# DUAL DISSIMILAR RADIATORS

# Dual Dissimilar Radiators

Professional loudspeakers are required to exhibit engineered acoustic radiation patterns. This is accomplished in a multitude of ways including the use of horns and numerous line array techniques. Thus, pattern creation is an important engineering task in the design of any loudspeaker.

The invention presented here is a new technique for creation of useful radiation patterns not possible with traditional methods. In practice, it uses two distinct horns as its baseline devices. However, the invention is not limited to horns. however, the primary plane will have the greatest degree of freedom.

# General

The invention utilizes two distinctly different radiation devices aimed in the same direction to create a derived pattern unique to either of the two original patterns. Manipulation of several key design variables allows a multitude of unique patterns to be derived in this way using the same two devices. This is useful when engineering a radiation pattern to match the unique geometry of a room. Actual room shapes require radiation patterns that are often impossible for single devices to achieve. Single devices have patterns that are naturally smooth and rounded in shape where room geometries require much sharper transitions, often in areas off radiation axis which is near impossible to create from a single device.

Sharp transitions and unique shapes can be achieved when multiple acoustic devices are directed in the same direction. This is a well known phenomenon and the basis of line array behavior. It is based on acoustic interference which can be both constructive and destructive and is governed primarily by the acoustic time of flight differential from each device, which means it is wavelength (frequency) dependent.

The most dramatic reaction in this manner is between two devices. In most design cases, this is considered something to avoid except when trying to create very small radiation solid angles over a limited frequency range. The invention uses a different technique and aims two dramatically different radiation patterns in the same direction. In practice, one device will serve as a primary and the other a secondary. In this way, the secondary pattern is used to alter the primary. Altering the amounts and timing of the secondary to the primary creates completely different results. The roles can be reversed between primary and secondary giving completely different results yet again. The multitude of resulting patterns are typically shapes not attainable from single devices alone, and can be quite useful in mapping to room geometries.

Electronic filtering is the primary tool used to manipulate the mix between primary and secondary. The reaction is so dramatic that even the most basic form of filtering (analog passive) can produce good results. With better filter precision (FIR), the derived shapes become more precise and consistent.

Prior art utilizes arrays of the same devices (usually more than two) into the same space 'line arrays' or devices (similar and dissimilar) aimed in different directions 'clusters' to create unique radiation patterns. These techniques can be very effective but often are too expensive or too large for the application. In general, devices aimed in the same direction intensify the energy lobe and those aimed in different directions spread the energy lobe.

The invention has the ability to do both depending on the fundamental design variables. The fundamental variables of the design are: spacing and size of the two devices (inter-related to each other); the individual patterns of the devices; and the position of each device in the primary plane. These parameters set the operating range of the resulting pattern and its primary operational radiation axis. From this foundation, electronic filtering is then used to manipulate pattern within this framework. Alterations of any of the above variables can directly affect the derived radiation pattern.

The invention can offer radiation manipulation in all directions to some extent. It is important to note there is a primary plane of operation. The devices are displaced from each other in the primary plane and in most practical cases, this is the vertical plane. Since the two devices are distinctly different, this can be true in all directions. Therefore, the derived pattern will include manipulations in all planes. It should be under -stood, however, the primary plane will have the greatest degree of freedom.

# Practical Design

Any acoustic device is frequency dependent due to the fact audible wavelengths vary by a factor of 1000. Loudspeaker design requires careful attention to frequency dependent behavior. In this way, the invention has 4 operable frequency design regions each approximately one octave wide.

The most critical of these ranges is the center frequency region. This is the region with the most shape control and must be chosen for the application. The wavelength of the center frequency ($\lambda c$) shall be an important dimension in the design. From this, we first establish the distance between the devices to be ~1.5$\lambda$c. This now also establishes the average dimension of each device in the primary plane, also ~1.5$\lambda$c. This ensures good pattern control from each device in the center frequency range and a wide operational solid angle of pattern control.

One octave below center frequency is the point sound wavelengths grow large enough that each device begins to lose pattern control capability. This phenomenon is true of all acoustical devices. The invention combats this phenomenon by alterations in the filtering to each device. In this range, neither device is primary but both are used in tandem. In this way, the control frequency is extended a full octave while allowing for a much more gradual and controlled transition away from engineered pattern. In practice, this can be extended even further by proper system crossover design into the lower frequency device in the loudspeaker.

The octave above center frequency begins the region of most erratic behavior. This is the region where the distance between the devices as compared to wavelength is not as complementary and the interference between the devices is most destructive. This is also the region, however, where each individual device has its most precise pattern control. In this region, as before, the filtering is altered to accommodate this change. This region typically defines the fundamental radiation pattern for each device, as the primary device will dominate in this region.

