Dolby

Dolby Atmos Home Entertainment Studio

Technical Guidelines

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Notices

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Dolby Laboratories, Inc.
1275 Market Street
San Francisco, CA 94103-1410 USA
Telephone 415-558-0200
Fax 415-645-4000
http://www.dolby.com

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Contents

1

Introduction to this documentation

This documentation details technical guidelines for studios wishing to employ a 7.1.4 or greater home entertainment Dolby Atmos monitoring setup. You can alternatively use a 5.1.4 layout, although 7.1.4 or greater is the preferred layout for a Dolby Atmos Home Entertainment Studio.

1.1 Abbreviated speaker notations

Dolby documentation uses specific names and abbreviations to describe speakers or speaker channels. Dolby notation may differ from the names and abbreviations used by other organizations and companies.

Note: This information is provided for reference only. Not all speaker outputs identified in the table are supported by your product.

Table 1: Dolby speaker notation correspondences

Dolby notation		CTA-861	ITU-R BS.2159-5 (Type B 10.2 channel)	SMPTE 2036-2 (22.2 channel)	IEC 62574 (30.2 channel)
L	Left	FL	L	FL	FL
R	Right	FR	R	FR	FR
C	Center	FC	C	FC	FC
Ls	Left surround	RL	LS	—	LS, LSd
Rs	Right surround	RR	RS	—	RS, RSd
Lrs	Left rear surround Left back	RLC	LB	BL	BL
Rrs	Right rear surround Right back	RRC	RB	BR	BR
Cs S	Center surround	RC	—	BC	BC
Lw	Left wide	FLW	—	—	FLW
Rw	Right wide	FRW	—	—	FRW
Lc	Left center	FLC	—	FLC	FLC
Rc	Right center	FRC	—	FRC	FRC
Ls1	Left surround 1	—	—	SiL	SiL
Rs1	Right surround 1	—	—	SiR	SiR
Lfh Lvh	Left front height	FLH	LH	TpFL	TpFL
Rfh Rvh	Right front height	FRH	RH	TpFR	TpFR
Ltm Lts	Left top middle Left top surround	—	—	TpSiL	TpSiL
Rtm Rts	Right top middle Right top surround	—	—	TpSiR	TpSiR
Ltf	Left top front	—	—	—	—
Rtf	Right top front	—	—	—	—
Ltr	Left top rear	—	—	—	TpLS
Rtr	Right top rear	—	—	—	TpRS
Lrh	Left rear height	—	—	TpBL	TpBL

Table 1: Dolby speaker notation correspondences (continued)

Dolby notation		CTA-861	ITU-R BS.2159-5 (Type B 10.2 channel)	SMPTE 2036-2 (22.2 channel)	IEC 62574 (30.2 channel)
Rrh	Right rear height	—	—	TpBR	TpBR
LFE LFE1	Low-frequency effects 1	LFE	LFE1	LFE1	LFE1
LFE2	Low-frequency effects 2	—	LFE2	LFE2	LFE2
Lsc	Left screen	—	—	—	—
Rsc	Right screen	—	—	—	—
Ls2	Left surround 2	—	—	—	—
Rs2	Right surround 2	—	—	—	—
Lcs	Left center surround	—	—	—	—
Rcs	Right center surround	—	—	—	—
Ch Cvh	Center height	FCH	—	TpFC	TpFC
Ts	Top surround	TC	—	TpC	TpC
Lbin	Left binaural	—	—	—	—
Rbin	Right binaural	—	—	—	—
Lo	Left only	—	—	—	—
Ro	Right only	—	—	—	—
Lsd	Left surround direct	—	—	—	—
Rsd	Right surround direct	—	—	—	—
Le	Left Dolby Atmos enabled	—	—	—	—
Re	Right Dolby Atmos enabled	—	—	—	—
Lse	Left surround Dolby Atmos enabled	—	—	—	—
Rse	Right surround Dolby Atmos enabled	—	—	—	—
Lrse	Left rear surround Dolby Atmos enabled	—	—	—	—
Rrse	Right rear surround Dolby Atmos enabled	—	—	—	—
Lrs1	Left rear surround 1	—	—	—	—
Rrs1	Right rear surround 1	—	—	—	—
Lrs2	Left rear surround 2	—	—	—	—
Rrs2	Right rear surround 2	—	—	—	—
Sh	Single height	—	—	—	—

1.2 Contacting Dolby

For more information, or if you have questions, visit our Knowledge Base and Discussion Community.

If you have questions or comments about this documentation, send an email to documentation@dolby.com.

2

Technical guidelines

The technical guidelines for creating a 5.1.4, 7.1.4, or greater Dolby Atmos home entertainment monitoring setup consider room geometry, room acoustics, speaker positioning and electroacoustic performance, mix equipment, and applicable Dolby Atmos rendering solutions.

2.1 About the technical guidelines

The technical guidelines are founded on the algorithms and function of the Dolby Atmos Renderer. They detail the best practices for accurate mix and replay capability.

In addition, we recommend that you consult the ITU-R Rec. BS.2051 standard publication for immersive audio.

2.2 Room design dimensions, terminology, and fundamentals

The home entertainment Dolby Atmos room geometry and speaker layout specification takes into account several factors to provide a commercial facility with an optimum space for mixing. These include speaker positions used by the Dolby Atmos Renderer, typical studio geometry, and multiperson production teams.

2.2.1 Room layout design

When considering planning for a home entertainment Dolby Atmos studio setup, the key dimensions to consider should be those of the speaker layout rather than the room dimensions.

These dimensions are considered:

- Speaker layout height: This is the distance from the floor to the lowest top surround speaker baffle.
- Speaker layout width: This is the maximum width between side wall speaker pairs as measured between speaker baffles. For circular layouts, use the circle diameter.
- Speaker layout length: This is the maximum length between screen and rear speakers as measured between speaker baffles. For circular layouts, use the circle diameter.

To ensure an accurate mix environment for Dolby Atmos for home entertainment, we recommend these layout dimensions and acoustic criteria.

Table 2: Recommended minimum and maximum layout dimensions

Dimension	Specification
Minimum layout height	2.4 m
Minimum layout width	3 m
Minimum layout length	3.5 m
Recommended room volume	>50 m^3
Speaker distance to mix position	≤5 m (<4 m recommended) [a]

[a] For rooms that require greater distances to the mix position, visit our Knowledge Base and Discussion Community and see *Extended speaker layout design* in this documentation.

Related information

Extended speaker layout design on page 23

Additional room design terminology and fundamentals

Your layout plan is subject to certain basic guidelines.

