

Dolby Atmos[®] Specifications

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Dolby Atmos Specifications

1 Introduction

Dolby Atmos® achieves unprecedented levels of audience immersion and engagement by offering powerful new authoring tools to mixers. Its new cinema processor features a flexible rendering engine that optimizes the audio quality and surround effects of the Dolby Atmos soundtrack to the loudspeaker layout and characteristics of each auditorium. In addition, Dolby Atmos has been designed from the ground up to maintain backward compatibility and minimize the impact on production, distribution, and exhibition workflows.

The introduction of a new audio format allows for changes in the design of sound systems without breaking compatibility with existing practices. Dolby has revisited critical areas of soundtrack reproduction, including equipment performance, layout, and installation for dubbing theaters and cinemas. This specification provides the recommended and minimum performance requirements for Dolby Atmos installations. In many cases, exceeding the minimum performance requirements can add value to system performance. This document replaces the previously issued *Dolby Atmos Technical Guidelines* document.

2 Screen Loudspeakers

Dolby Atmos does not place new demands on the screen loudspeakers. Existing best practice still applies. The loudspeakers must be capable of full dynamic range digital cinema content playback through a cinema screen, with a response that conforms to ISO 2969:1987/SMPTE ST 202:2010 specifications.

To ensure this performance, the following specifications are provided.

2.1 Number of Screen Loudspeakers

A minimum of three screen loudspeakers is required. For a screen wider than 12 meters (approximately 40 feet), we recommend the addition of left center and right center loudspeakers.

2.2 Sound Pressure Level: 105 dB

Each screen loudspeaker system and associated amplifiers must have a maximum output capability of 105 dB continuous sound pressure level (SPL) at the reference listening position (RLP), a point two-thirds of the distance to the rear wall of the auditorium in the middle of the seating area. Loudspeaker capability must be determined as described in [Section 6](#). If the system specifications are not known or not provided by the manufacturer, use the following guidelines for SPL at the RLP to assess each component:

- Two-way/biampfier: 105 dB for the low-frequency section, 101 dB for the middle-frequency and high-frequency sections
- Three-way/triampfier: 105 dB, 101 dB, 98 dB for the low-frequency, middle-frequency, and high-frequency sections, respectively
- Four-way/quad amplifier: 105 dB, 101 dB, 98 dB, 92 dB for the low-frequency, middle-frequency, high-frequency, and ultra high-frequency sections, respectively

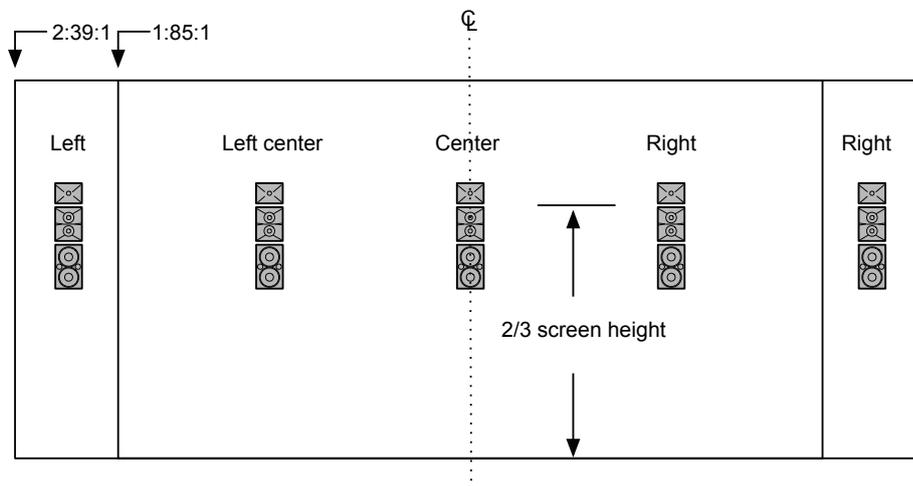
When determining the SPL capability of a screen loudspeaker system or the low-frequency component, use half-space sensitivity if the loudspeaker is mounted in a baffle wall. We recommend an amplifier with 3 dB of headroom (that is, twice the required continuous power) to drive each element.

2.3 Frequency Range: 40 Hz to 16 kHz, +3/−6 dB

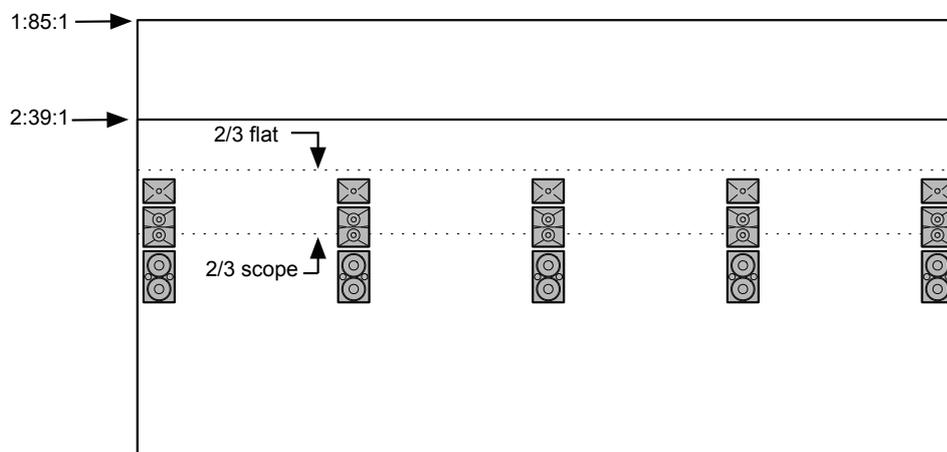
2.4 Frequency Response: 80 Hz to 16 kHz, ±3 dB

2.5 Position

Always place the center loudspeaker at the screen center line. Place the left and right loudspeakers equidistant from the center loudspeaker, regardless of the position of the screen within an auditorium. If installed, place the left center and right center loudspeakers midway between the center loudspeaker and the left and right loudspeakers, respectively. Place all screen loudspeakers vertically at the same height. In auditoriums with a fixed image height, position the left and right screen loudspeakers midway between the 1.85:1 (flat) and 2.39:1 (scope) images, with the acoustic center placed at approximately two-thirds of the screen height, as shown in the following figure.

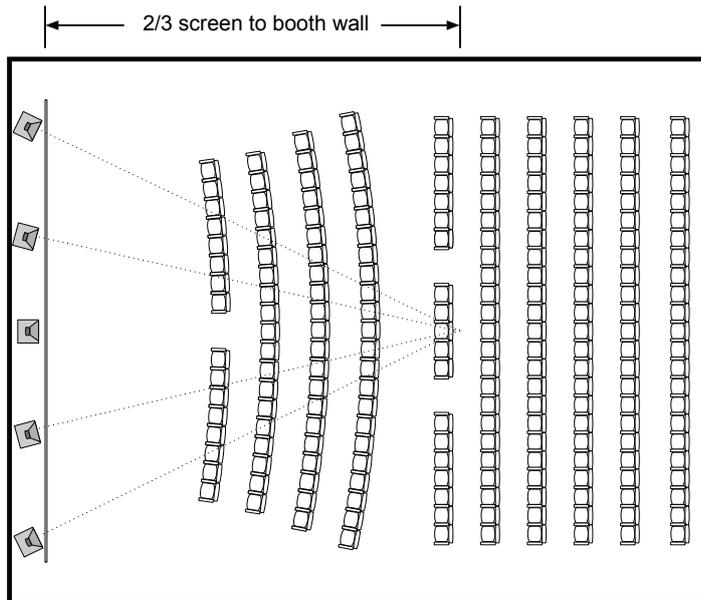


In auditoriums with a fixed image width and top moving masking, place the left and right screen loudspeakers just inside the edge of the image, with the acoustic center midway between the two-thirds image height for the flat and scope images, as shown in the following figure.

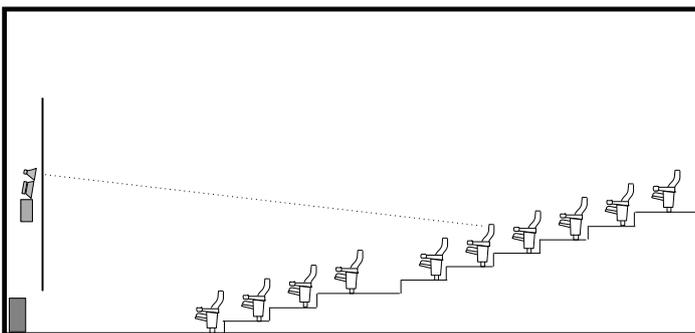


2.6 Aiming

Rotate the screen loudspeakers horizontally so that the axis of the loudspeaker is oriented at a point two-thirds of the distance to the back of the auditorium, along the screen center line, as shown in the following figure. Only the horns should be rotated horizontally for loudspeakers mounted in a baffle wall, keeping the low-frequency section flush with the wall.



