



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 content creators. Dolby Atmos cinema processors feature a flexible rendering engine that optimizes the audio quality and surround effects of the Dolby Atmos soundtrack to the speaker layout and characteristics of each auditorium. In addition, Dolby Atmos was designed from the ground up to maintain backward compatibility and minimize the impact on production, distribution, and exhibition workflows.

Since launching in 2012, Dolby Atmos has revolutionized how moviegoers experience entertainment and was honored with a Scientific and Engineering Award from the Academy of Motion Picture Arts and Sciences. 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 Specifications Issue 3*.

This Dolby Atmos specification document should be used in conjunction with the Dolby Audio Room Design Tool (DARDT) for Cinema. DARDT provides access to a large equipment database and allows you to perform power calculations in accordance with the Dolby Atmos Specifications. DARDT provides guidance for speaker layout creation, predicting the performance of speakers and amplifiers in a given environment. In addition, DARDT helps users assemble equipment that meets the Dolby Atmos theatrical power requirements, while maintaining cost-efficiency.

2 Screen Speakers

Dolby Atmos does not place new demands on the screen speakers (passive or self-powered). Existing best practice still applies. The speakers must be capable of full dynamic range digital cinema content playback, with a response that conforms to ISO 2969:1987/SMPTE ST 202:2010 specifications. All screen speakers should be the same make and model.

To ensure this performance, the following specifications are provided.

2.1 Number of Screen Speakers

A minimum of three screen speakers is required. For a screen wider than 12 meters (approximately 40 feet), we recommend the addition of left center and right center speakers. With these wider screens, the use of left center and right center speakers improves audio placement, allowing for smoother panning information across the screen.

2.2 Screen Speaker Sound Pressure Level: 105 dB

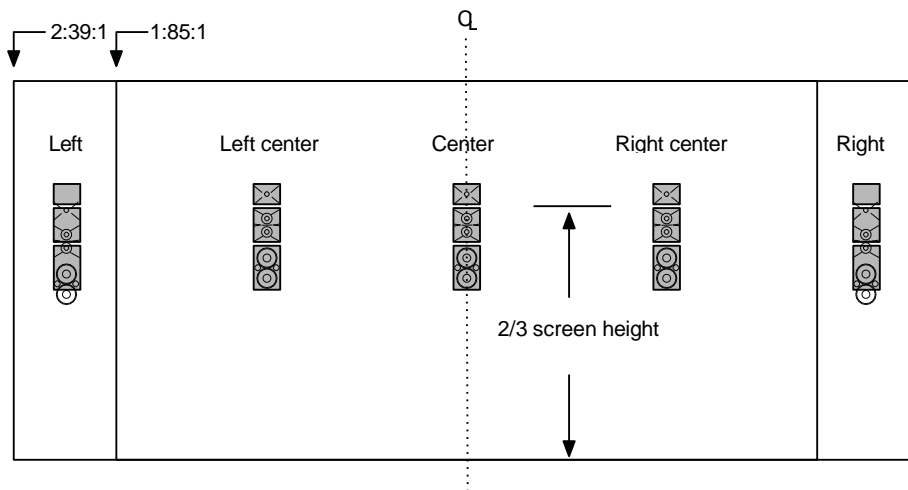
Each screen speaker system and the associated amplifiers must have a maximum output capability of 105 dB continuous sound pressure level (SPL) at the reference listening position (RLP), a point two-thirds of the distance to the rear wall in the auditorium, typically on the center line of the screen. Multi-way passive speakers that are bi-amplified, tri-amplified, or quad-amplified have SPL targets for each passband that are based on the bandwidth of each passband. The passband targets are calculated in the DARDT spreadsheet based on the data in the speaker database. Equipment that is not listed in the speaker database can be entered manually via the **ExtraEquipmentEntry** tab.

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

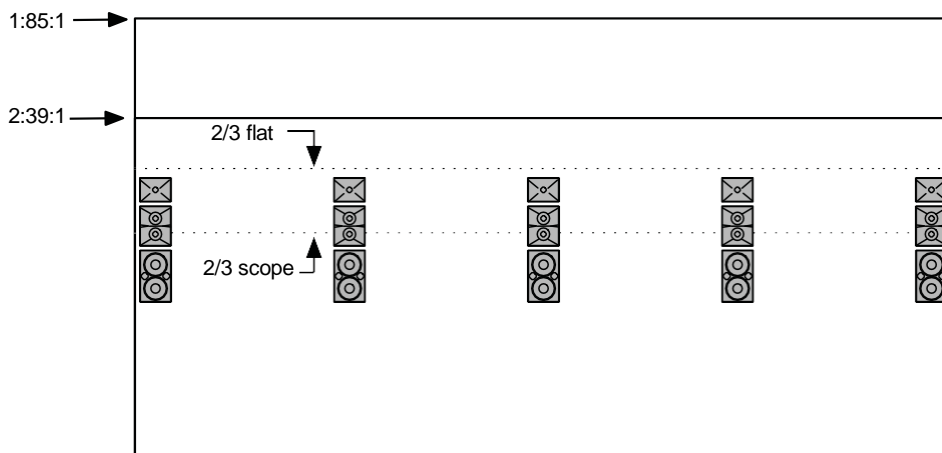
2.4 Screen Speaker Frequency Response: 80 Hz to 16 kHz, ±3 dB

2.5 Screen Speaker Position

Always place the center speaker at the screen center line. Place the left and right speakers equidistant from the center speaker, regardless of the position of the screen within an auditorium. If installed, place the left center and right center speakers midway between the center speaker and the left and right speakers, respectively. Place all screen speakers vertically at the same height. In auditoriums with a fixed image height, position the left and right screen speakers 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. When using masking between aspect ratios, acoustically transparent material must be used.

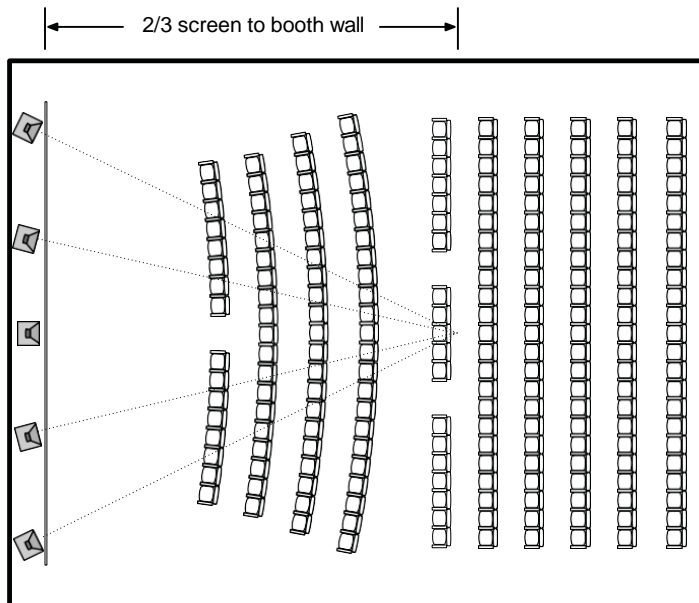


In auditoriums with a fixed image width and top moving masking, place the left and right screen speakers just inside the edge of the image, with the acoustic center midway between the two-thirds image height for the flat and scope images, as shown in the following figure.

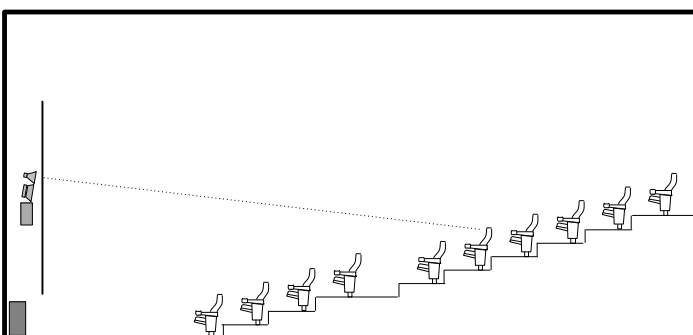


2.6 Screen Speaker Aiming

Rotate the screen speakers horizontally so that the axis of the speaker is oriented at the RLP, along the screen center line, as shown in the following figure. Only the horns should be rotated horizontally for speakers mounted in a baffle wall, keeping the low-frequency section flush with the wall. In cases where the screen speaker is within a single cabinet, rotate the entire cabinet.