- Speaker layouts are referred to in the form x.y.z, where x is the number of standard plane speakers, y the number of subwoofers, and z the number of top surround speakers.
- The preferred speaker layout for a Dolby Atmos home entertainment studio is 7.1.4. For an alternative layout (such as 9.1.4 or 9.1.6), see *Extended speaker layout design*.
- A 5.1.4 layout is acceptable, however the absence of rear surrounds will lead to a difference in spatial resolution. Refer to *Speaker configuration design guidance for 5.1.4 speaker layouts in a Dolby Atmos Home Entertainment Studio* for 5.1.4 layout design guidance.

- The mix position is the reference point from which all speakers are placed in a home entertainment Dolby Atmos speaker layout. The ideal location for the mix position is 1.2 m in height, directly above the rear edge of the console arm rest, and in line with the center speaker.
- Ideally, all speakers should be equidistant from the mix position. Where this is not possible, and the distance to the mix position varies between speakers, delay and amplitude compensation are applied, to a suggested maximum of 10 ms.
- All speakers should be angled both vertically and horizontally toward the mix position, where possible. Where this is not possible, the mix position should be well within the dispersion angle of the speaker.
- The standard plane speakers are defined as L, R, C, Ls, Rs, Lrs, and Rrs. The overhead plane speakers are defined as Ltf, Rtf, Ltr, and Rtr.
- All measurements should be taken at the acoustic center of the speaker. This is typically at the mid-point of the low-frequency and high-frequency driver or waveguide, or the mid-frequency and high-frequency driver or waveguide.
- We use these geometric terms:

  Longitudinal plane
  A plane running from the front of the room to the rear, used to differentiate between references to in front of or behind the mixer, as opposed to on the sides.

  Longitudinal position
  The position of a speaker or mixer between the rear and front of the room.

  Longitudinal angle
  An angle between two positions on the longitudinal plane with reference to the mixer. For example, the longitudinal angle between the center speaker and the front top surround speaker could be 45°.

  Lateral plane
  A plane running from one side of the room to the other, used to differentiate references to the sides of the mix position, as opposed to in front of or behind it.

  Lateral position
  The position of an item between one side of the room and the other.

  Lateral angle
  An angle between two positions on the lateral plane with reference to the mix position. For example, the lateral angle between the left side surround speaker and the left top front surround speaker could be 60°.

  Horizontal plane
  This is the plane extending from the mix position at head height in a flat manner.

  Horizontal angle
  In Dolby Atmos room design, this is the angle from the center speaker to another speaker in the horizontal plane, with reference to the mix position.

  Horizontal angular placement
  The reference to the method used to determine the placement of a speaker using an angle.

  Vertical plane
  A plane running from the floor of a room to the ceiling.

Related information

Extended speaker layout design on page 23
Sample reference 7.1.4 layout diagrams on page 39
Speaker configuration design guidance for 5.1.4 speaker layouts in a Dolby Atmos Home Entertainment Studio on page 21

2.2.2 Room layouts

There are two common types of room layouts: equidistant and orthogonal.

Equidistant layout
In this layout, the distance to each speaker is approximately equal. The mix position is generally central at between 0.4 and 0.6 of the speaker layout length. This layout more closely adheres to Rec. ITU-R BS.2051, but can deviate from a completely circular shape.

Orthogonal layout
In this layout, the room usually has greater length than width, and the mix position is in the back half of the room. The mix position is typically between 0.5 to 0.7 of the speaker layout length.

The equidistant and orthogonal layouts both represent an accurate mixing environment and are possible within Dolby recommendations. The choice between them is largely based on room shape, preferred mix position, additional seating layout, multiple uses of a room, and space available.

2.2.3 Acoustics criteria

Your studio should meet the recommended acoustic criteria to ensure an accurate mix environment for Dolby Atmos for home entertainment.

Recommended acoustic criteria:

- Maximum noise floor level of NC25, with all equipment on, plus all intermittent and continuous noise sources present. Audible discrete noise sources should be addressed where possible.
- Strong discrete reflections should be suitably treated with absorption or diffusion as applicable to reduce coloration.
- In terms of reverberation decay time, RT60 measurements are taken at 125 Hz, 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, and 8 kHz. The results should fall between the upper and lower limits when plotted in the Dolby Audio Room Design Tool `.xlsb` Excel file. This file is available for download at our Knowledge Base and Discussion Community.

2.3 Speaker layout design

The step-by-step process for designing your speaker layout is influenced by whether you are using an equidistant or orthogonal layout.

2.3.1 Screen speakers

The position of the screen speakers is dictated by three main design aspects.

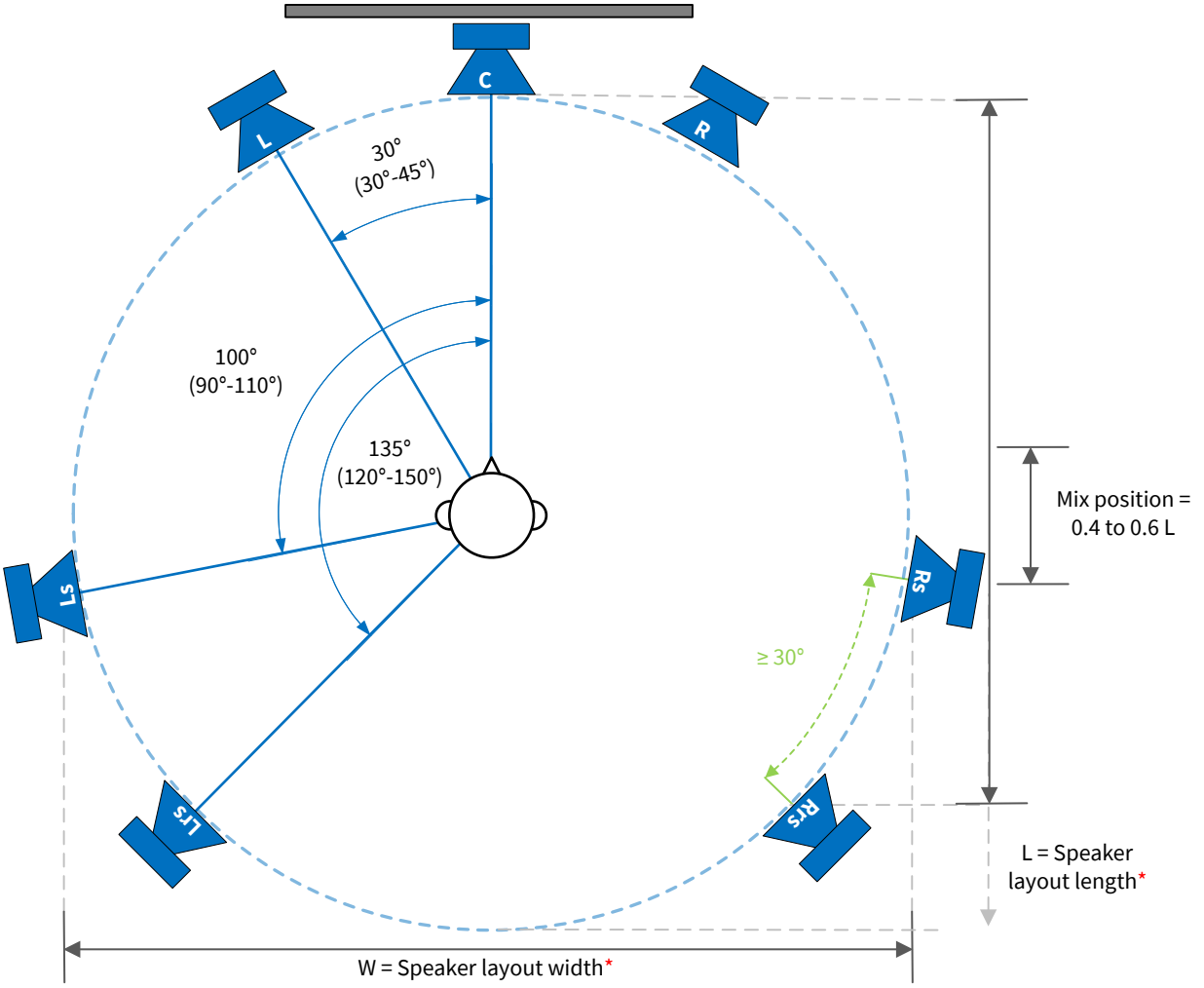
- Horizontal angular placement and angular separation from each other
- The desired elevation of the screen speakers, measured as an angle from the mix position
- The position and type of the display used