For vertical aiming, tilt the screen speaker horns downward to optimize coverage over the seating area. The down angle should aim the axis at a point two-thirds of the auditorium length in stadium seating auditoriums, as shown in the following figure.



3 Screen Subwoofer

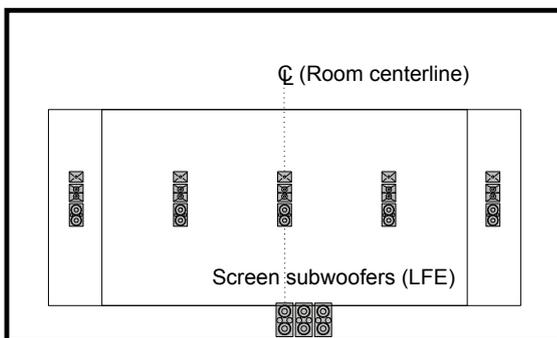
3.1 Sound Pressure Level: +10 dB (Compared to Center Loudspeaker)

The Low-Frequency Effects channel subwoofer must have a flat response over the range of 31.5 to 120 Hz. When compared with a full-range screen channel, the subwoofer channel must be capable of producing +10 dB of in-band gain (for example, as viewed on a real-time analyzer).

3.2 Frequency Response: 31.5–120 Hz, ± 3 dB

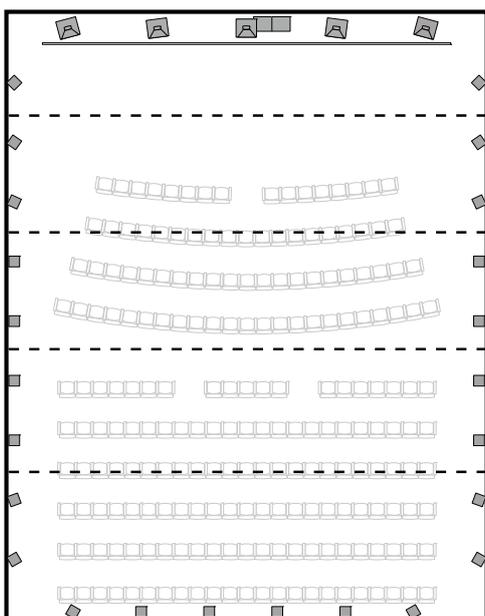
3.3 Position

When multiple screen subwoofers are used, closely clustering the cabinets can increase the efficiency through mutual coupling, as shown in the following figure. If a single cabinet or cluster is used, it should be placed near screen center, but asymmetrically with respect to the center of the auditorium to minimize stimulation of standing waves (room modes). Other configurations are also acceptable, such as uniformly spacing multiple cabinets along the front wall to improve coverage.

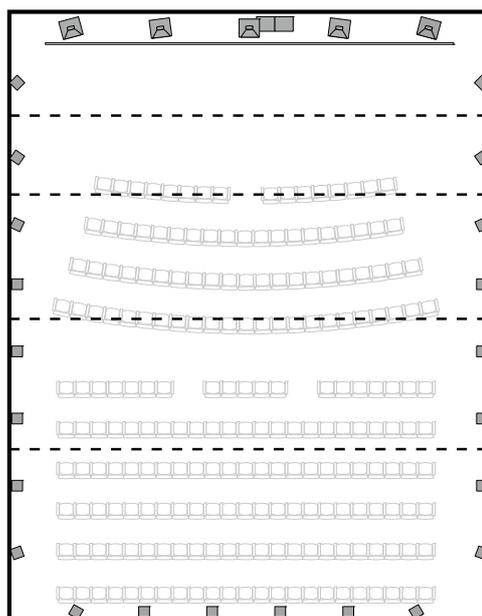


4 Surround Zones and Regions

B-chain requirements (including the number and distribution of surround loudspeakers and amplifier channels) are specified in terms of zones and regions within the cinema. There are five zones: left side, right side, rear, left top, and right top. The side and top zones are divided into regions, such that each region contains a pair of left and right side surround loudspeakers, except for the front-most (closest to the screen) region(s). The front-most region always consists of a single L/R loudspeaker pair, as shown in the examples below. For auditoriums with an even number of side surrounds, the two front-most regions each consist of a single side surround loudspeaker pair.



Odd Number of Side Surrounds Region



Even Number of Side Surrounds Region

The number of regions, R, is determined by Nss, the number of side surround loudspeakers used on each side of the cinema.