For vertical aiming, tilt the screen speaker horns downward to optimize coverage over the seating area. Typically, the down angle should aim the axis at the RLP, as shown in the following figure. Refer to the speaker manufacturer aiming recommendations, as axis and directional characteristics change from product to product. We recommend modeling the coverage with manufacturer supplied speaker data files and modeling software provided by a vendor other than Dolby.



2.7 Screen Speaker Requirements for LED Screens

In auditoriums with an LED screen, the capabilities of the speakers and amplifiers must satisfy the Dolby Atmos requirements, as determined by the Dolby Audio Room Design Tool (DARDT).

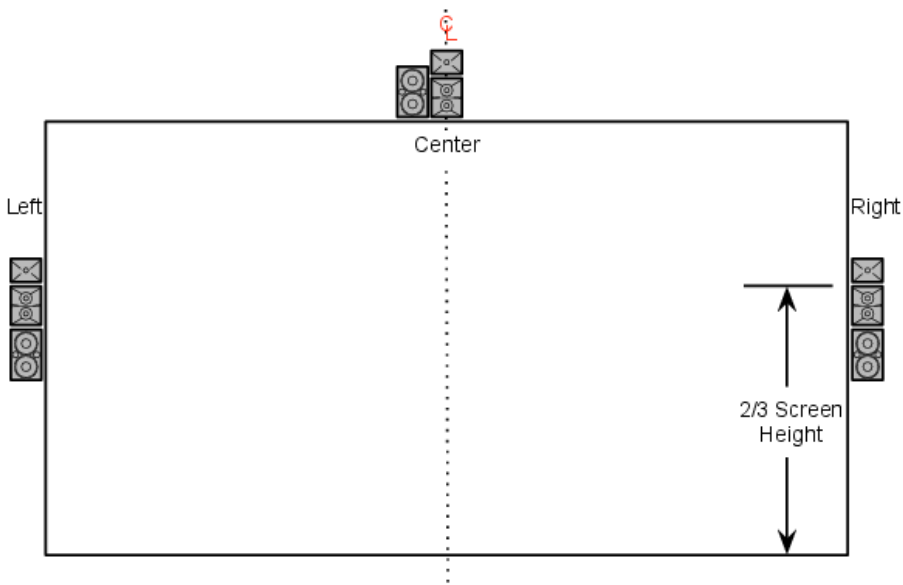
The center speaker must be placed over the top of the screen. The center speaker must be positioned directly above the screen and positioned so the mid/high frequency assembly is at the centerline of the screen with the low frequency positioned next to the mid/high frequency.

The ceiling design and other architectural features cannot block the output of the center speaker to all rows of seats in the auditorium. If there is an architectural feature that creates an acoustic shadow for any seats, the auditorium is not a candidate for Dolby Atmos if modifications cannot be made to eliminate the blockage.

Depending on the auditorium geometry, seating proximity to the screen, and the directional characteristics of the chosen speakers, a down firing speaker may be required to ensure adequate high frequency performance at the front of the seating area. The down firing speaker must be placed adjacent to the center speaker. The down firing speaker needs additional processing for equalization and gain.

The left and right speakers must be placed to the sides of the screen. The elevation of the left and right speakers is based on the speaker selected, such that its acoustic center is $\frac{2}{3}$ the screen height, which is consistent with current Dolby Atmos practices when speakers are behind the screen. Left and Right screen speakers cannot be placed above the screen. If there is insufficient space adjacent to the screens to install the left and right speakers in the wide positions, the auditorium is not a candidate for Dolby Atmos.

The screen speakers must be baffled to control the acoustic conditions near each speaker. If a baffle is not viable, it is a requirement that the wall and ceiling and wall surfaces near each speaker are covered with ≥ 50 mm of absorptive treatment to mitigate potential artifacts. The demising wall and sidewalls adjacent to the left and right speakers should be covered with ≥ 50 mm of absorptive treatment to prevent sound from building up behind the LED screen, which then becomes audible in the auditorium. If the screen speakers are hidden behind material, it must be acoustically transparent.



3 Screen Subwoofer

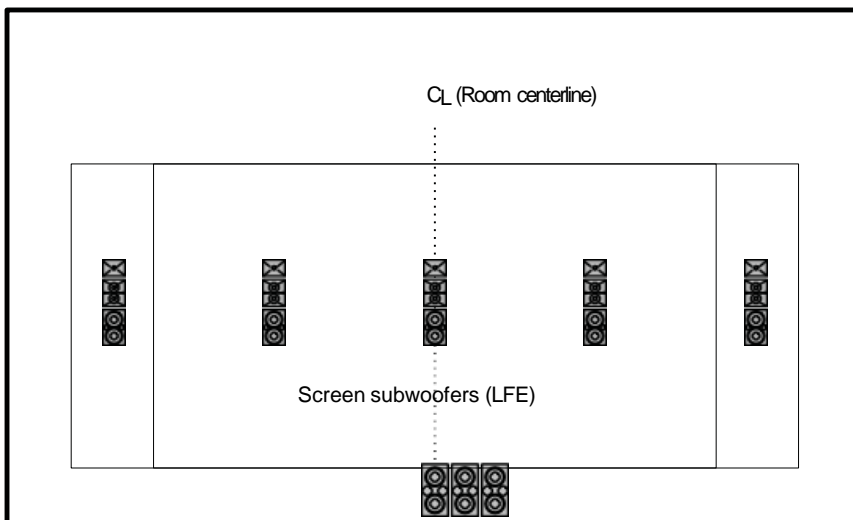
3.1 Screen Subwoofer Sound Pressure Level: +10 dB (Compared to Center Speaker)

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 (SMPTE RP 200). For example, as viewed on a real-time analyzer.

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

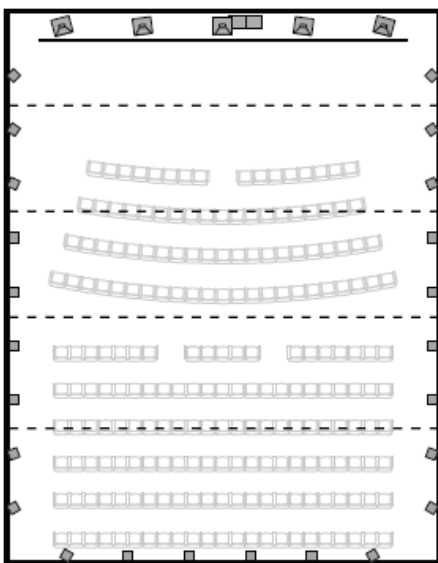
3.3 Screen Subwoofer Position

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. In the case of alternate configurations with multiple cabinets, best practices such as gain shading and delay should be applied.

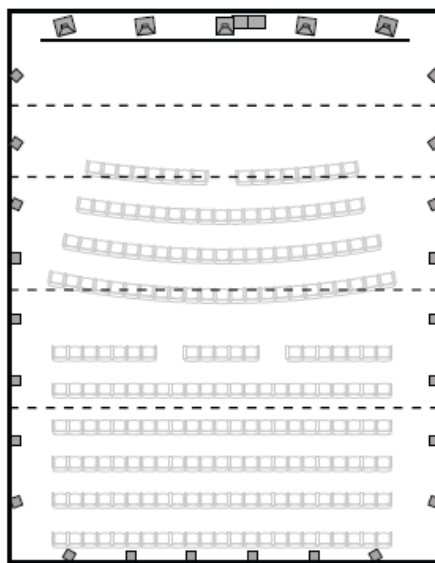


4 Surround Zones and Regions

B-chain requirements (including the number and distribution of surround speakers and amplifier channels) are specified in terms of zones and regions within the cinema. There are six zones: left side, right side, left rear, right 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 speakers, except for the front-most (closest to the screen) region(s). The front-most region always consists of a single L/R speaker 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 speaker pair. In addition, DARDT indicates the number of side surround speakers identified as front wide positions and are part of the side surround arrays. For auditoriums with LED screens, side surrounds, rear surrounds, and top surrounds must be installed following the same rules.



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 speakers used on each side of the cinema.