Screen speaker horizontal angles

The recommended ranges and the ideal horizontal angles from the center speaker are dependent on the layout type.

Refer to the drawing for your layout type.

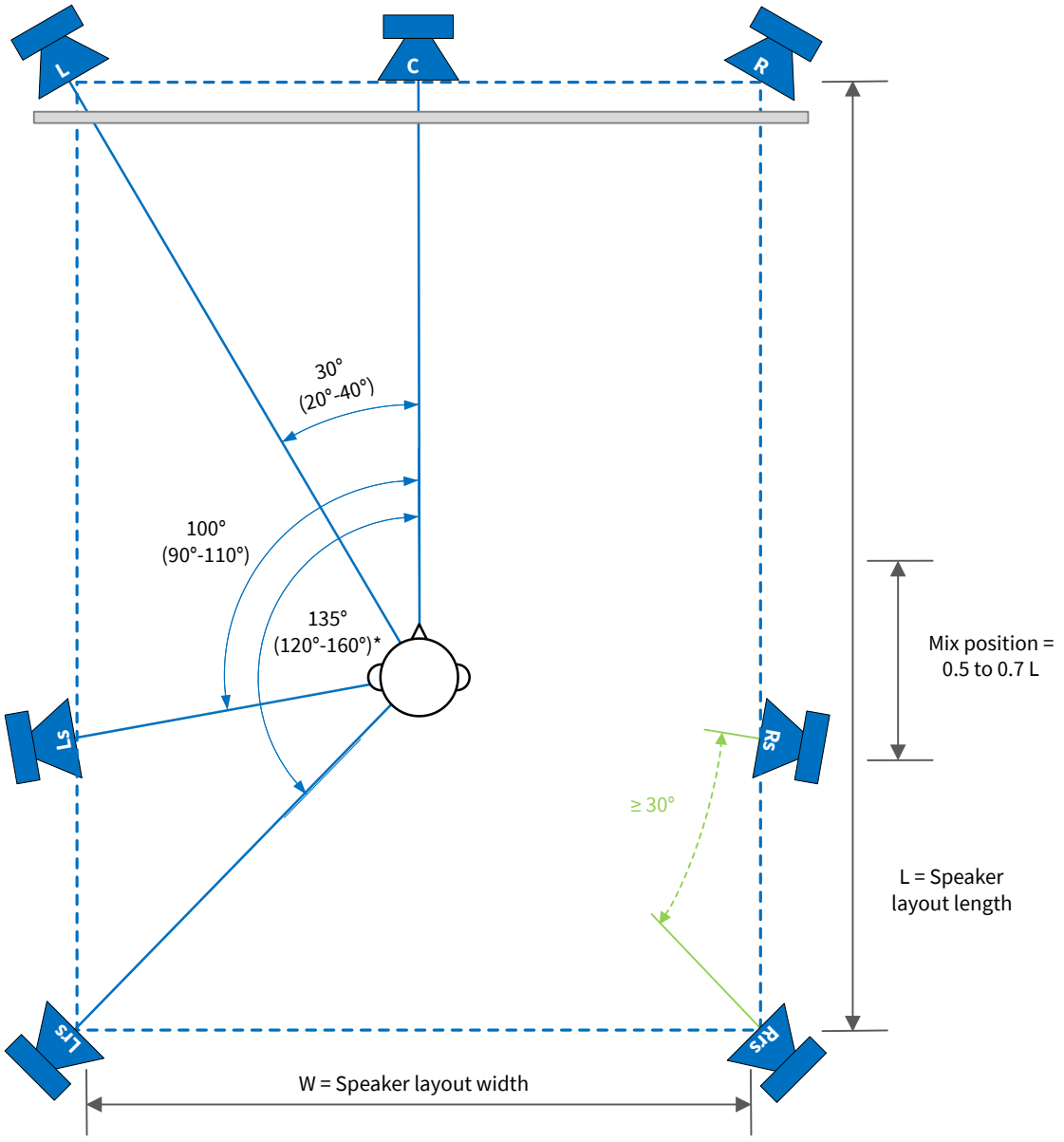
Figure 1: Equidistant layout plan view showing screen and surround speaker positions



Key

Ls/Rs = Left and right side surround
Lrs/Rrs = Left and right rear surround
n° = Recommended angle
(n°-n°) = Angle limits
W = Speaker layout width
L = Speaker layout length
≥ n° = Minimum separation angle
* = Layout width and length: For circular layouts, use the circle diameter. For other configurations, use the width and length between speakers.

Figure 2: Orthogonal layout plan view showing screen and surround speaker positions



Key

Ls/Rs = Left and right side surround
Lrs/Rrs = Left and right rear surround
n° = Recommended angle
(n°-n°) = Angle limits
W = Speaker layout width
L = Speaker layout length
* = 120°-150° preferred, but 160° is acceptable to enable rear wall positioning.
≥ n° = Minimum separation angle

Screen speaker elevation

We recommend that the screen speakers be positioned at seated ear height, at approximately 1.2 m. It may be necessary, however, to elevate them due to image displays, sight lines, and room use and geometry.