$$R > (Nss+1) / 2$$

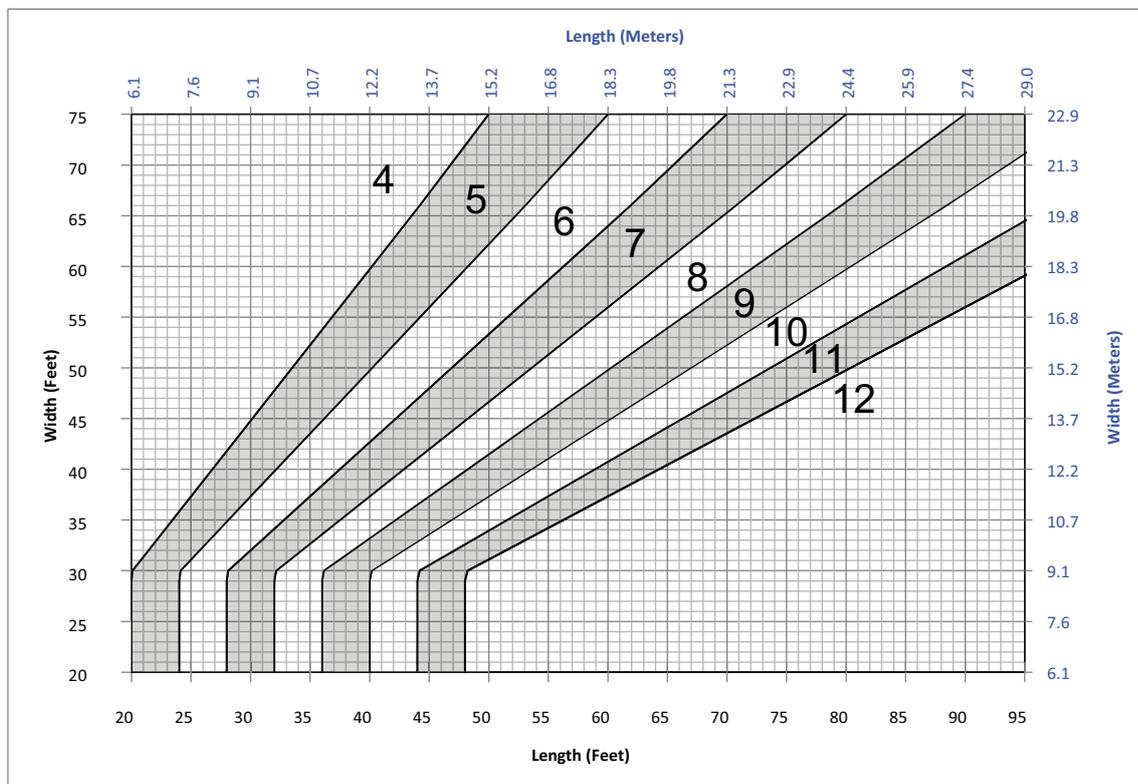
and

$$R \geq \min(4, Nss)$$

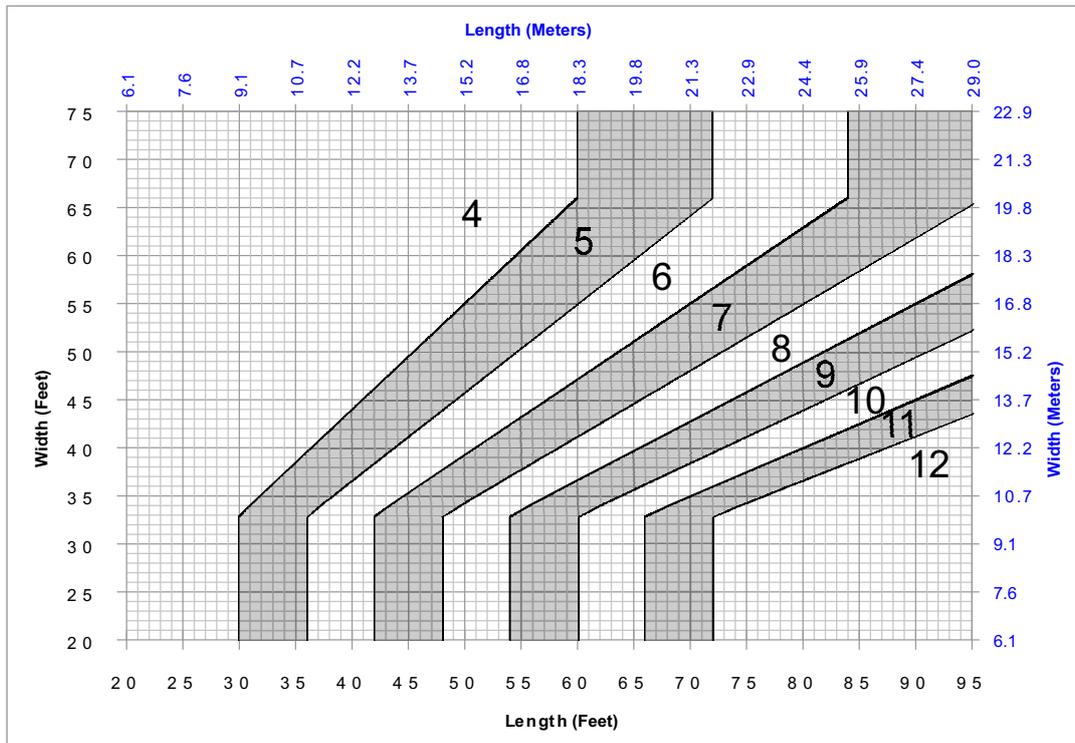
NSS	(NSS+1)/2	min(4, NSS)	R
4	2.5	4	4
5	3	4	4
6	3.5	4	4
7	4	4	4
8	4.5	4	5
9	5	4	5
10	5.5	4	6
11	6	4	6
12	6.5	4	7

4.1 Number of Side Surround Loudspeakers

The following figure shows the recommended number of loudspeakers in the left and right side surround zones, as a function of auditorium length and width (shown in feet and meters). Meters are in blue text.



The following figure shows the required (minimum) number of loudspeakers in the left and right side surround zones, as a function of auditorium length and width (shown in feet and meters). Meters are in blue text.



4.1.1 Pairing of Side Surround Loudspeakers

Loudspeakers within the same zone and region can be paired (driven by a single signal) to jointly optimize for uniform coverage, power efficiency, spatial resolution, and system complexity. The signals are distributed to each loudspeaker without phase, level, or delay differences, and can be driven by a single amplifier channel. Some or all of the loudspeakers within a region can be paired in accordance with the following rules:

- The number and location of side surround loudspeakers must conform to the normal specification, as defined in the previous figures.
- Paired loudspeakers must be the same make and model.
- All paired loudspeakers must be located to the rear of discrete unpaired loudspeakers, that is, when pairing loudspeakers, start by pairing the rear-most (closest to the booth wall) region, and move forward.

Note: The front-most left and right side surround speakers are always in their own region and must not be paired.

4.2 Number of Top Surround Loudspeakers

The recommended number of top surround loudspeakers matches the number of side surround loudspeakers, as indicated in the previous section.

The next section describes optional pairing or reduction in the number of ceiling loudspeakers.

4.2.1 Pairing and Culling Top Surround Loudspeakers

Two loudspeakers within the same zone and region can be paired (driven by a single amplifier) or replaced by a single loudspeaker (culled) to jointly optimize for uniform coverage, power efficiency, spatial resolution, and system complexity.

Culling reduces the number of top surround loudspeakers relative to the previous figures. The loudspeaker count provided in the figures is determined entirely by the horizontal dimensions of the auditorium. For auditoriums with relatively high ceilings, wider top surround spacing provides adequate coverage and was found to be subjectively acceptable.

To pair top surround loudspeakers, follow these guidelines:

- The loudspeakers must be in the same region and zone (for example, rear-most region on the left side surround zone).
- The left and right zones must be the same, that is, both must be discrete or paired.
- Paired loudspeakers must be of the same make and model.
- All paired loudspeakers must be located to the rear of discrete, unpaired loudspeakers. When pairing loudspeakers, start by pairing the rear-most region, and then move forward.

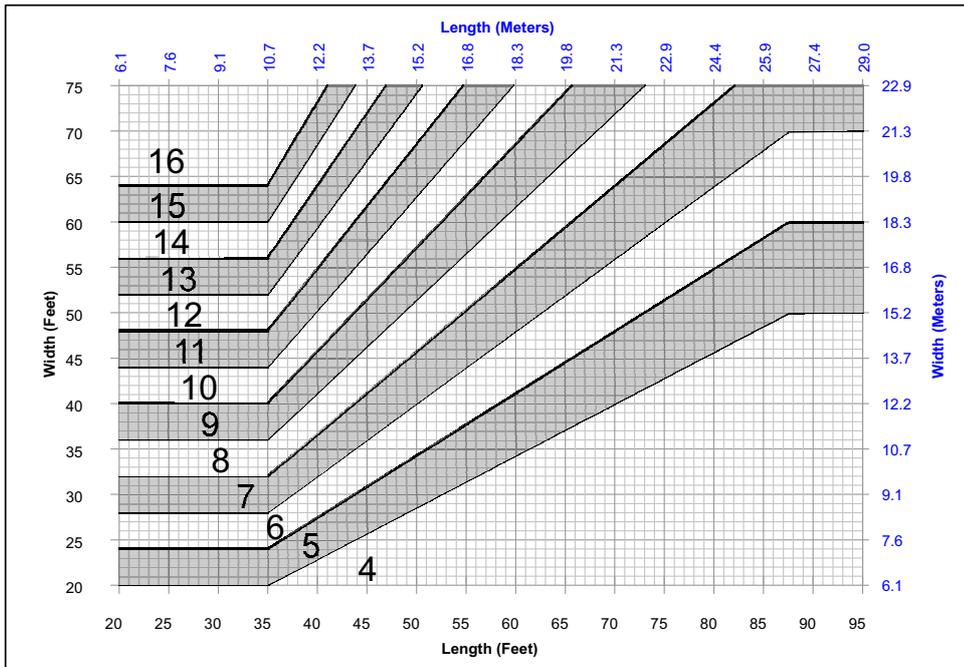
Note: The front-most left and right top surround loudspeaker are always located in their own region and must not be paired.

To reduce the number of top surround loudspeakers, follow these guidelines:

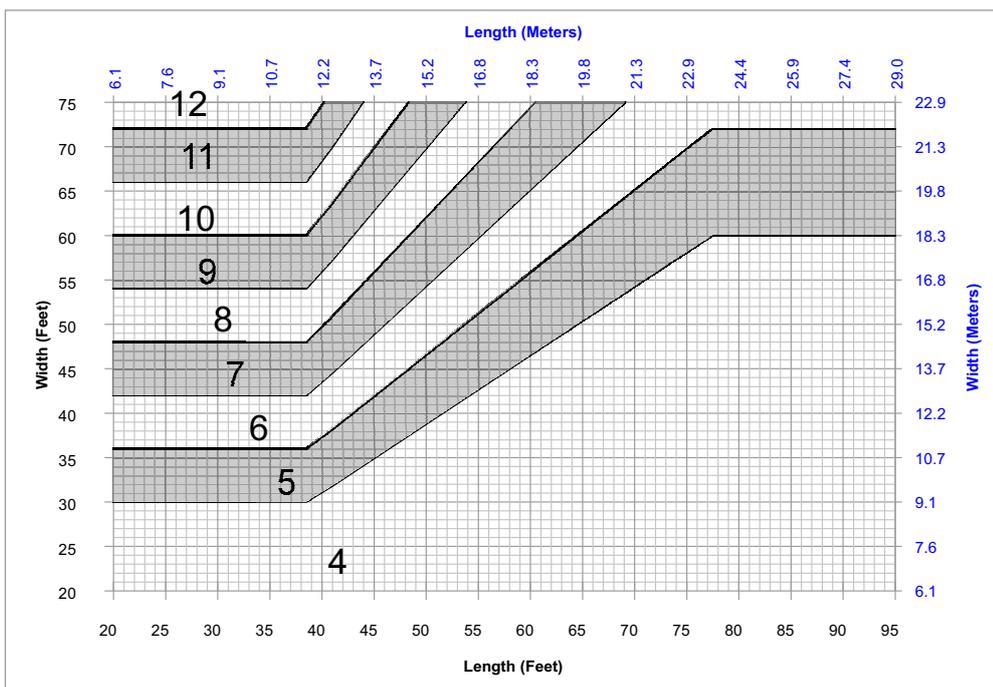
- The loudspeakers must be in the same region and zone (for example, front-most, 2-loudspeaker region on the left top surround zone).
- The left and right zones must be the same, that is, both must be discrete, culled, or paired.
- All regions where the quantity of loudspeakers are reduced must contain single (individually driven) loudspeakers located to the front of regions with two loudspeakers. When reducing loudspeakers, start from the front and move backward.
- The loudspeaker location must be at the mid-point between the side surround loudspeakers in the same region.
- The floor-to-loudspeaker height of a loudspeaker in a culled region must be greater than the front-to-back length of the region. Otherwise, this region cannot be culled (though it can be paired, as described previously).