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

and

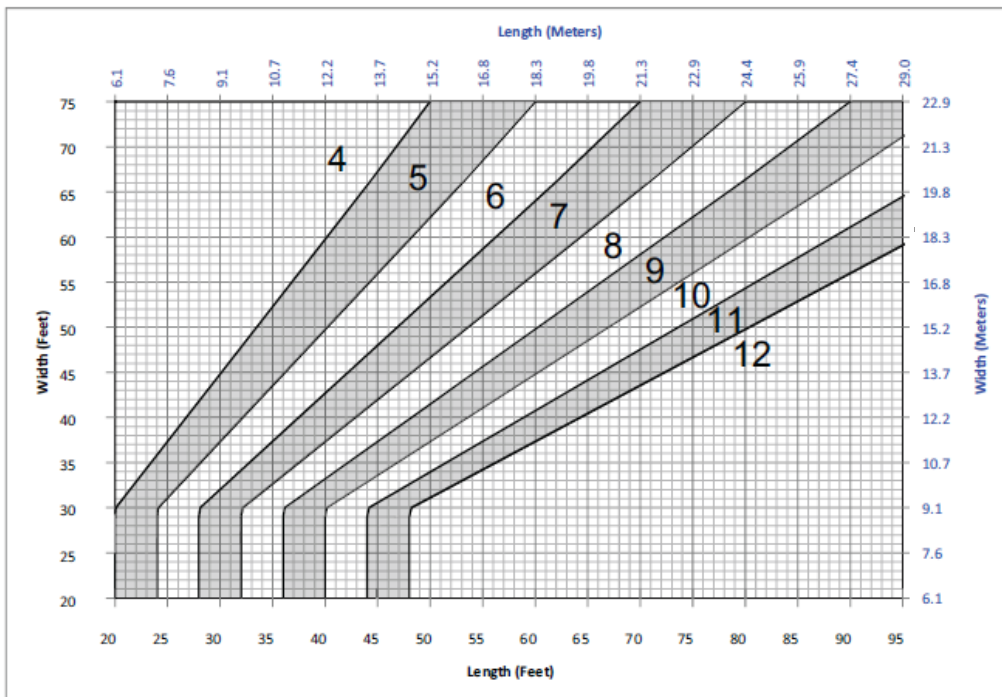
$$R \geq \min(4, Nss)$$

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

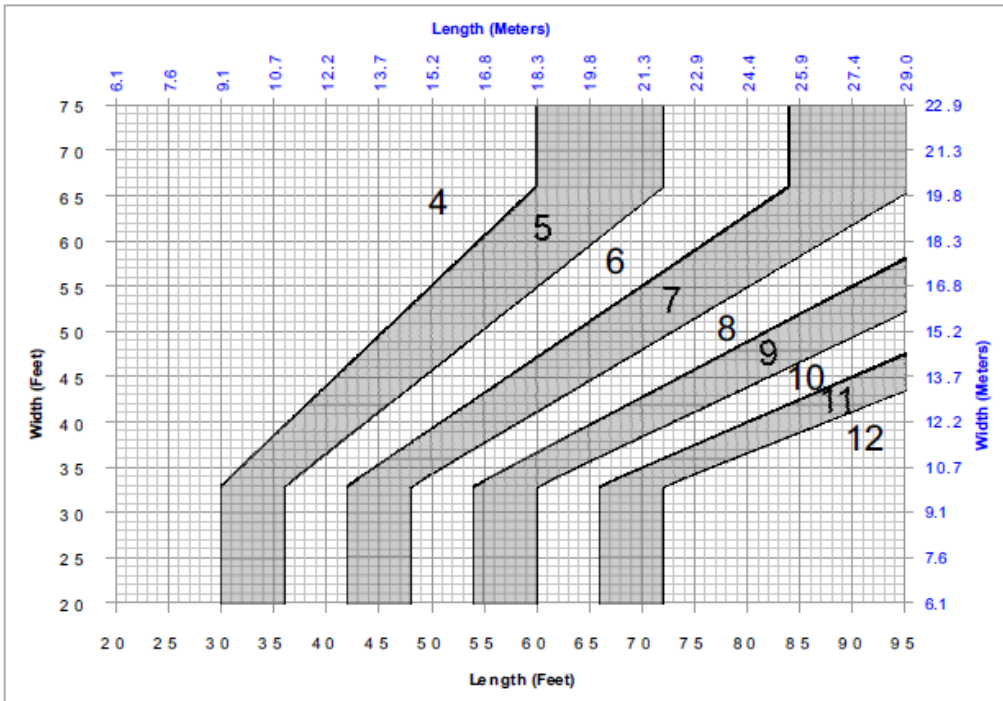
4.1 Number of Side Surround Speakers

To maintain sound quality and accurately reproduce the original intent of the content creator, the number of speakers required for a particular installation is a function of the auditorium dimensions. Dolby Atmos systems generally require a large number of speakers.

The following figure shows the recommended number of speakers in the left and right-side surround zones, as a function of the auditorium length and width of the rear wall (shown in feet and meters). Meters are in blue text. In the case of curved screens, the auditorium length is defined from the screen edge to the corner of the rear wall.



The following figure shows the required (minimum) number of speakers in the left and right-side surround zones, as a function of the auditorium length and width (shown in feet and meters). Meters are in blue text. In the case of curved screens, the auditorium length is defined from the screen edge to the corner of the rear wall.



4.1.1 Pairing of Side Surround Speakers

Speakers 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 speaker without phase, level, or delay differences, and can be driven by a single amplifier channel. Some or all of the speakers within a region can be paired in accordance with the following rules:

- The number and location of side surround speakers must conform to the normal specification, as defined in the previous figures.
- Paired speakers must be the same make and model.
- All paired speakers must be located to the rear of discrete unpaired speakers, that is, when pairing speakers, start by pairing the rear-most (closest to the booth wall) region, and move forward.
- The front-most left and right-side surround speakers are always in their own region and must not be paired.
- For LED screens, side surround speakers cannot be paired.

4.2 Number of Top Surround Speakers

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

The next section describes optional pairing or reduction in the number of top surround speakers.

4.2.1 Pairing and Culling Top Surround Speakers

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

Culling reduces the number of top surround speakers relative to the previous figures. The speaker 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 spatial resolution.

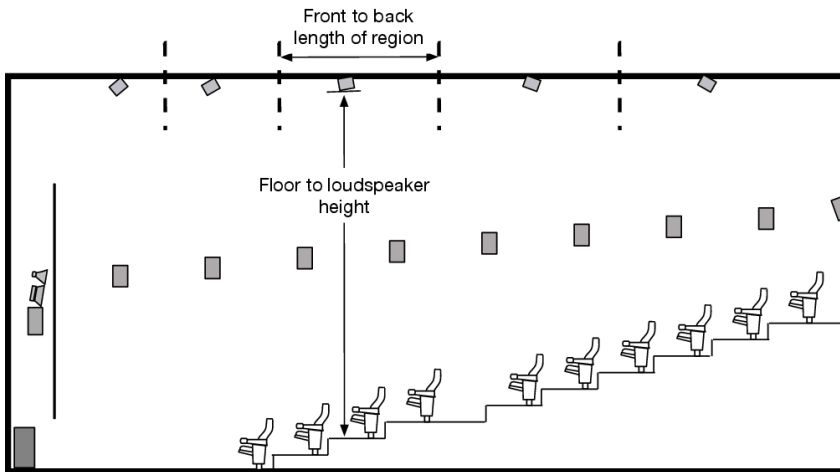
To pair top surround speakers, follow these guidelines:

- The speakers 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 speakers must be of the same make and model.
- All paired speakers must be located to the rear of discrete, unpaired speakers. When pairing speakers, start by pairing the rear-most region, and then move forward.
- The front-most left and right top surround speaker are always located in their own region and must not be paired.
- In the case of LED screens, top surround speakers cannot be paired.