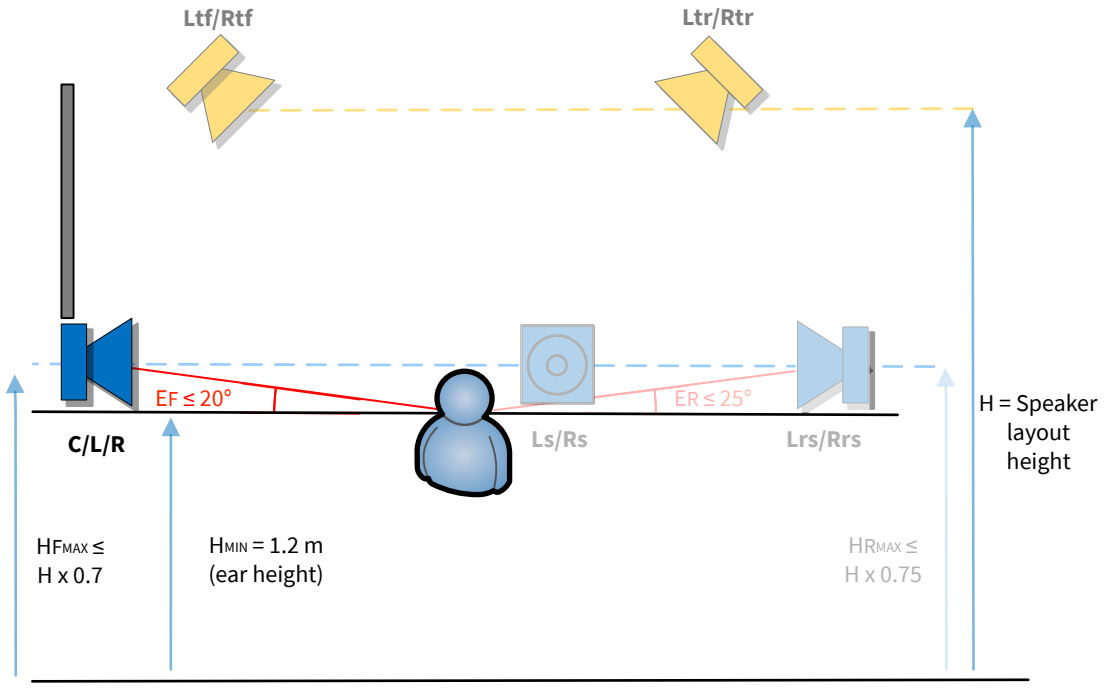
To minimize the sense of height when screen speakers are slightly elevated and ensure to adequate separation to the overhead speakers, these guidelines apply:

- The angle of elevation of the screen speaker should be no greater than 20°.

- The screen speaker height should be no greater than 0.7 multiplied by the layout height. For example, if the measured distance from the floor to the overhead speaker acoustic center is 3 m, the maximum screen speaker acoustic center height should be 2.1 m.

This diagram shows the recommended screen and front surround speaker positions for side elevation.

Figure 3: Side elevation diagram showing screen speaker positions



Key

Ltf/Rtf = Left and right top front speakers
Ltr/Rtr = Left and right top rear speakers
EF = Angle from horizontal to C, L, and R
ER = Angle from horizontal to Lrs and Rrs
H = Speaker layout height
HMIN = Minimum speaker height
HFMAX = Maximum screen, wide, and side speaker height
HRMAX = Maximum rear surround height

Display type and position of screen speakers

The position of the screen speaker is dependent on the display type: projected image or flat-panel monitor.

Projected image

When a projected image is used, the screen speakers should be behind an acoustically transparent screen, at equal height, and equally spaced, with the left and right speakers just within the width of, or slightly outside of, the screen. Ideally, the acoustic center of the screen speakers should be one-third to two-thirds the height of the screen.

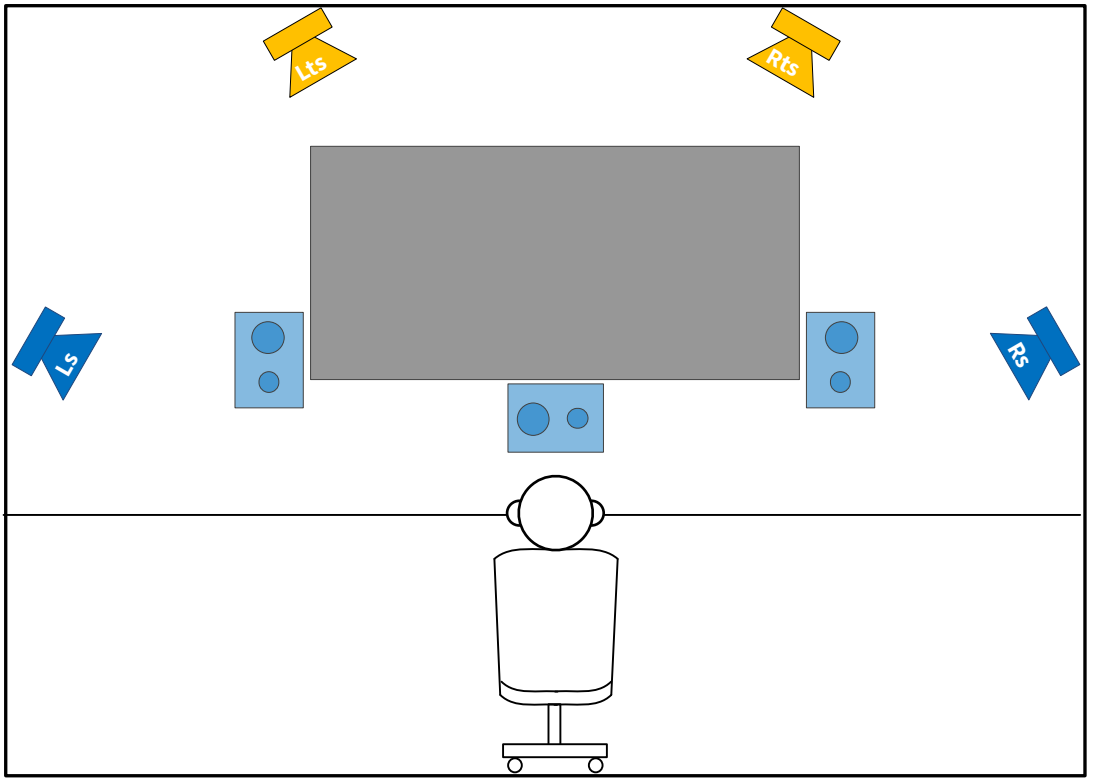
Flat-panel monitor

When a flat-panel monitor is used, the left and right speakers should be placed at the corresponding monitor edges, as long as this does not narrow the angle below the specification minimum. Where the angle is narrower than the specification minimum, place left and right speakers at the minimum angle, rather than the screen edge.

The center speaker should ideally be below the screen, and where possible, the left, center, and right speakers should be of equal height. If this is not possible, the acoustic center of the center speaker

should be vertically as close to the left and right as possible. Ideally, left and right should be no higher than midscreen.