4.3 Number of Rear Surround Loudspeakers

The following figure indicates the recommended number of loudspeakers for the rear zone, as a function of auditorium length and width (shown in feet and meters). Meters are in blue text.



The following figure indicates the required (minimum) number of loudspeakers required for the rear zone, as a function of auditorium length and width (shown in feet and meters). Meters are in blue text.



4.3.1 Pairing of Rear Surround Loudspeakers

It is permissible to pair rear surround loudspeakers. The signals are distributed to each loudspeaker without phase, level, or delay differences, and can be driven by a single amplifier channel. Some or all of the loudspeakers can be paired in accordance with the following rules:

- The number and location of rear surround loudspeakers must conform to the normal specification as defined in the previous figures.
- Paired loudspeakers must be of the same make and model.
- All paired loudspeakers must be located to the outside of discrete, unpaired loudspeakers. When pairing rear surround loudspeakers, start by pairing the speakers closest to the side wall (outer-most pair) and move toward the center of the auditorium.
- There must always be at least four discrete rear surround signals (two left, two right).
- If there are an odd number of rear surround loudspeakers, the center loudspeaker cannot be paired.

4.4 Surround Loudspeaker Sound Pressure Level: 99 dB

Each loudspeaker and associated amplifier must have a maximum output capability of 99 dB continuous SPL at the RLP (defined on [page 1](#)). Loudspeaker capability must be determined, as described in [Section 6](#). We recommend an amplifier with 3 dB of headroom (that is, twice the required continuous power).

4.5 Surround Array Sound Pressure Level: 105 dB

Each surround array and the associated amplifiers must be able to produce 105 dB continuous SPL at the RLP. To meet this requirement for surround arrays with fewer than four loudspeakers, each loudspeaker must be able to produce more than 99 dB continuous SPL.

4.6 Surround Sound Frequency Response: 40 Hz to 16 kHz, +3/–6 dB

Dolby Atmos auditoriums must support playback of full-range surround signals. To meet this specification standard, cinema surround loudspeakers with limited bass response require bass management. If bass management is used, the surround loudspeakers frequency response (± 3 dB) must extend to 90 Hz or lower. The crossover frequency should be set based on the capabilities of the surround loudspeakers, but must not be higher than 100 Hz.

4.7 Surround Loudspeaker Coverage Angles

To provide uniform coverage across the listening area, we recommend the following nominal surround loudspeaker coverage angles. Use these guidelines to select the most appropriate loudspeaker model from the manufacturer's line. In all of the following cases, coverage angle refers to the nominal angle between the loudspeaker –6 dB points.

4.7.1 Horizontal Coverage Angle, Front Side Surround Loudspeakers: 60°

Each front side surround loudspeaker that is forward of the listening area should have a horizontal coverage angle $\geq 60^\circ$.

4.7.2 Vertical Coverage Angle, Front Side Surround Loudspeakers: 40°

Each front side surround loudspeaker that is forward of the listening area should have a vertical coverage angle $\geq 40^\circ$.

4.7.3 Horizontal Coverage Angle, Side Surround Loudspeakers: 90°

Each side surround loudspeaker that is adjacent to the listening area should have a horizontal coverage angle $\geq 90^\circ$. For best audience coverage, we recommend a wider dispersion, $>100^\circ$.

4.7.4 Vertical Coverage Angle, Side Surround Loudspeaker: 50°, $\pm 10^\circ$

Each side surround loudspeaker that is adjacent to the listening area should have a vertical coverage angle of 50°, $\pm 10^\circ$.

4.7.5 Coverage Angle, Front and Rear Top Surround Loudspeakers: 50°

The front-most top surround loudspeakers (those in front of the first audience seats) and the rear-most top surround loudspeakers should have vertical and horizontal coverage angles $\geq 50^\circ$. A conical dispersion horn should have a coverage area $\geq 50^\circ$.

4.7.6 Coverage Angle, Top Surround Loudspeaker: 100°

The top surround discrete loudspeakers directly above the listening area should have vertical and horizontal coverage angles $\geq 100^\circ$. A conical dispersion horn should have a coverage area $\geq 100^\circ$.

4.7.7 Coverage Angle, Top Surround Loudspeaker: 100°

The top surround paired loudspeakers directly above the listening area should have vertical and horizontal coverage angles $\geq 100^\circ$. A conical dispersion horn should have a coverage area $\geq 80^\circ$.

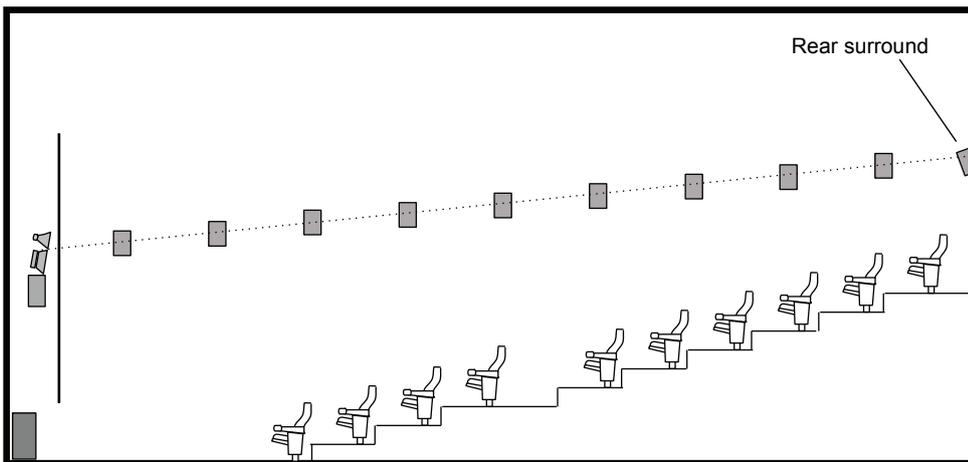
4.8 Rear Surround Elevation

The rear surround loudspeakers must be positioned at a uniform height. The position should be sufficiently high to maintain good coverage across the seating area according to the directivity of the loudspeaker and be out of the reach of patrons, where possible, to prevent tampering, damage, or theft. One-quarter auditorium width is a good guideline.

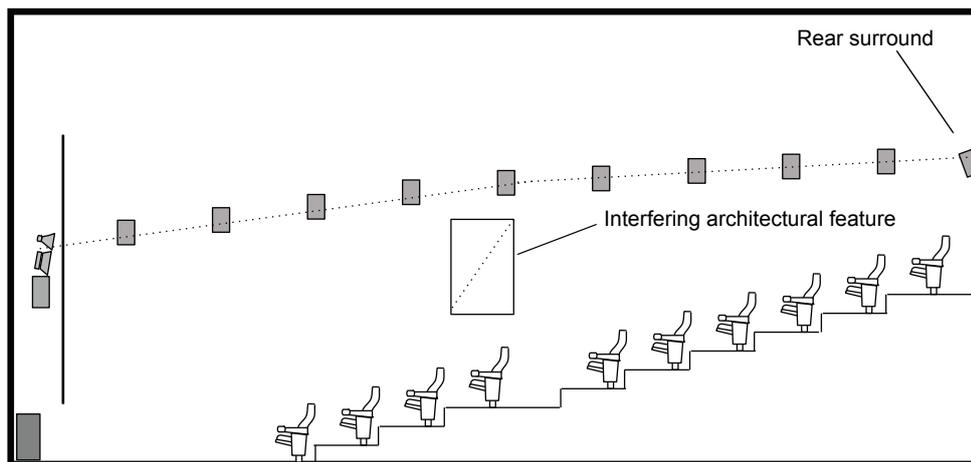
4.9 Side Surround Location and Aiming

4.9.1 Side Surround Elevation

The elevation of the side surround loudspeakers should form a straight line from the acoustic center of the screen loudspeaker array to the rear surround loudspeakers, as shown in the following figure. In new construction, Atmos installations should place the surround loudspeakers on this line. The following figure shows the optimal side surround alignment.