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

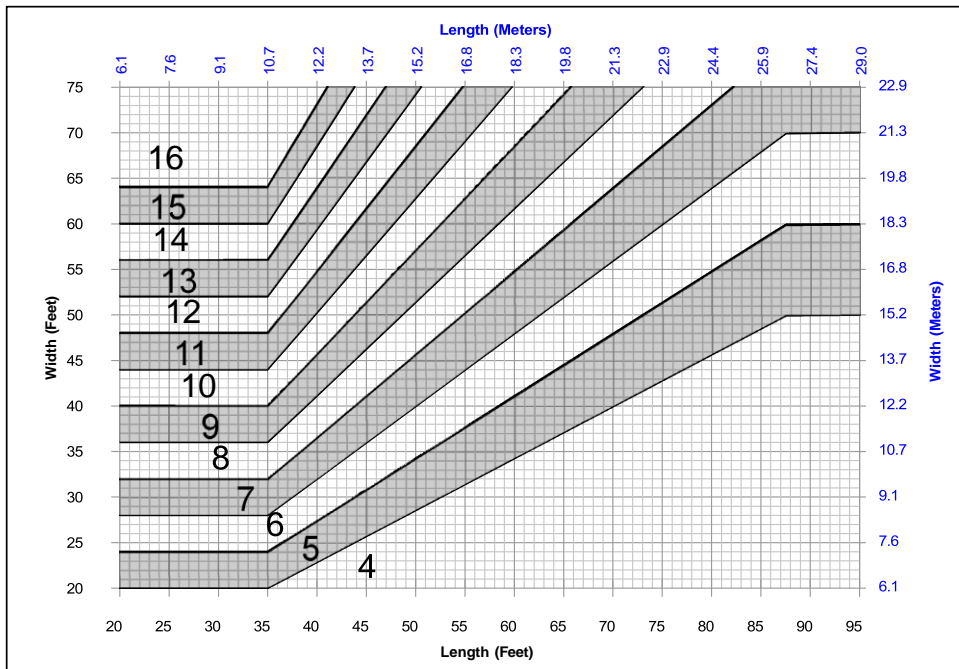
- The speakers must be in the same region and zone (for example, front-most, 2-speaker region on the left top surround zone).
- The left and right zones must be the same, that is, both must be discrete, culled, or paired.
- All regions where the quantity of speakers is reduced must contain single (individually driven) speakers located to the front of regions with two speakers. When reducing speakers, start from the front and move backward.

- The floor-to-speaker height of a speaker 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).

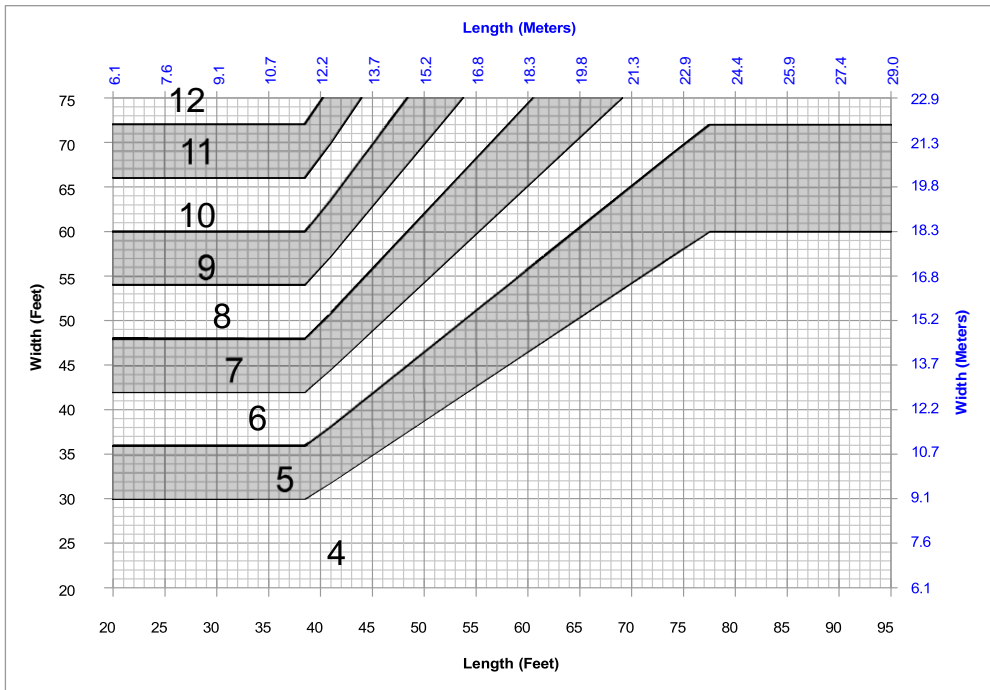


4.3 Number of Rear Surround Speakers

The following figure indicates the recommended number of speakers 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 speakers 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 Speakers

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

- The number and location of rear surround speakers must conform to the normal specification as defined in the previous figures.
- Paired speakers must be of the same make and model.
- All paired speakers must be located to the outside of discrete, unpaired speakers. When pairing rear surround speakers, 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 speakers, the center speaker cannot be paired.
- In the case of LED screens, rear surround speakers cannot be paired.

4.4 Surround Speaker Sound Pressure Level: 99 dB

Each speaker and associated amplifier must have a maximum output capability of 99 dB continuous SPL at the RLP (defined on [page 1](#)). Speaker 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 speakers, each speaker 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 speakers with limited bass response require bass management. If bass management is used, the recommended surround speaker frequency response (+/-3 dB) is 90 Hz or lower. The required surround speaker frequency response is (+/-3 dB) at ≤ 130 Hz. The crossover frequency should be set based on the capabilities of the surround speakers, but must not be higher than 130 Hz.

For larger auditoriums (>500 seats), auditoriums with more than seven surround speakers on a side wall, or where the specified bass management crossover frequency is higher than 80 Hz, we recommend additional subwoofer pairs.

4.7 Surround Speaker Coverage Angles

To provide uniform coverage across the seating area, the following nominal surround speaker coverage angles are required. Use these guidelines to select the most appropriate speaker model from the manufacturer line. In all of the following cases, coverage angle refers to the nominal angle between the speaker –6 dB points.

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

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

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

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

4.7.3 Horizontal Coverage Angle, Side Surround Speakers: 90°

Each side surround speaker that is adjacent to the CLA 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 Speaker: 50°, $\pm 10^\circ$

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

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

The front-most top surround speakers (those in front of the first audience seats) and the rear-most top surround speakers 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 Speaker: 100°

The top surround discrete speakers directly above the CLA 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 Speaker: 100°

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

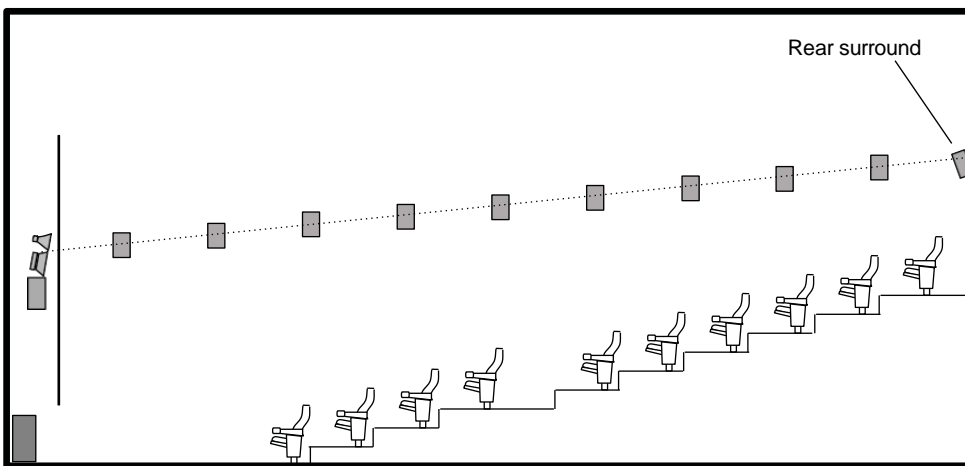
4.8 Rear Surround Elevation

The rear surround speakers 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 speaker and be out of the reach of patrons, where possible, to prevent tampering, damage, or theft. We recommend that the rear surround speakers be positioned at a height equal to one-quarter of auditorium width. In cases where the recommended elevation cannot be met, place the rear surround speaker at the ceiling and wall junction.