Figure 4: Front elevation diagram showing screen speaker positions



2.3.2 Subwoofer placement

Place subwoofers off-center on the lateral plane, ideally on the floor, to avoid modal build up. Multiple cabinets, all fed from the LFE channel, can produce improved results.

2.3.3 Standard-plane surrounds

In a 7.1.4 Dolby Atmos setup, there are four standard-plane surround speakers. These are labeled left surround (Ls), right surround (Rs), left rear surround (Lrs), and right rear surround (Rrs).

Positioning of the standard-plane surround speakers is dictated by two main design aspects:

- Horizontal angular placement and angular separation from each other
- The desired elevation of the surround speakers, measured as an angle from the mix position

Standard-plane surrounds horizontal angles

The recommended ranges and the ideal horizontal angles for the side and rear surrounds are dependent on the layout type. For both types, we suggest a separation of at least 30° between Ls, Lrs, Rrs, and Rs.

For the equidistant and orthogonal layouts, see the respective figures in *Screen speaker horizontal angles*.

Related information

Screen speaker horizontal angles on page 11

Standard-plane surrounds elevation

We recommend that the standard-plane surround speakers be positioned at seated ear height, around 1.2 m, matching the ideal height of the screen speakers. It might be necessary, however, to elevate them due to room use, geometry, and architectural features.

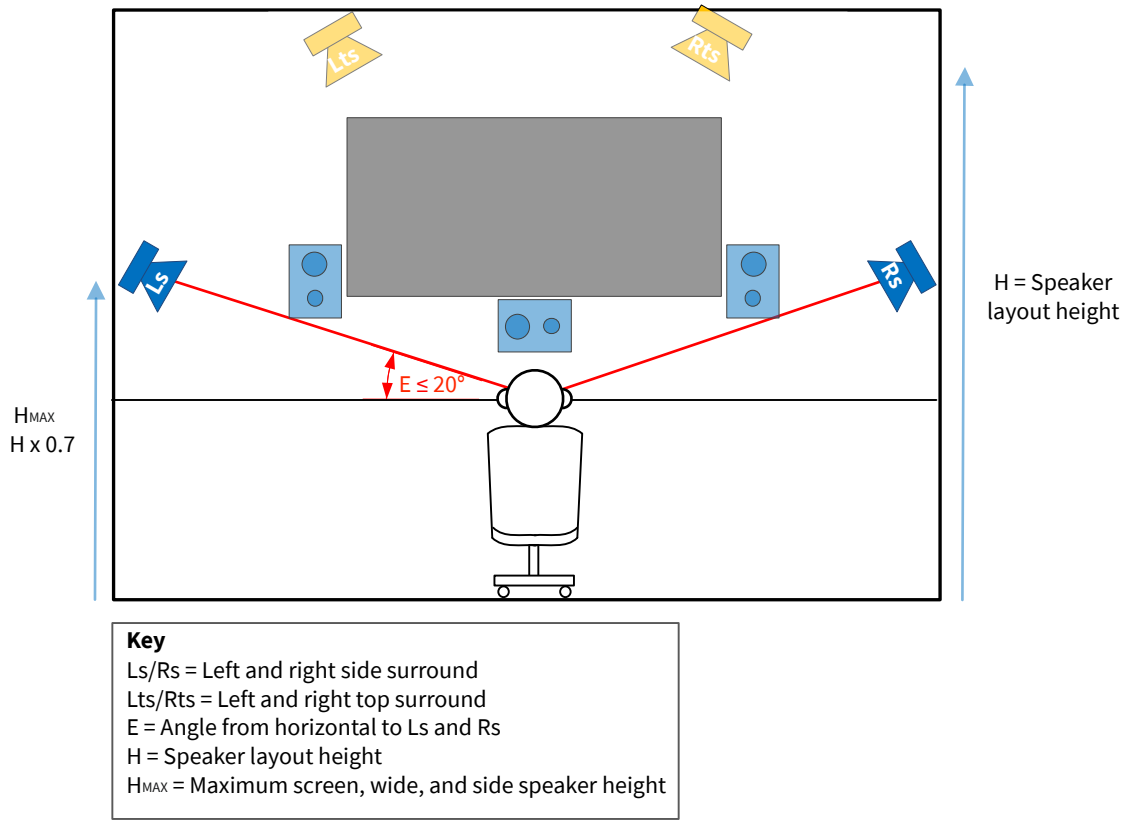
To minimize the sense of height when surround speakers are elevated, and to ensure adequate separation from the overhead speakers, follow the guidelines for side and rear surround elevation.

Side surround elevation guidelines

- The angle of elevation of the side surround speakers should be no greater than 20°.
- The side surround height should be no greater than 0.7 multiplied by the layout height. This provides vertical separation between top surrounds and the other speakers.

Note: Surround speakers of differing heights should follow a smooth line from the screen speakers through the acoustic center of the surround speakers.

Figure 5: Front elevation diagram showing side surround speaker positions

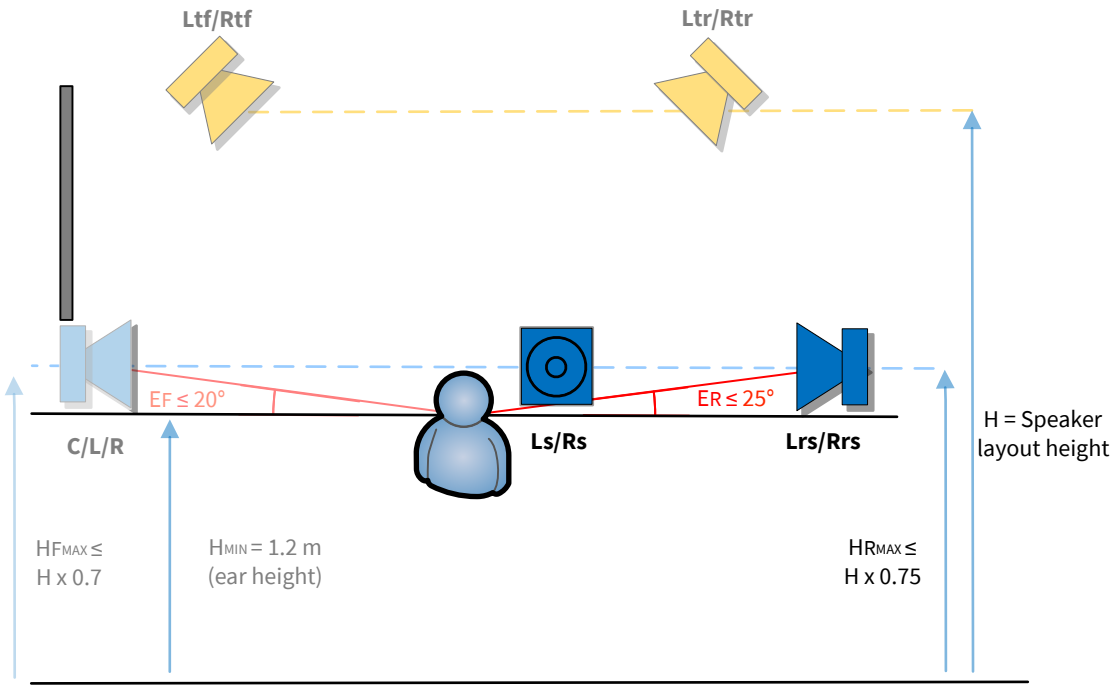


Key
Ls/Rs = Left and right side surround
Lts/Rts = Left and right top surround
E = Angle from horizontal to Ls and Rs
H = Speaker layout height
HMAX = Maximum screen, wide, and side speaker height

Rear surround elevation guidelines

- The angle of elevation to the rear surround speakers should be no greater than 25°.
- The rear surround height should be no greater than 0.75 multiplied by the layout height.