If auditorium features interfere with placement on a continuous line, it is better to break the line into two segments than to have a single loudspeaker out of line. “Going around” interfering auditorium features is acceptable as long as the resulting layout meets the tolerances provided in the next section. The following figure shows an alternative configuration to accommodate wall features.

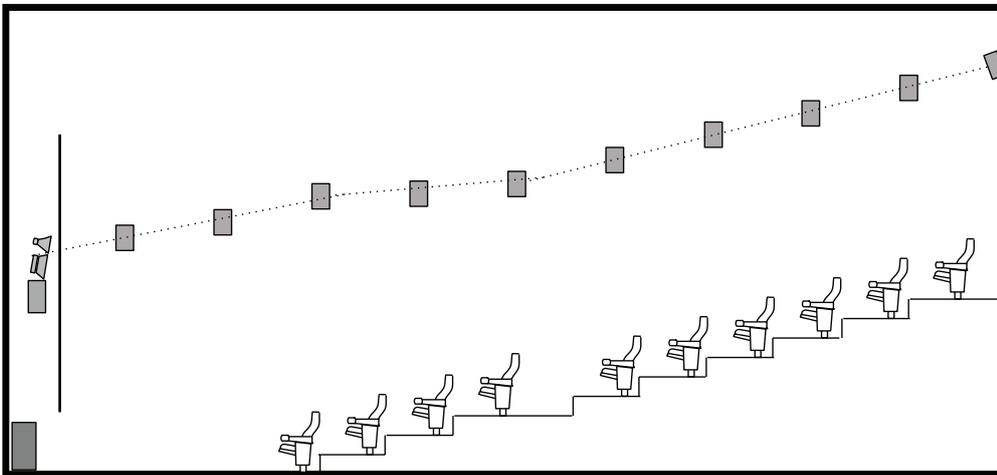


Similar principles apply when upgrading a legacy surround system to Dolby Atmos. Reusing existing loudspeaker locations can ease the upgrade process, and is acceptable as long as the existing speaker placement falls within the specified tolerance. Many cinemas configured for legacy surround sound formats place the surround loudspeakers at a fixed elevation from the floor, rather than in a single straight line front-to-back. For Dolby Atmos, additional side surround loudspeakers are typically required near the screen.

New side surround loudspeakers (those forward of the existing side surround loudspeakers) should be placed in a straight line as follows:

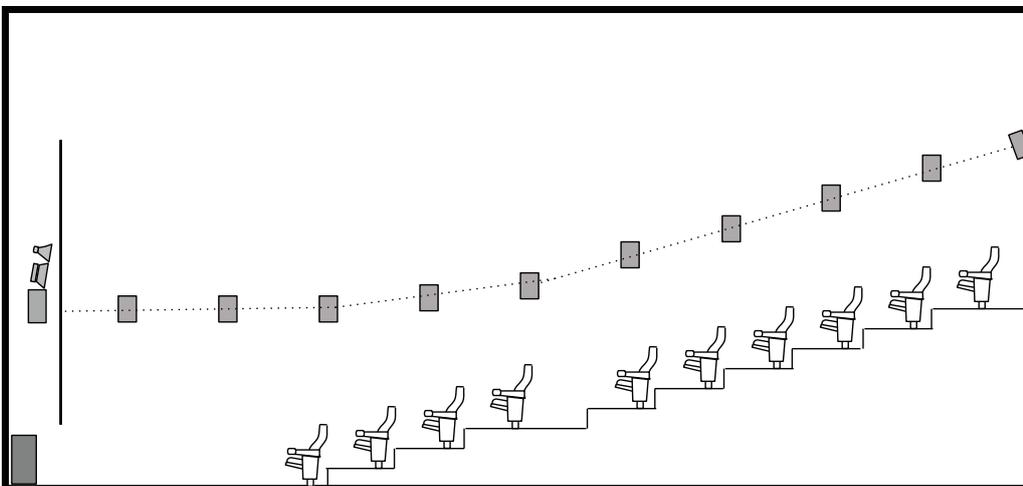
- If the acoustic center of the screen loudspeaker array is lower than the front-most legacy side surround loudspeaker, the line should connect these two points.
- If the acoustic center of the screen loudspeaker array is higher than the front-most legacy side surround loudspeaker, the line of the new loudspeakers should extend forward horizontally with the front-most legacy side surround loudspeaker.

The following figure shows the alignment of new surround loudspeakers for high-mounted legacy loudspeakers. The additional loudspeakers angle down in a line to the screen loudspeaker acoustic center.



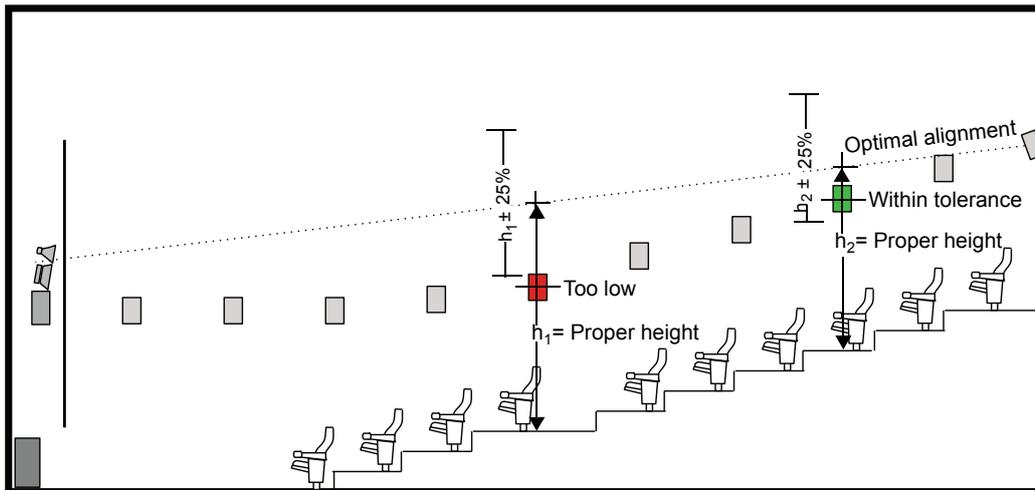
The following figure shows the alignment of new surround loudspeakers for low-mounted legacy loudspeakers. In this configuration, the new loudspeakers are placed horizontally in line with the front-most legacy side surround loudspeakers.

Note: The new loudspeakers should not angle up to the screen loudspeakers.



4.9.2 Side Surround Elevation Tolerance

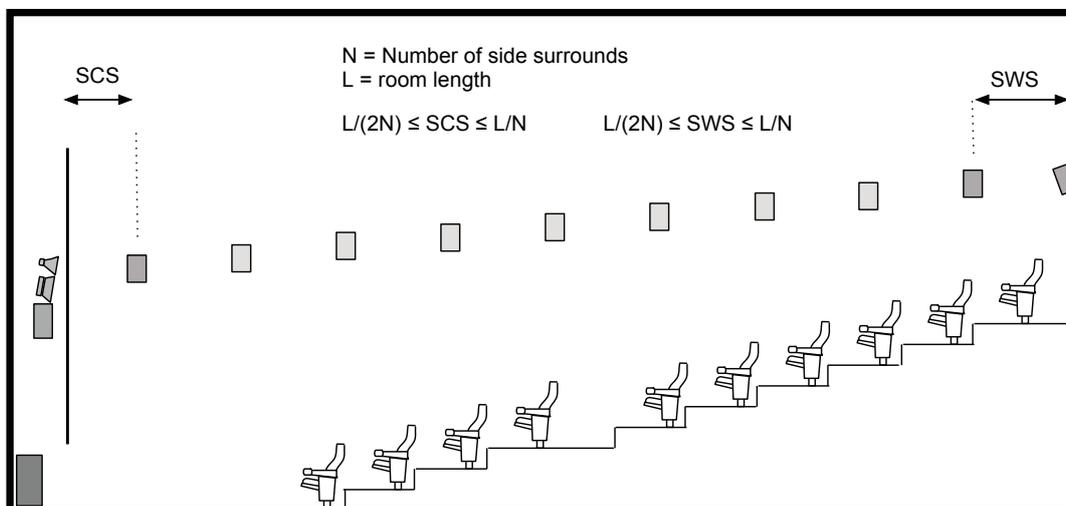
The proper elevation for each loudspeaker corresponds to the height of the straight line joining the rear surround height and the screen loudspeaker acoustic center as described above. Each loudspeaker shall be within 25% of the proper elevation. Allowance for upgrades from legacy systems will typically be given if a few of the existing speakers locations fail to meet these specifications. The following figure shows the side surround height tolerance.