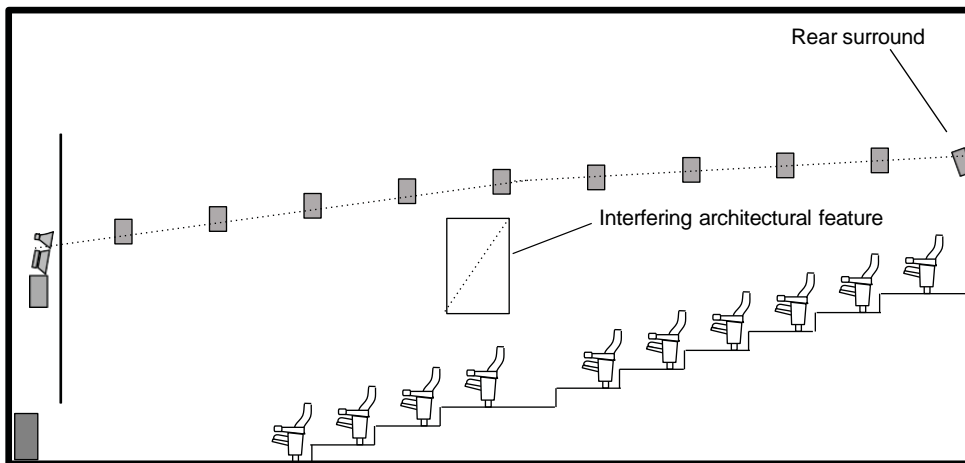
4.9 Side Surround Location and Aiming

4.9.1 Side Surround Elevation

The elevation of the side surround speakers should form a straight line from the acoustic center of the screen speaker array to the rear surround speakers, as shown in the following figure. The placement of the rear surrounds determines the rake of the line that is used to position the side surround speakers. In new constructions, Dolby Atmos installations should place the surround speakers on this line.



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 speaker 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.

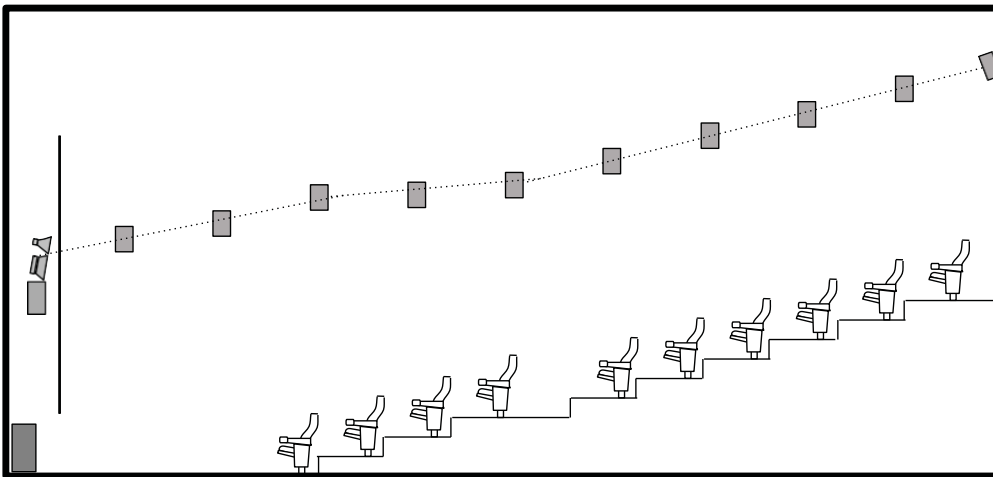


Similar principles apply when upgrading a legacy surround system to Dolby Atmos. Reusing existing speaker locations can ease the upgrade process and is acceptable if the existing speaker placement falls within the specified tolerance. Existing speaker mounts need to be upgraded to allow for both pan and tilt capabilities. Many cinemas configured for legacy surround sound formats place the surround speakers at a fixed elevation from the floor, rather than in a single straight line front-to-back. For Dolby Atmos, additional side surround speakers are typically required near the screen.

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

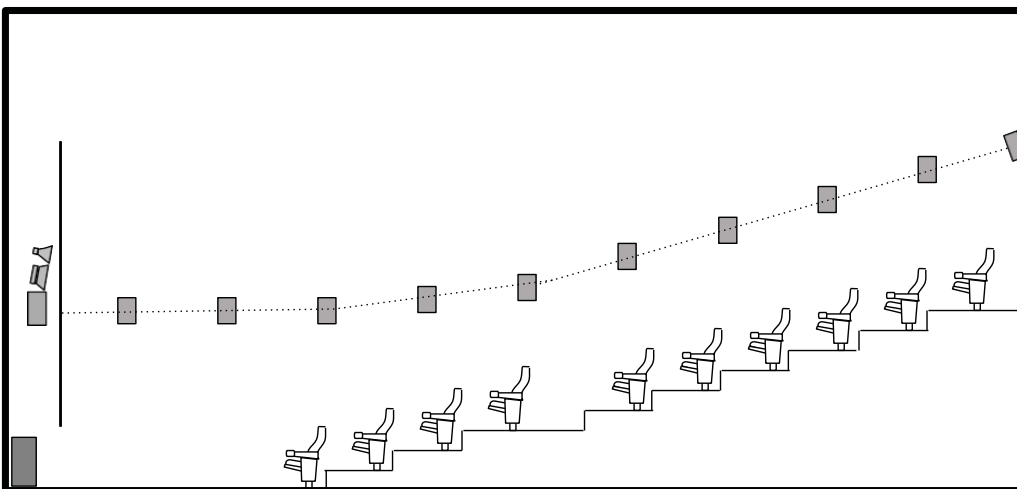
- If the acoustic center of the screen speaker array is lower than the front-most legacy side surround speaker, the line should connect these two points.
- If the acoustic center of the screen speaker array is higher than the front-most legacy side surround speaker, the line of the new speakers should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

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



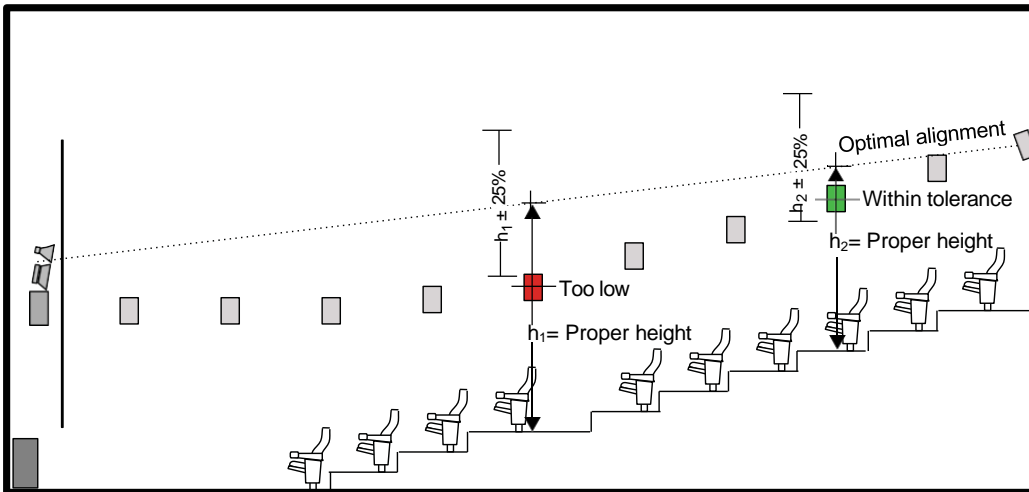
The following figure shows the alignment of new surround speakers for low-mounted legacy speakers. In this configuration, the new speakers are placed horizontally in line with the front-most legacy side surround speakers.