Figure 6: Side elevation diagram showing rear surround speaker positions



Key

Ltf/Rtf = Left and right top front speakers
Ltr/Rtr = Left and right top rear speakers
EF = Angle from horizontal to C, L, and R
ER = Angle from horizontal to Lrs and Rrs
H = Speaker layout height
HMIN = Minimum speaker height
HFMAX = Maximum screen, wide, and side speaker height
HRMAX = Maximum rear surround height

Note: Surround speakers of differing heights should follow a smooth line from the screen speakers through the acoustic center of the surround speakers.

2.3.4 Top surround speakers

In a 7.1.4 Dolby Atmos setup, there are four top surround speakers. These are labeled left top front (Ltf), right top front (Rtf), left top rear (Ltr), and right top rear (Rtr).

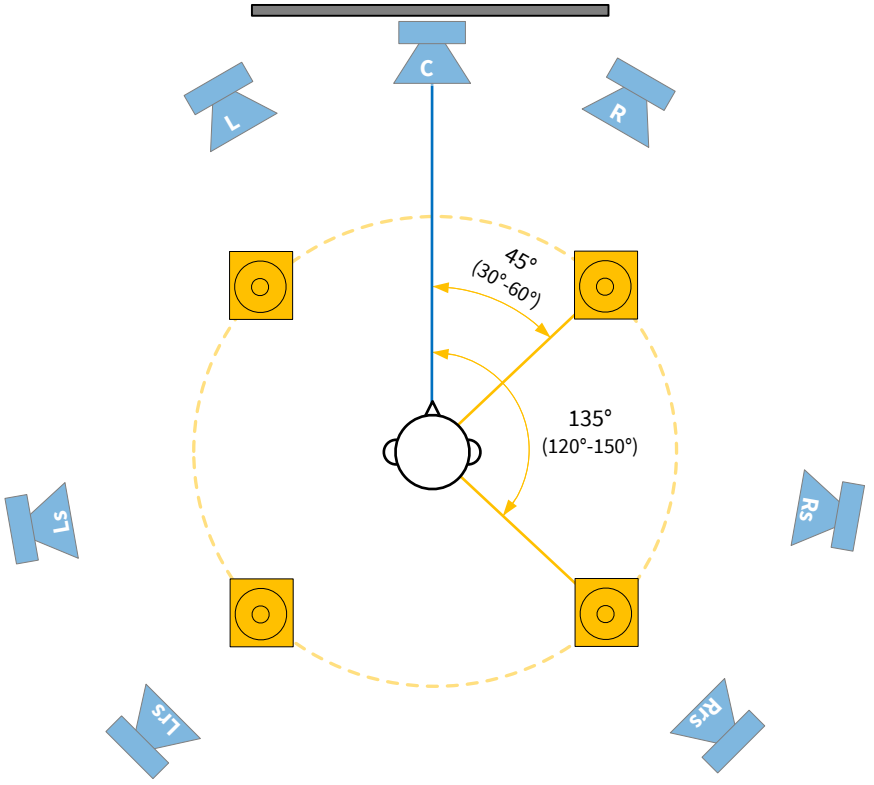
When referring to left or right top surrounds, the abbreviation Lts or Rts can be used.

Positioning of all top surround speakers is dictated by these design aspects:

- Achievable height of the top surround speaker
- Horizontal angular placement
- Lateral angle to the top surround speaker from horizontal at the mix position
- Longitudinal angle to the top surround speaker from horizontal at the mix position

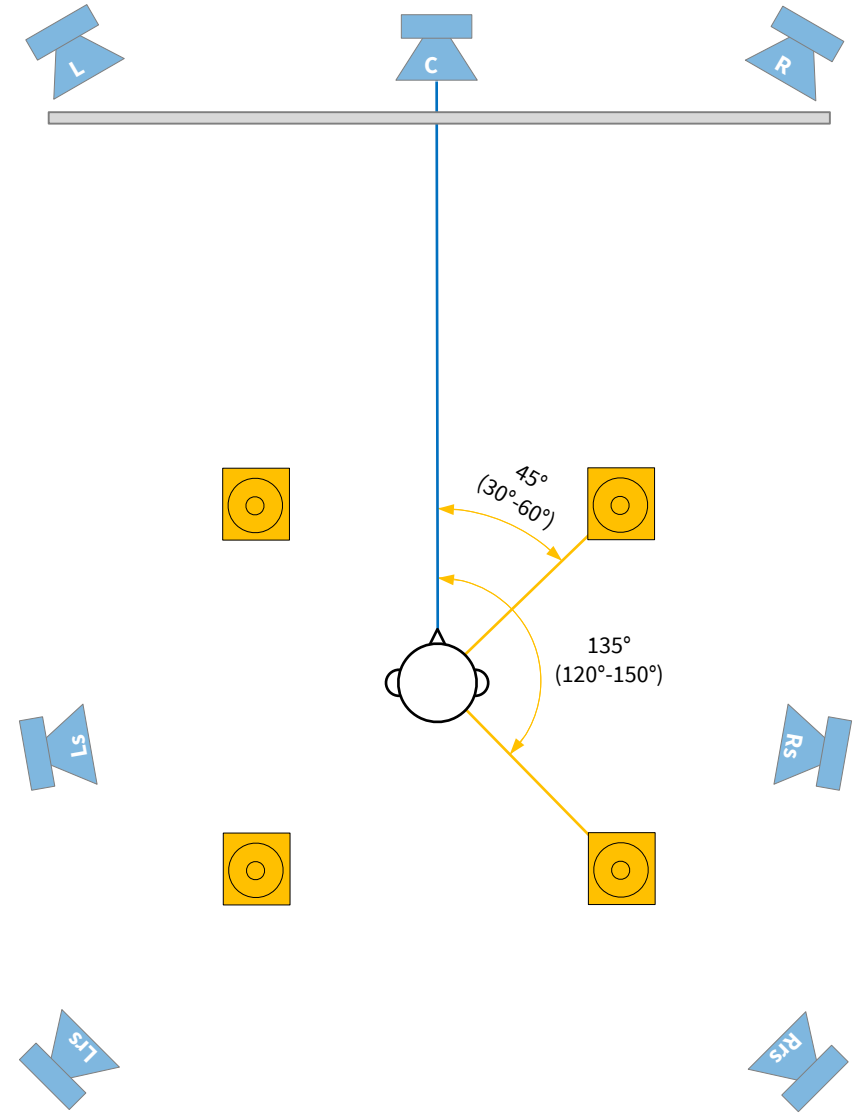
The result of these guidelines is a quad of overhead speakers placed centrally over the mixer, as shown in these figures.