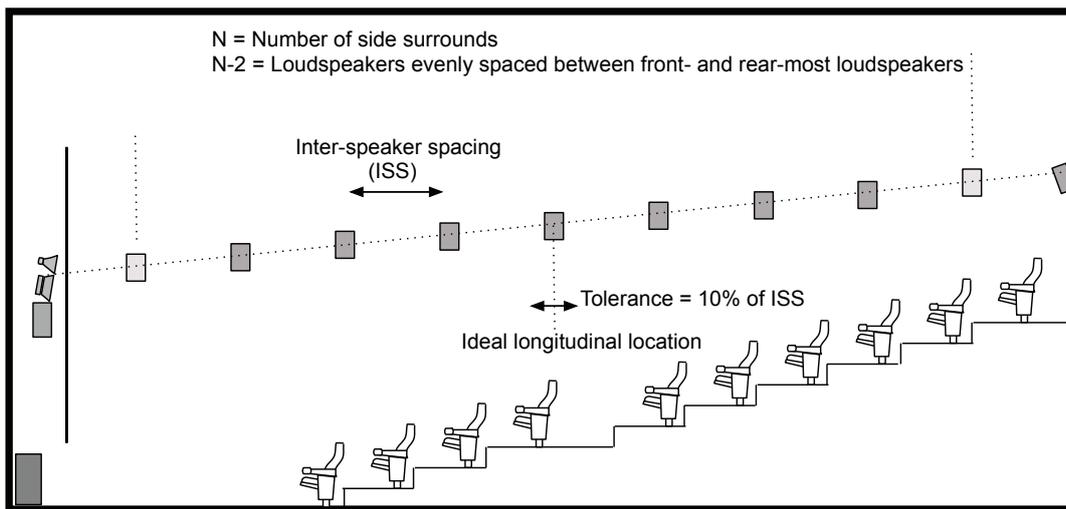
4.9.3 Side Surround Longitudinal Location

Side surround loudspeakers shall be placed as left/right pairs, with the left loudspeaker and right loudspeaker at the same distance from the front wall. The loudspeakers should be placed with constant linear spacing.

For new construction, place the front-most loudspeaker at a distance between L/N and $L/(2N)$ from the front wall, and likewise, place the rear-most loudspeaker at a distance of between L/N and $L/(2N)$ from the rear wall. The following figure shows the longitudinal location of the front-most and rear-most side surround loudspeakers and the correct speaker-screen spacing (SCS) and speaker-wall spacing (SWS). Please note that in the case of a curved screen, the distance from each side of the screen to the first speaker should be used rather than from the center of the screen.



The remainder of the loudspeakers should be evenly spaced to within $\pm 10\%$ between the front- and rear-most loudspeakers. The inter-speaker spacing (ISS) is the distance between the front- and rear-most side surround, divided by $N-1$. The following figure shows the longitudinal locations of the middle side surround loudspeakers.



For existing auditoriums being upgraded from a legacy surround sound system to Dolby Atmos, it can be time and cost effective to reuse the existing loudspeaker positions. To determine if the existing loudspeaker position is acceptable, extend the side surround arrays to the front of the auditorium with the same longitudinal spacing as the existing loudspeakers. The existing loudspeaker longitudinal position is acceptable if the following conditions are met:

- The resulting loudspeaker count meets the requirements indicated in the table above
- The front-most loudspeaker is at a distance of between L/N and $L/(2N)$ from the front wall
- The rear-most loudspeaker at a distance of between L/N and $L/(2N)$ from the rear wall

The loudspeakers are at a constant longitudinal spacing to within $\pm 10\%$ of inter-speaker spacing.

4.10 Rear Surround Spacing

The rear surround interspeaker spacing, which is the distance between the loudspeakers on the rear wall, must be between the value of $W \div N$ and the value of $W \div (N + 1)$, where W is the auditorium width and N is the number of loudspeakers on the rear wall. The distance between the outside loudspeakers and the side walls must be between 50 and 100% of the interspeaker spacing.

4.11 Side and Rear Surround Horizontal Aiming

To determine the proper horizontal aiming for the side and rear surround loudspeakers, define a rectangle in the central listening area (CLA).

Side and rear surround loudspeakers adjacent to the CLA must aim directly into the auditorium (that is, 0° from perpendicular), $\pm 10^\circ$.

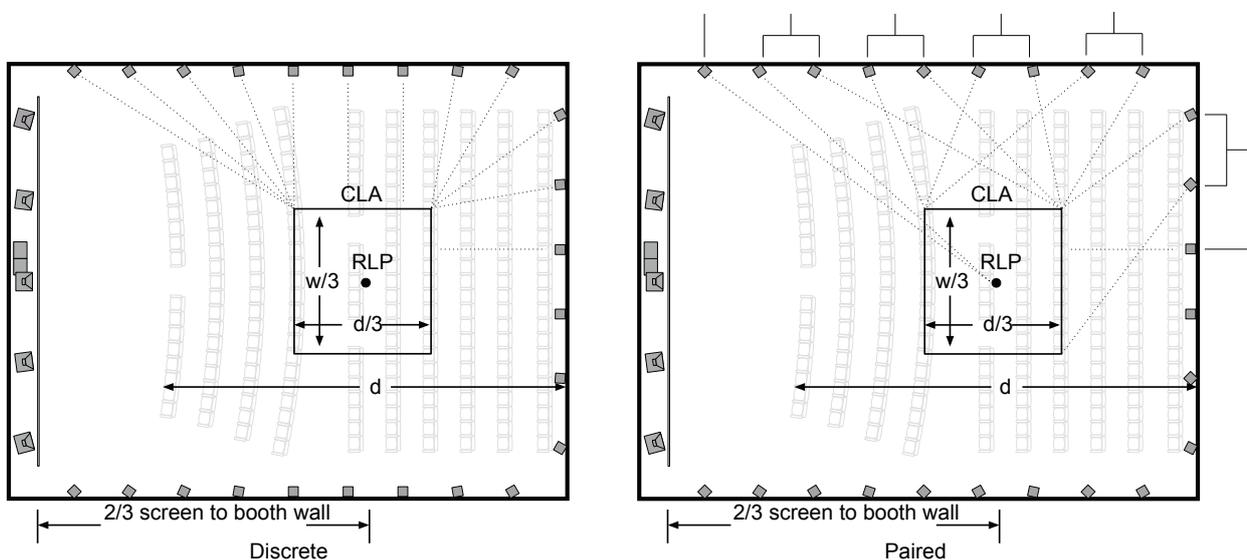
The remaining side and rear surround loudspeakers must be angled horizontally toward the nearest corner of the CLA, but not beyond the RLP (defined on [page 1](#)), $\pm 10^\circ$. Avoid abrupt changes in horizontal aiming ($\geq 30^\circ$) from loudspeaker to loudspeaker. Left/right loudspeaker pairs should have the same aiming.

Discrete loudspeakers shall be aimed based on the CLA.

- Central listening area width is $W \div 3$ (one-third the auditorium width).
- Central listening area length is $D \div 3$ (one-third the distance between the first and last row).
- Central listening area is centered on the reference listening position.