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



4.9.2 Side Surround Elevation Tolerance

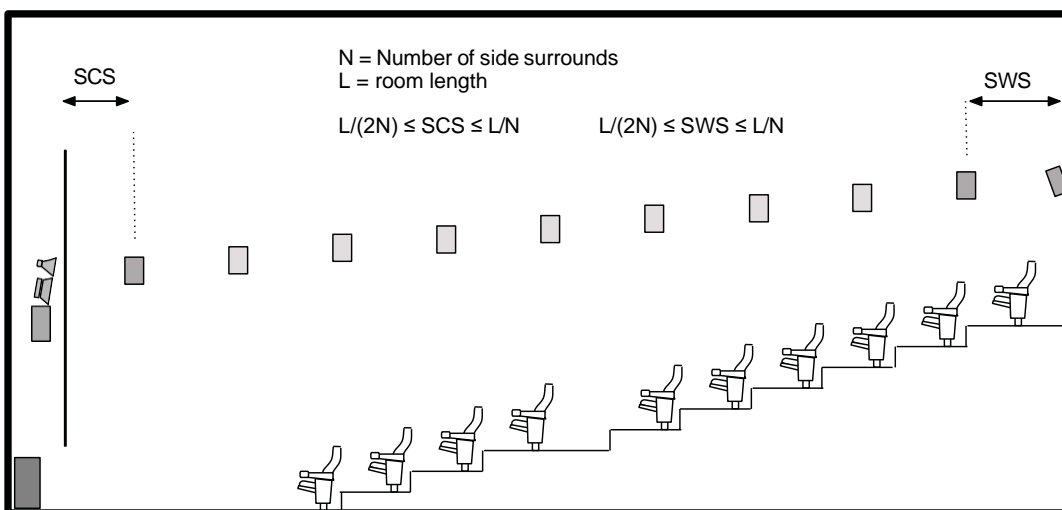
The proper elevation for each speaker corresponds to the height of the straight line joining the rear surround height and the screen speaker acoustic center as described above. Each speaker must be within 25% of the proper elevation. Allowance for upgrades from legacy systems will typically be given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



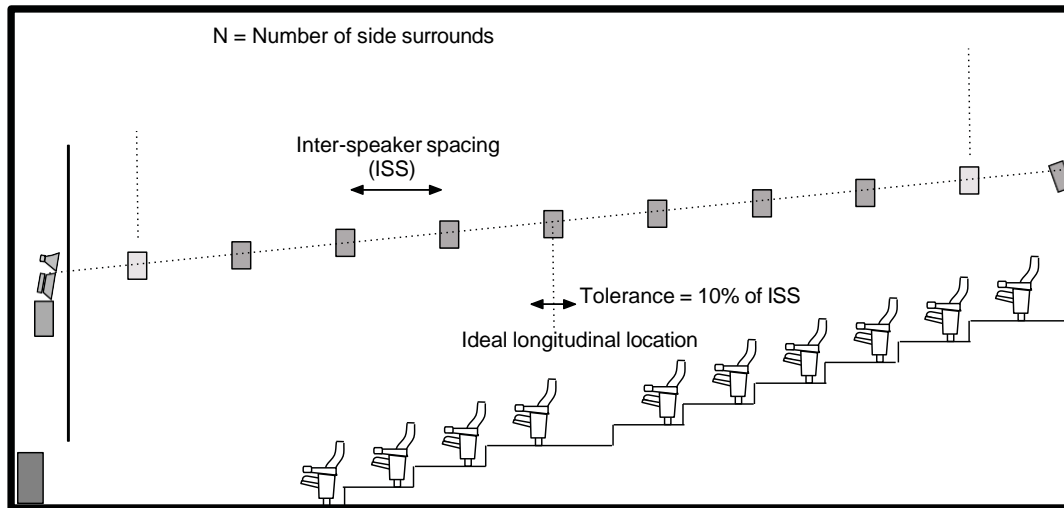
4.9.3 Side Surround Longitudinal Location

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

For new construction, place the front-most speaker at a distance between L/N and $L/(2N)$ from the front wall, and likewise, place the rear-most speaker 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 speakers and the correct speaker-screen spacing (SCS) and speaker-wall spacing (SWS). Note that in the case of a curved screen, the distance from the edge of the screen to the first speaker should be used rather than from the center of the screen. However, the distance between the center of the screen and the front most surround row should not exceed the maximum SCS.



The remainder of the speakers should be evenly spaced to within $\pm 10\%$ between the front- and rear-most speakers. 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 speakers.



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 speaker positions. To determine if the existing speaker position is acceptable, extend the side surround arrays to the front of the auditorium with the same longitudinal spacing as the existing speakers. The existing speaker longitudinal position is acceptable if the following conditions are met:

- The resulting speaker count meets the requirements indicated in the previous table.
- The front-most speaker is at a distance of between L/N and $L/(2N)$ from the front wall.
- The rear-most speaker at a distance of between L/N and $L/(2N)$ from the rear wall.
- The speakers 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 speakers 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 speakers on the rear wall. The distance between the outside speakers and the side walls must be between 50 and 100% of the inter-speaker spacing.

4.11 Side and Rear Surround Horizontal Aiming

To determine the proper horizontal aiming for the side and rear surround speakers, define a rectangle in the CLA.

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

The remaining side and rear surround speakers 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 speaker to speaker. The front-most side surround speakers should be aimed to the RLP if the speaker aiming angle is less than the angle to the nearest corner of the CLA. Left/right speaker pairs should have the same aiming.

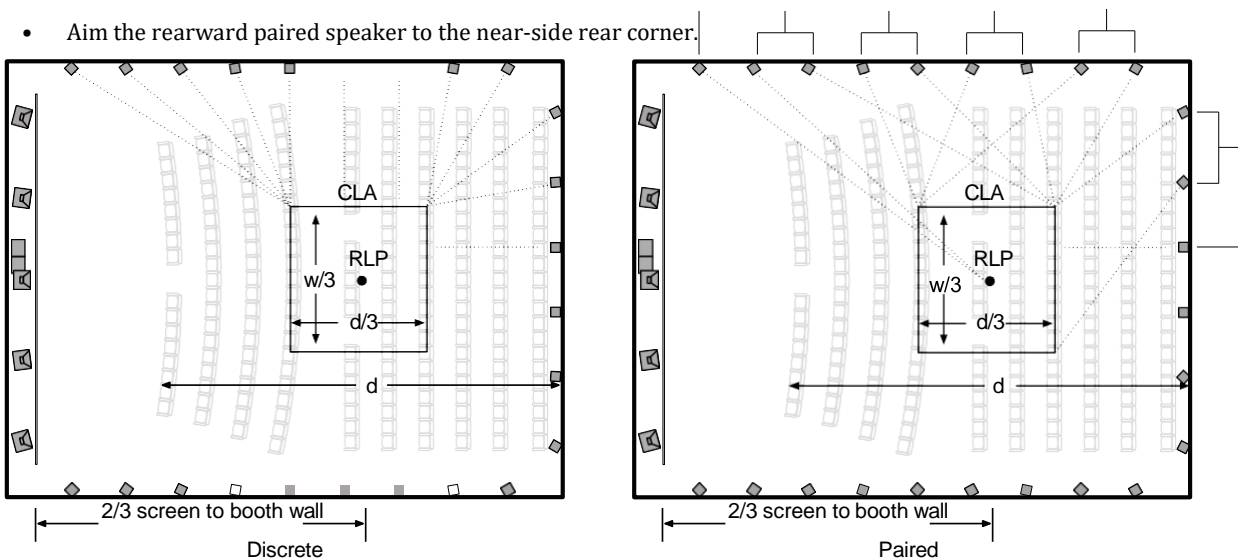
Discrete speakers must be aimed based on the CLA.

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

Note: CLA can be centered to the seating area in long and narrow auditoriums. If the forward most surround speaker aiming angle is greater than 65° , the CLA can be adjusted to the center of the seating area.

For installations that utilize speaker pairing, splaying the paired speakers is required to improve sound coverage. Paired speakers must be aimed based on the CLA.