Figure 7: Equidistant layout plan view showing top surround speaker positions



Key
Ls/Rs = Left and right side surround
Lrs/Rrs = Left and right rear surround
n° = Recommended angle
(n°-n°) = Angle limits

Figure 8: Orthogonal layout plan view showing top surround speaker positions



Key
Ls/Rs = Left and right side surround
Lrs/Rrs = Left and right rear surround
n° = Recommended angle
(n°-n°) = Angle limits

Top surround speaker height

The top surround speakers are normally placed adjacent to the ceiling, with a minimum height of 2.4 m from the floor level at mix position.

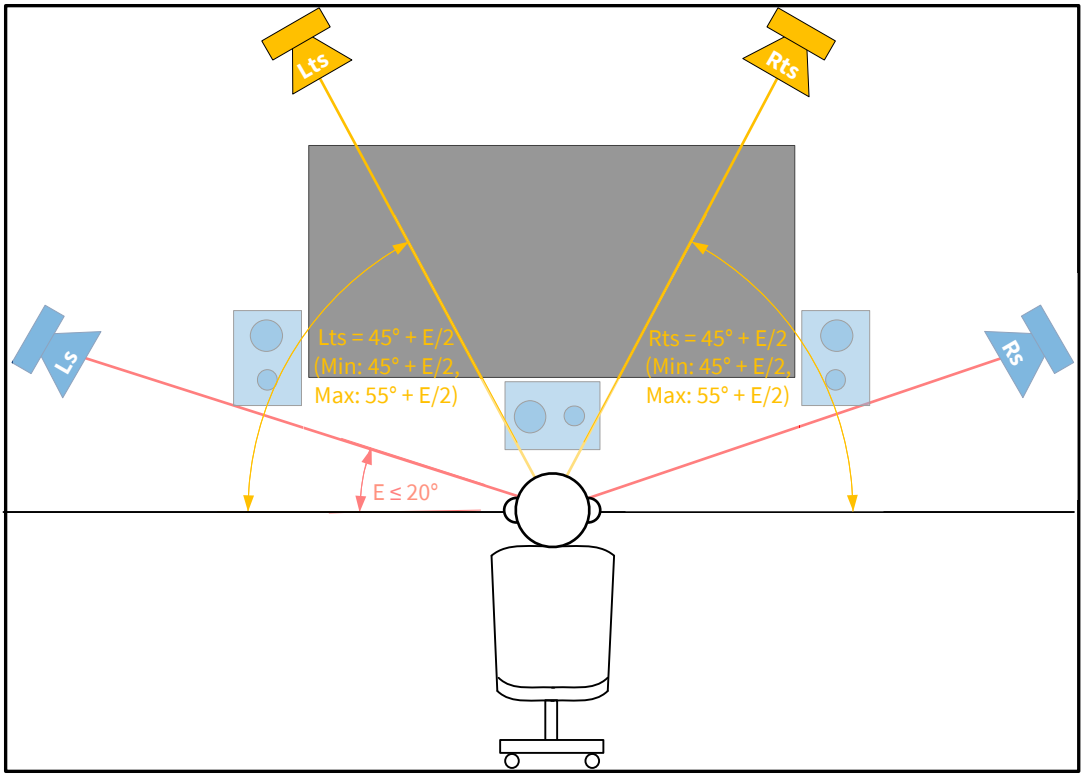
Top surround speaker lateral position

The placement of the top surrounds should be such that there is symmetry between the right and left halves of the room, on each side of the mixer (so that the lateral angle to each overhead surround is the same).

The minimum top surround elevation angle as viewed on a front elevation diagram is 45˚ + (E ÷ 2), where E is the elevation angle of the side surround loudspeaker from horizontal. This is also the ideal angle.

The maximum top surround elevation angle is 55˚ + (E ÷ 2), as shown in this figure.

Figure 9: Front elevation diagram showing top surround speaker positions



Key

Ls/Rs = Left and right side surround
Lts/Rts = Left and right top surround recommended angle
(Min: Max): = Top surround angle limits
E = Angle from horizontal to Ls and Rs

Top surround speaker longitudinal position

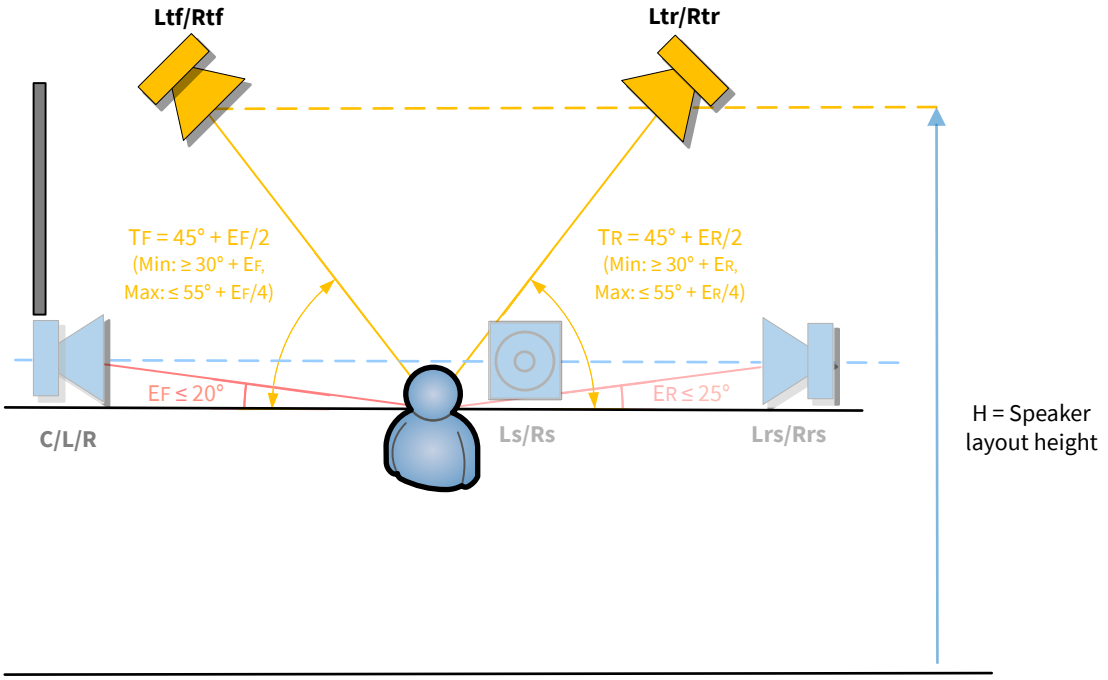
The ideal angle of the front top surrounds from horizontal is 45˚ + (EF ÷ 2), where EF is the elevation angle of the screen speakers from horizontal.