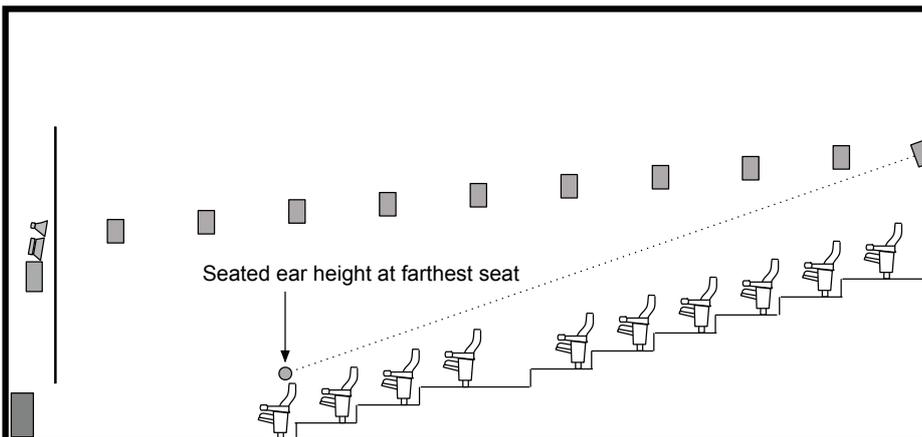
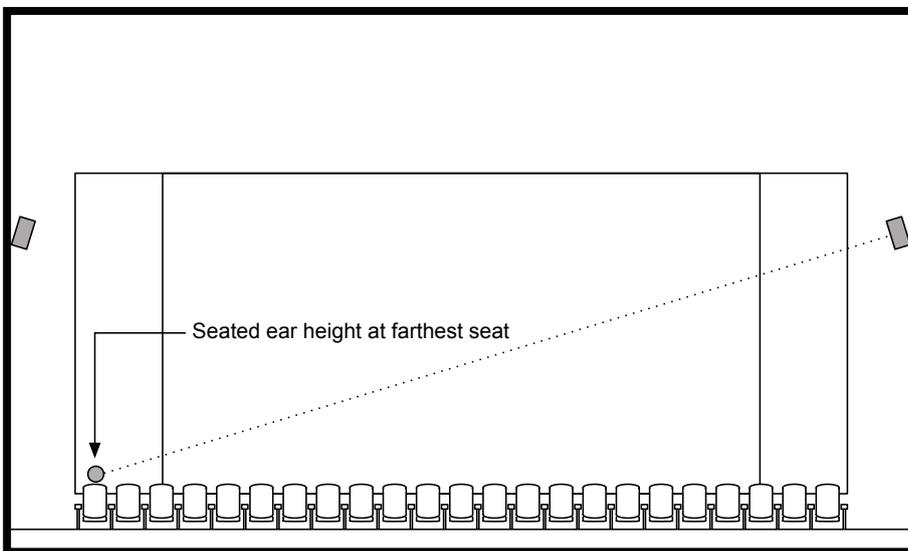
For installations that utilize loudspeaker pairing, splaying the paired loudspeakers will improve sound coverage. For all paired loudspeakers, we recommend these aiming parameters, based on the CLA.

- Aim the forward paired loudspeaker to the near-side forward corner.
- Aim the rearward paired loudspeaker to the near-side rear corner.



4.12 Side and Rear Surround Elevation Aiming

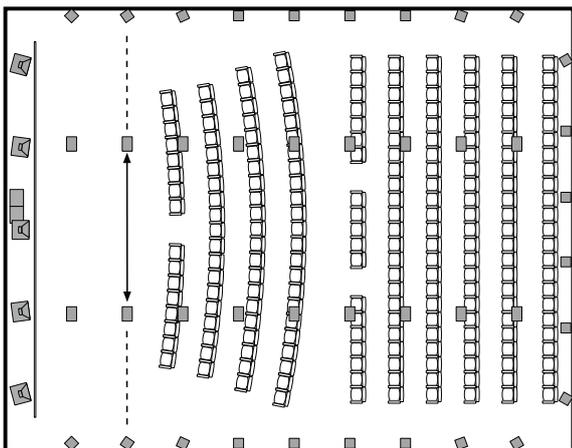
Side and rear surround loudspeakers should be tilted vertically to orient the axis of each loudspeaker to the ear height of a seated listener in the farthest seat, based on the horizontal, lateral aim of the particular loudspeaker. (See the following figures.) The loudspeaker can be aimed higher, but not by more than half the loudspeaker vertical coverage angle. Depending on the auditorium geometry, the soundfield may benefit from individual aiming of the surround loudspeakers. For example, in a steeply raked theatre, the front-most side surrounds can be aimed in a nearly horizontal position, whereas the rear surrounds are tilted more downward. Typically, rear surround loudspeakers should have the same downward tilt. The tilt of the side surround loudspeakers should not change abruptly ($>10^\circ$) from speaker to speaker along the array.



4.13 Top Surround Position

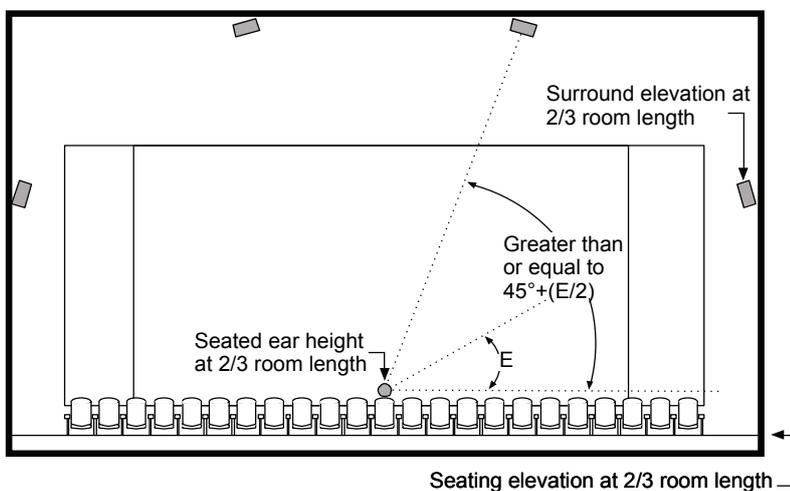
Top surround loudspeakers must always be placed as left/right pairs, with the left loudspeaker and right loudspeaker at the same distance from the front wall.

The top surround loudspeaker pairs must be placed symmetrically with respect to the screen center line. The top surround arrays should typically be placed in line with the left center and right center screen loudspeakers, which is the minimum width. (See the following figure.)



We recommend wider spacing for tall auditoriums, which is also acceptable for typical auditoriums when standard placement is unachievable. The maximum width between top surround loudspeakers should then be determined by elevation angles as follows: Let E be the elevation angle of the nearest side surround loudspeaker measured from the RLP (defined on [page 1](#)). The elevation angle of the corresponding top surround array should be greater than or equal to 45 degrees plus half of angle E . For example, if E is 20 degrees, then the elevation angle of the top surround array should be greater than or equal to 55 degrees. (See the following figure.)

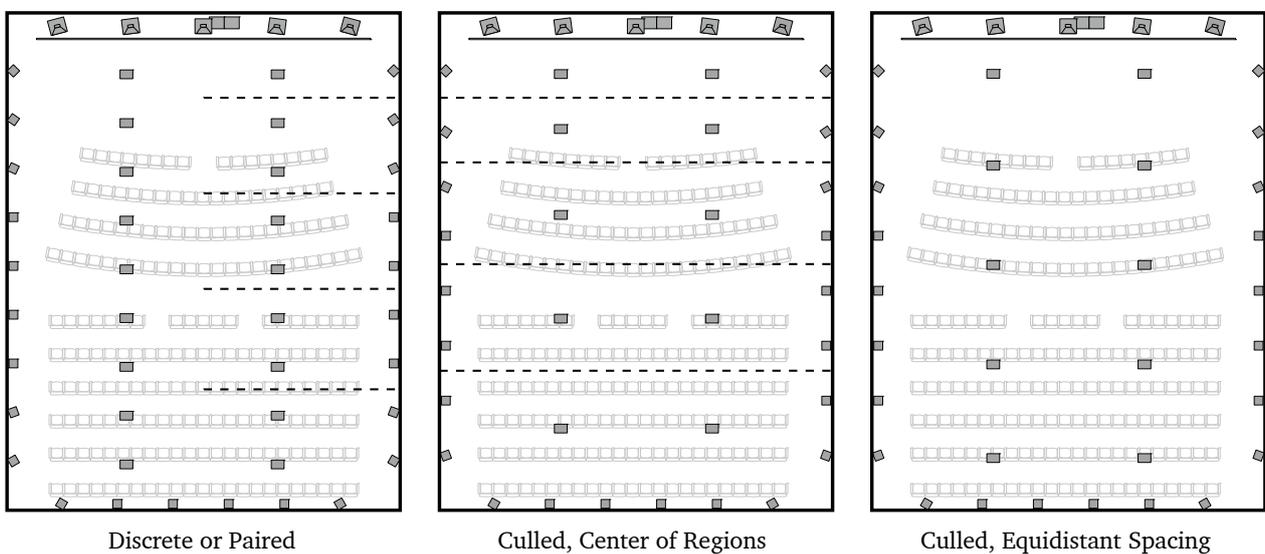
If there is no side surround loudspeaker directly adjacent to the RLP or it is unclear which loudspeaker to reference, it is acceptable to take angle E from the mid-point between two side surround loudspeakers, a unit slightly in front and a unit slightly behind the RLP. Likewise for the top surround elevation angle, 45 degrees + $E/2$, an interpolated point between two top surround loudspeakers can be used.