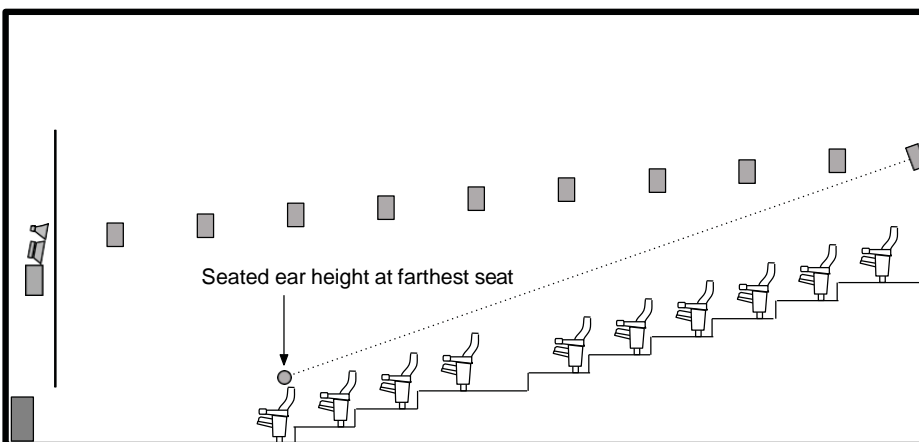
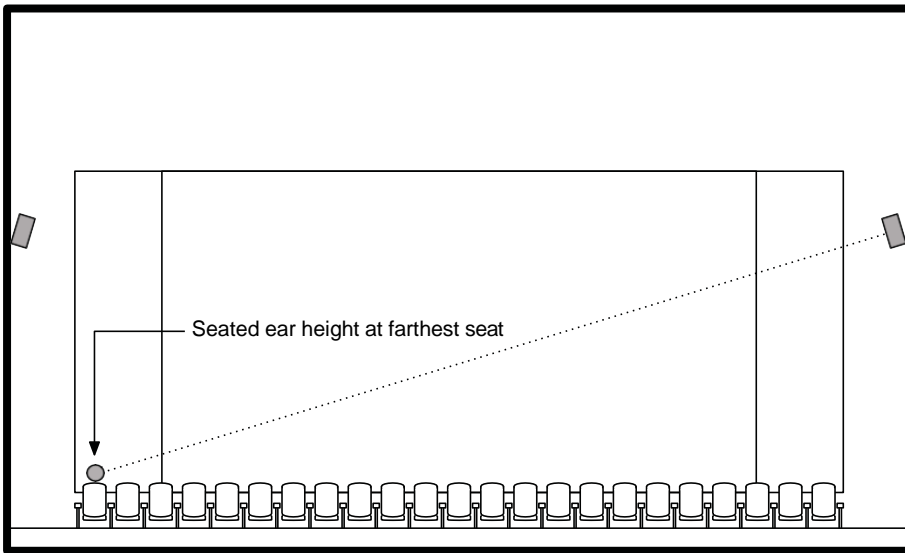
- Aim the forward paired speaker to the near-side forward corner.
- Aim the rearward paired speaker to the near-side rear corner.



4.12 Side and Rear Surround Elevation Aiming

Side and rear surround speakers should be tilted vertically to orient the axis of each speaker to the ear height of a seated listener in the farthest seat, after the horizontal, lateral aim of the particular speaker. (See the following figures.) The speaker can be aimed higher or lower, but not by more than half the speaker vertical coverage angle. Depending on the auditorium geometry, the soundfield benefits from individual aiming of the surround speakers. 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 speakers should have the same downward tilt. The tilt of the side surround speakers should not change abruptly ($>10^\circ$) from speaker to speaker along the array.

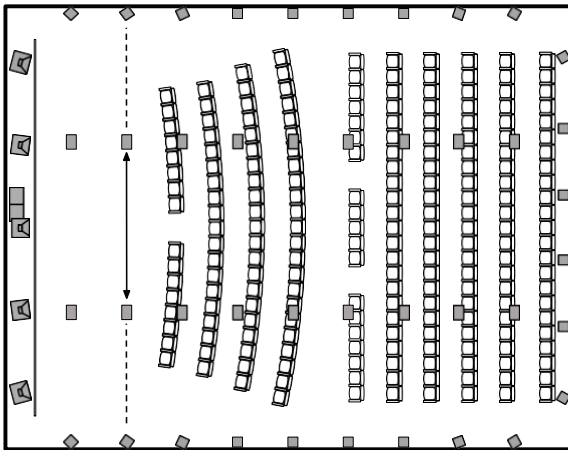
For installations with non-transparent LED screens, rear wall surrounds are aimed to minimize potential long delayed reflections off the screen.



4.13 Top Surround Position

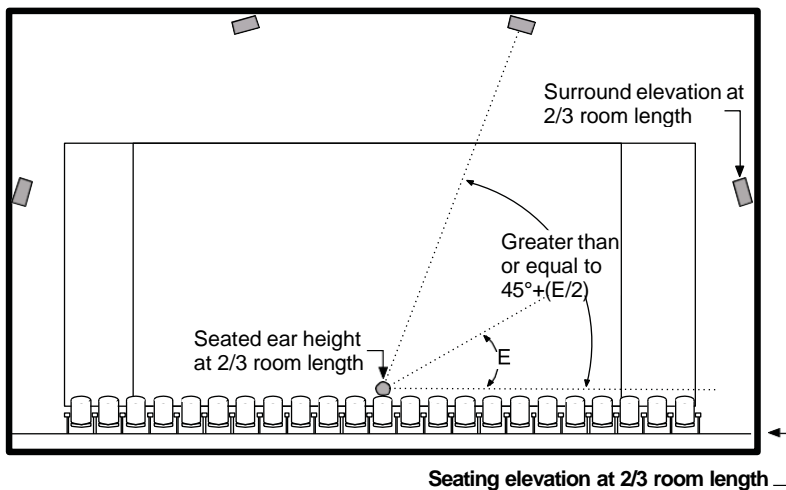
Top surround speakers must always be placed as left/right pairs, with the left speaker and right speaker at the same distance from the front wall.

The top surround speaker pairs must be placed symmetrically with respect to the screen center line. Typically, the top surround arrays should be placed in line with the left center and right center screen speakers, which is the minimum width between top surround speakers on center. Auditoriums with three screen channels should use the midway point between left and center and right and center to define the minimum width between top surrounds. (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 speakers should then be determined by elevation angles as follows: Let E be the elevation angle of the nearest side surround speaker 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.)

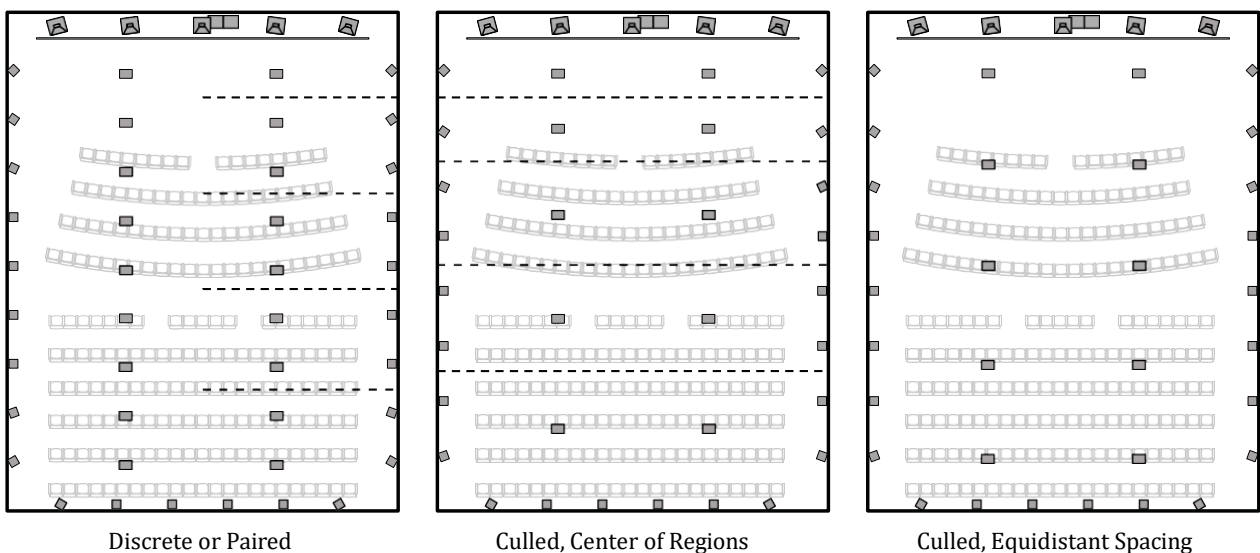
If there is no side surround speaker directly adjacent to the RLP or it is unclear which speaker to reference, it is acceptable to take angle E from the mid-point between two side surround speakers, a unit slightly in front and a unit slightly behind the RLP. Likewise for the top surround elevation angle, $45 \text{ degrees} + E/2$, an interpolated point between two top surround speakers can be used. The top surround arrays must not be placed in a position that is wider than the outer screen speakers.