Two octaves above center frequency is the upper region of operation. In this region, the interference patterns created are so dense (wavelengths very small) such that radiation shape is only marginally effected. However, this is the region where each individual device has its least effective output capability. In this region, the combination of devices doubles the output capability of the overall system, lowering distortion and maintaining good linearity in a region that normally suffers in this regard.

In practice, several key design techniques have been discovered.

First, one pattern can make useful manipulations to another while being up to 20dB below the other in output. This is particularly true in the fringes of the pattern where the primary pattern will be naturally attenuated and the secondary pattern can be used to either boost this area or attenuate this area, depending on the requirement. When the wavefronts are in phase, they add, when out of phase, they subtract. This can be controlled by filtering or even polarity inversion. In this way, one can control the outer fringes of a pattern that normally cannot.

Second, the ability to create useful patterns is predicated by the individual patterns of the two devices. If they are chosen to be the same, this is a two element line array that has impacted radiation throughout each individual pattern. The invention is different in that it uses one pattern to sculpt another, requiring each to be distinctly different. The easy description is for one to be very wide and one to be very narrow (in the primary plane).

In this case, three very different shape combinations exist.

**1.** The narrow pattern is dominant and the wide pattern is used to alter the fringes, either constructive or destructive.

**2.** The wide pattern is dominate and the narrow pattern is used to sharpen the pattern at a certain area.

**3.** Both are used in tandem and major shape alteration occurs including lobe alteration, anti-lobe creation, and lobe steering – all manipulated by electronic filtering.

Third, it should be noted here that anti-lobe creation can be a very useful design feature and is used in the invention to eliminate coverage 'hot spots' that often occur in actual application with single devices. The invention has the ability to create and manipulate 'soft' anti-lobes in strategic areas.

# Actual Product

The first application of the presented invention is in professional cinema surrounds. This is a unique case where the same sound characteristic is required from multiple locations in a theater. Each loudspeaker 'sees' a distinctly different room geometry. Ideally, the requirement of cinema is for each to cover the room identically. This mandates a distinctly different radiation pattern from each loudspeaker location, but with the same sound characteristic. The inability of typical loudspeakers to accomplish this is a known flaw in modern cinema design.

The invention takes the art to a new level and greatly improves the cinema experience for all audience members.

9350 patent ideas - Radiation shape sculpting using two distinct radiators.

A professional loudspeaker is most effective when its radiation pattern is 'sculpted' to the audience area. That is, it must have its most intense energy focused in the direction where the audience is furthest away and must be less intense for those audience areas closer. When this reduction in intensity is in proportion to the square of the distance then the 'coverage' of the loudspeaker is uniform across the audience area. This almost never happens in exact precision, but in successful audio systems it must be close.

Cinema requires the above to be true for multiple loudspeakers covering the same audience area from entirely different orientations to the audience.

For any multi-channel soundtrack to be effective, each 'track' i.e. loudspeakers that present this information to the audience - must 'see' the audience in the same manner. In a studio or home environment, this is not a big challenge because the audience area is small. In a professional cinema room, however, this is not simple. The screen channels are the foundation for a cinema system and they 'map' a room from a coverage standpoint almost identically with each other. The surrounds, however, do not. They 'see' a completely different geometry and yet have the requirement to match the screen channels.

Until now, no manufacturer has taken any major strides in achieving this goal. This has left surround information in the cinema experience.

In most cases, this is a continuous function of distance and the loudspeaker radiation pattern should take a shape that proportional to the distance function. This is best described using polar coordinates and relates to distance and angle from the loudspeaker position in 3 dimensions.

When defined in this fashion, the line array theory is in general based on using identical radiators in an array and adjusting signal and some positioning to achieve radiation contours specific to an application. This can be quite effective but requires a moderate to large number of devices to be effective, usually more than 5 and more than 10 to be best effective. This has a cost and complexity impact on all products that use this technique.

The idea utilized here is to use two distinctly different radiators in combination to sculpt pattern for a particular application. Those familiar with the art may immediately draw similarities to a "long throw/near throw" combination of horn patterns widely used for years in venue audio system design. In this scenario, the devices are intended to 'cover' different areas of the room and their interaction meant to be minimized, because this interaction is largely destructive due to positional alignment and geometry differences between the devices.

This is in some ways similar to using two pattern horns as a 'far throw' and In terms of a loudspeaker mapping to a room; this is primarily the shape of the underside of the radiation envelope. The upper section only serves to excite the room and, in general, should be minimized. The bottom surface of the envelope excites the audience area and its shape determines uniformity and balance of the direct sound.

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