4.14 Top Surround Longitudinal Location and Aiming

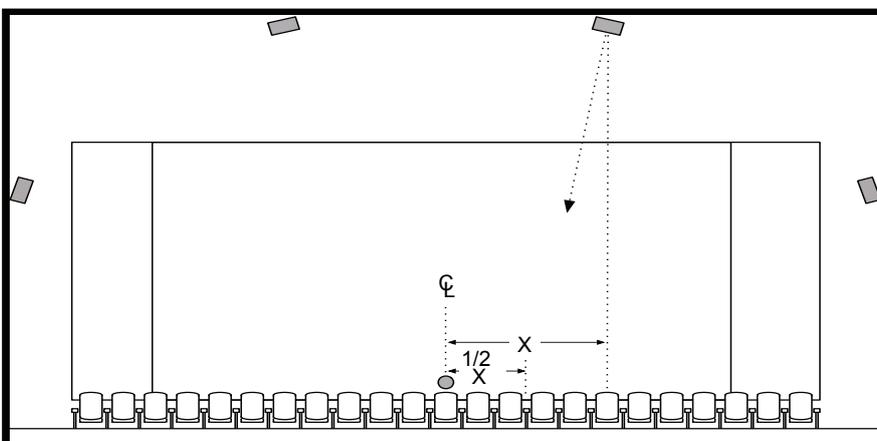
Top Surround Longitudinal Location

The top surround loudspeakers should typically be placed in line with the corresponding side surround loudspeakers for non-culled top surround loudspeakers or in line with the corresponding paired side surround loudspeakers for paired top surround loudspeakers. For ceiling loudspeakers within a region that has been culled, the longitudinal location of the top surround loudspeaker pair should be placed in the center of the region, half way between the side surround loudspeakers in the corresponding region. Alternatively the top surround loudspeakers can be equidistantly spaced where the front-most and rear-most top surround loudspeaker is in line with the corresponding front-most and rear-most side surround loudspeaker. (See the following figures.)



4.14.1 Top Surround Aiming

The top surround loudspeakers must be angled laterally (across the width of the auditorium) to a position halfway between the lateral position of the top surround loudspeaker and the screen center line, $\pm 10^\circ$. (See the following figure.)



Top surrounds should be angled longitudinally (along the length of the auditorium) in a manner similar to the angling of the side surrounds (taking 0° as aiming vertically downward). (See the following figure.)

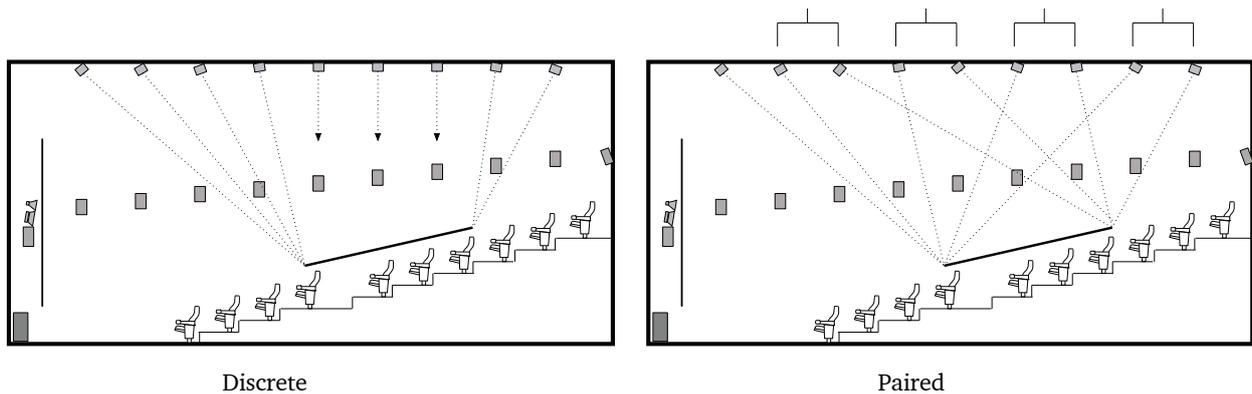
When aiming discrete loudspeakers:

- Loudspeakers over the CLA should aim neither forward nor backward. That is, they should be aimed at 0°. (CLA is defined on [page 15](#).)
- Loudspeakers in front of and behind the CLA should aim toward the front and back of the CLA, respectively.
- Abrupt changes in aiming (≥ 30 degrees) from loudspeaker to loudspeaker should be avoided.

When aiming paired loudspeakers:

- Aim the forward paired loudspeaker to the front edge of the CLA.
- Aim the rearward paired loudspeaker to the rear edge of the CLA.

To improve sound coverage, we recommend splaying the paired loudspeakers.



4.15 Loudspeaker Aiming Tolerance

Loudspeaker aiming is defined at several locations within the main body of this specification. All loudspeaker aiming specifications have a of $\pm 10^\circ$ tolerance unless stated otherwise.

5 Surround Subwoofers

Dolby Atmos auditoriums must support playback of full-range surround signals. Surround loudspeakers with limited bass are acceptable if surround subwoofers and bass management are used. The Dolby Atmos Cinema Processor CP850 supports bass management signal generation. For practical installations, this is the most common approach. When using bass management, the surround subwoofers must meet the requirements described in this section.

5.1 Number of Surround Subwoofers

For larger auditoriums (>500 seats), auditoriums with more than seven surround speakers on a side wall, or if the bass management cross-over frequency to be used is higher than 80 Hz, we recommend additional subwoofer pairs.

5.2 Surround Subwoofer Frequency Response: 40–120 Hz, +3/–6 dB

Each surround subwoofer (if bass management is used) must have a frequency response of 40–120 Hz, +3/–6 dB.

5.3 Surround Subwoofer Sound Pressure Level: 0 dB (Compared to Center Loudspeakers)

The left surround subwoofers and right surround subwoofers—loudspeaker and amplifier—must be capable of producing the same in-band gain as a screen channel (for example, as viewed on a real-time analyzer).

5.4 Surround Subwoofer Placement

The following guidelines pertain to the placement of surround subwoofers in auditoriums:

- The distance from a surround subwoofer to an auditorium corner should be ≥ 1 meter.
- For rear wall or ceiling placement, the surround subwoofers should be placed wider than the top surround arrays.
- For front wall placement, the surround subwoofers should be wider than the left and right screen loudspeakers.
- If multiple pairs of surround subwoofers are used, distribute the pairs along the length of the auditorium. For example, if two pairs are used, place one pair in the back of the auditorium, and one pair in the front half of the auditorium.
- Avoid placing the subwoofers near any listening position. Placement high on the side walls or on the ceiling is best. The distance from each surround subwoofer to the nearest listening position should be \geq than one-quarter the distance from the subwoofer to the RLP (defined on [page 1](#)). For a steeply inclined theatre (with rear seats near the ceiling), we recommend placing the subwoofers farther from the rear wall.

6 Estimating Loudspeaker Output

The SPL performance guidelines in this document are provided with respect to the RLP (defined on [page 1](#)) and are based on the capabilities and demands of a calibrated cinema auditorium. Many variables affect playback levels, including B-chain processing, amplifier and loudspeaker capabilities, and the auditorium itself. Existing loudspeaker and amplifier performance standards cannot account for the unique characteristics of each cinema auditorium (screen loss, auditorium equalization, SMPTE standards for level calibration and characteristic amplitude response, and so on). As a result, it is impossible to state with any certainty the loudspeaker performance requirements for achieving standard cinema levels in all cases; one can only estimate.

To assist you in determining the required loudspeaker output capability, we recommend the following:

1. Determine the loudspeaker maximum continuous output SPL (SPL_{max}). This is often specified in the documentation provided by the loudspeaker manufacturer. If SPL_{max} is not stated, compute it using the rated sensitivity of the loudspeaker (1 W at 1 m) and power handling (IEC noise, with AES duration of two hours), as follows:

$$SPL_{max} = \text{sensitivity} + 10 \times \log_{10}(\text{power handling})$$

2. Measure the distance in meters (D2) from the loudspeaker to the RLP.
3. Using this distance information, calculate the sound pressure attenuation from the loudspeaker to the RLP, as follows:

$$\text{Distance attenuation} = 20 \times \log_{10}(D1 \div D2)$$

In this equation, D1 is one meter, D2 is the distance measured in step 2, and distance attenuation is a negative number representing the level change (in decibels).

4. Add the values for distance attenuation and SPL_{max} to determine the level at the RLP.

$$\text{Level at RLP} = SPL_{max} + \text{distance attenuation}$$

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