4.14 Top Surround Longitudinal Location and Aiming

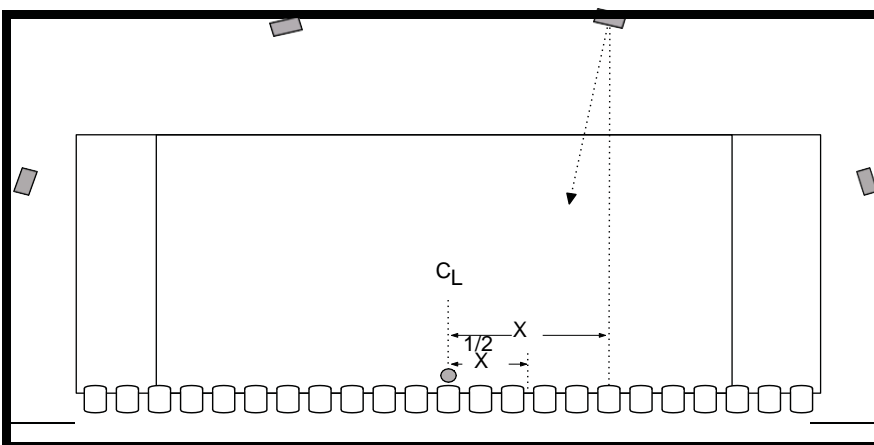
Top Surround Longitudinal Location

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



4.14.1 Top Surround Aiming

The top surround speakers must be angled laterally (across the width of the auditorium) to a position halfway between the lateral position of the top surround speaker and the screen center line, $\pm 10^\circ$. (See the following figure.) In some cases, cabinets with a built in 15 degree tilt can be rotated 90 degrees counterclockwise (for top left surround) and clockwise (for top right surround) to reduce the height of the cabinet and satisfy the inward tilt requirement.



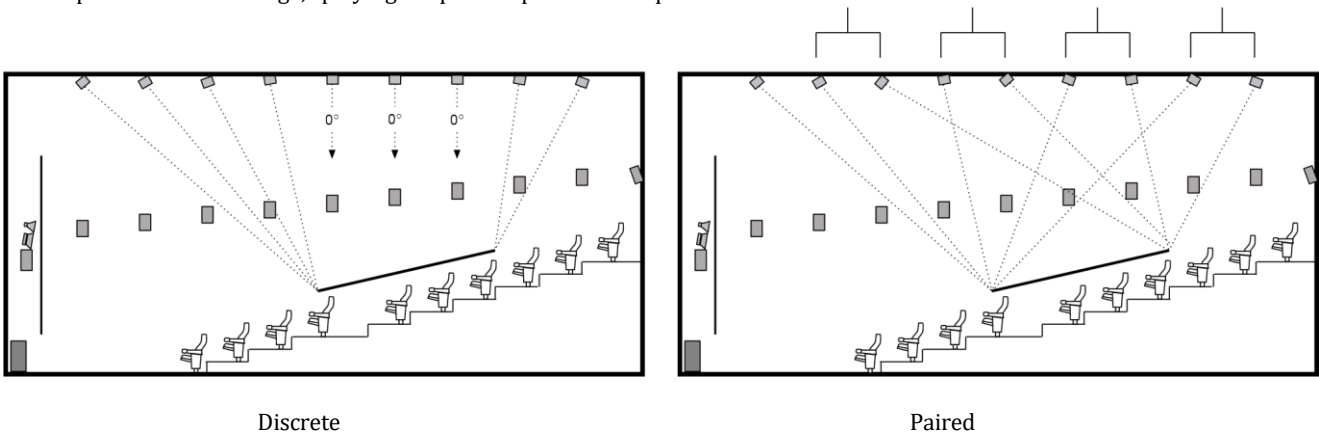
Top surrounds should be angled longitudinally (along the length of the auditorium) in a manner similar to the angling of the side surrounds (taking 0° as aiming vertically downward). (See the following figure.)

When aiming discrete speakers:

- Speakers over the CLA should aim neither forward nor backward. That is, they should be aimed at 0° . (CLA is defined on [page 15](#).)
- Speakers 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 speaker to speaker should be avoided. When aiming paired speakers:

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

To improve sound coverage, splaying the paired speakers is required.



Discrete

Paired

4.15 Speaker Aiming Tolerance

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

5 Surround Subwoofers

Dolby Atmos auditoriums must support playback of full-range surround signals. Surround speakers with limited bass are acceptable if surround subwoofers and bass management are used. Dolby Atmos cinema processors support bass-management signal processing. For practical installations, this is the most common approach. When using bass management, a minimum of two dedicated surround subwoofers are required and the surround subwoofers must meet the requirements described in this section. Subwoofers assigned as LFE cannot be used for surround speaker bass management.

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 in-band gain (Compared to Center speakers)

The left surround subwoofers and right surround subwoofers—speaker 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). Refer to [Section 2.2](#).

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. Always follow individual manufacturer guidelines. For example, some manufacturers do not recommend suspending their subwoofers with the drivers facing down.
- For front wall placement, the surround subwoofers should be wider than the left and right screen speakers and must be positioned within the perforated screen area.
- 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 seating area. Placement high on the side walls or on the ceiling is best. The distance from each surround subwoofer to the nearest seating area 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 Speaker 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 speaker capabilities, and the auditorium itself. Existing speaker 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 speaker performance requirements for achieving standard cinema levels in all cases; one can only estimate.

6.1 To assist in determining the required speaker output capability, we recommend the following:

- Determine the speaker maximum continuous output SPL (SPL_{max}). This is often specified in the documentation provided by the speaker manufacturer. If SPL_{max} is not stated, compute it using the rated sensitivity of the speaker (1 W at 1 m) and power handling (IEC noise, with AES duration of two hours), as follows: $SPL_{max} = \text{sensitivity} + 10 \times \log_{10}(\text{power handling})$
- Measure the distance in meters (D2) from the speaker to the RLP.
- Using this distance information, calculate the sound pressure attenuation from the speaker 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).

- Add the values for distance attenuation and SPL_{max} to determine the level at the RLP. $\text{Level at RLP} = SPL_{max} + \text{distance attenuation}$

6.2 To assist in determining screen speaker passband requirements, passband is calculated in the DARDT spreadsheet, based on the data in the speaker database. Equipment that is not listed in the speaker database can be entered manually via the **ExtraEquipmentEntry** tab.

When determining the SPL capability of a screen speaker system or the low-frequency component, use half-space sensitivity if the speaker 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 cabinet.

7 Glossary

Acoustic Center: An apparent location in a speaker where sounds appear to radiate from one single point.

CLA (Central Listening Area): Central listening area is centered on the reference listening position and is one-third the auditorium width and one-third the distance between the first and last row.

DARDT: Dolby Audio Room Design Tool. A Microsoft Excel based tool that helps users plan and specify the sound equipment required in cinema auditoriums for the faithful reproduction of Dolby Atmos cinema content.

Half space sensitivity: When a sound source is in a free field, the sound it produces radiates in all directions at low frequencies. When the source is placed against a single solid boundary, such as a wall, the low frequencies cannot expand in a spherical manner. The energy that should have gone backwards is directed forward due to the boundary, effectively doubling the amount of sound energy into that half space environment, resulting in increased sound power.

ISS (Inter speaker spacing): The distance between the front and rear-most side surround, divided by the number of side surrounds minus one.

Mutual Coupling: Mutual coupling occurs when two, or more, subwoofers are collocated whereby the sound pressure acoustically sums as vector quantities. The combined sound pressure level (dB) acts as one single waveform, increasing the acoustic output of the subwoofer cluster.

RLP (Reference Listening Position): A point two-thirds of the distance to the rear wall in the auditorium, typically on the centerline of the screen.

SCS (Speaker to screen spacing): The distance from the center of the screen, or edge of the screen in the case of a curved screen, to the first surround speaker.

Speaker Axis: A line that passes from a point on the speaker in a direction specified by the manufacturer. Adjusting the speaker to orient the speaker axis to aiming points in the auditorium optimizes frequency response uniformity over the listening area.

SWS (Speaker to wall spacing): The distance from the rear wall to the last surround speaker.

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