to leave this unity intact. Expanding radial slots within a compressing frame lower the mechanical reactance of the load facing the transducer without modifying the directivity associated with the source. This allows for faithful reproduction of the upper mid-frequencies without any narrowing of beamwidth.

The wavelets (below) illustrate the difference between old and new mid-frequency cone/phase plug technologies. These wavelets represent data gathered at 1 meter from devices mounted in a pseudo-infinite baffle wall. The vertical axis indicates frequency, the horizontal indicates time, and color indicates dB SPL with each color change indicating a 1 dB drop in level. The first illustration represents data obtained from a conventional midrange transducer. Particular attention should be paid to the upper midrange above 1 kHz. Note that the energy at the top of the passband centered around 2.1 kHz is slightly leading the rest of the broadband energy and also remains considerable after.

This difference of microseconds is difficult to observe without precision measurements, but the phenomenon is quite audible. The resulting reproduction would take a finite sonic event (a Foley door slam, gunshot, or footstep, for example) and reproduce it over a longer period of time than it had actually taken. The source has been compromised and the events' clarity and impact degraded. With the harmonics leading and/or lagging the fundamental tone, the timbral quality of the acoustic event is lost.

The next illustration results from an identical measurement taken on a new CSC mid-range transducer. Needless to say, the temporal inconsistencies have been eliminated through the implementation of a more logical transducer geometry.

In the end, the mid-frequency sub-system of the CSC Series exhibits the temporal clarity of a compression driver alone (as in a two-way system) and the natural low distortion sonic reproduction of a cone transducer (as in an EAW three-way system) while removing crossover transitions from the vocal region and maintaining the spatial performance required for broad band constant directivity.

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