Speakers should be placed as close to the ideal as possible; however, the suggested range of subtended angles to the front top surround speakers is:

- Minimum: 30˚ + EF
- Maximum: 55˚ + (EF ÷ 4)

The ideal and limits for the placement of the rear surrounds are the same, except that the angle to the rear surrounds is known as ER.

Figure 10: Side elevation diagram showing top surround speaker positions



Key
TF/TR = Recommended top surround angle
(Min: Max:) = Top surround angle limits
EF = Angle from horizontal to C, L, and R
ER = Angle from horizontal to Lrs and Rrs
H = Speaker layout height

2.3.5 Speaker configuration design guidance for 5.1.4 speaker layouts in a Dolby Atmos Home Entertainment Studio

Although 7.1.4 is the preferred layout for a Dolby Atmos Home Entertainment Studio, you can alternatively use a 5.1.4 layout. However, with a 5.1.4 layout, the absence of rear surround speakers will lead to a difference in spatial resolution.

Some key factors and expectations:

- Dolby Atmos 5.1.4 speaker layout sizes are often smaller than typical 7.1.4 layouts, but overall size guidance remains the same as described in *Room layout design*.
- Extended monitor layouts should not be used with a 5.1.4 configuration.

Related information

Room layout design on page 9

Screen speakers and subwoofer placement

Screen speaker and subwoofer placement guidance remains is the same.

Refer to the *Screen speakers* section for more information on this topic.

Related information

Screen speakers on page 11

Side surround speaker placement

The angles of the side surround speakers from the center speaker in the horizontal plane are adjusted to match typical 5.1 positions.

As detailed in figure *Equidistant layout plan view showing screen and surround speaker positions*, the ideal horizontal plane angle for Ls and Rs speakers is increased to 110° from Center speaker. The recommended guidance range for side surrounds extends from 90° to 120°.

Side surrounds should be positioned away from the rear corners of the room. There must be additional room length beyond the side surround positions to allow for the correct placement of Ltr/Rtr rearmost top surround speakers.

Related information

Calculating the layout length parameter on page 22

Calculating the layout length parameter

Before the positions of the top surrounds can be calculated, the layout length parameter must be calculated.

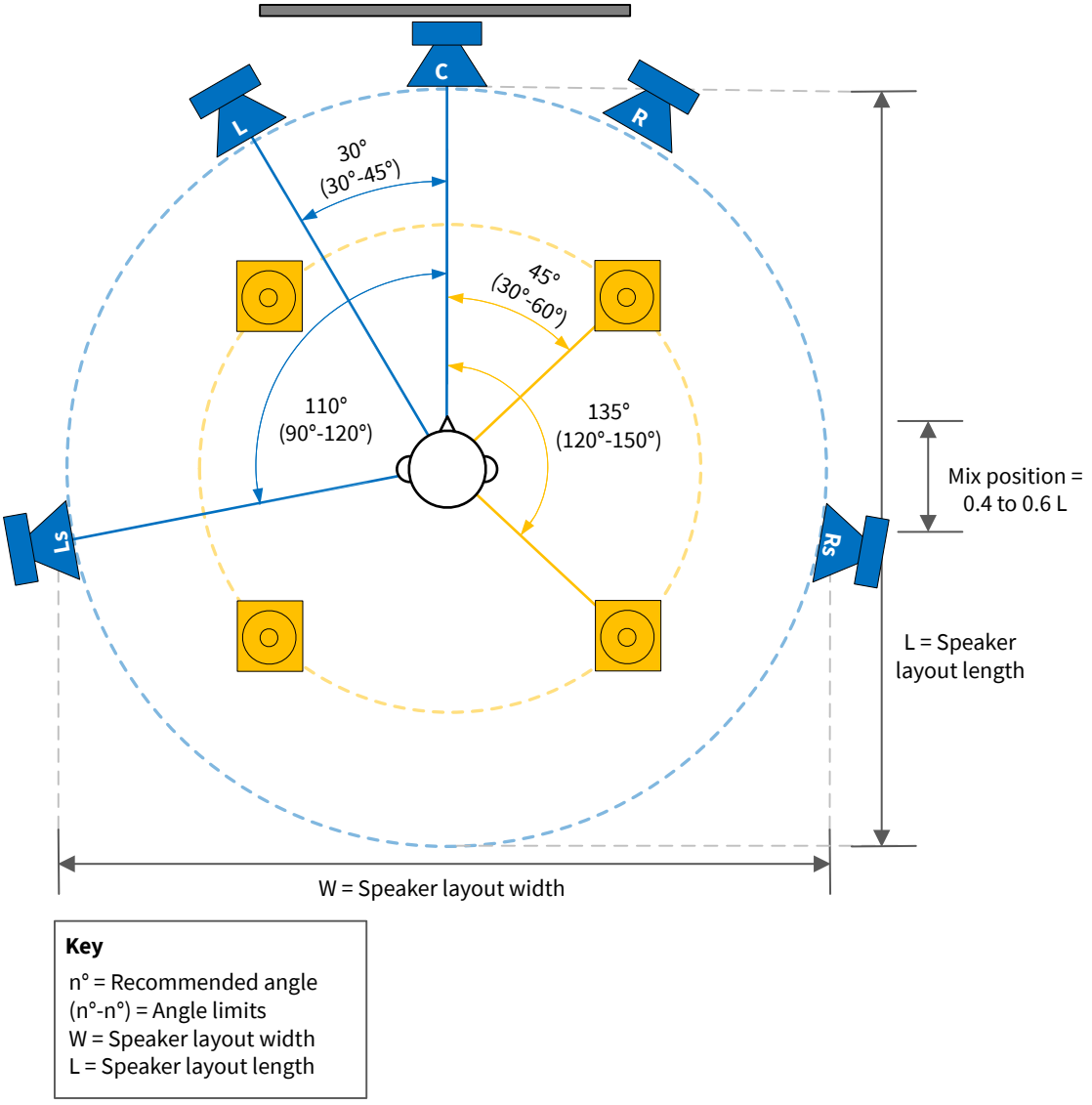
In a 7.1.4 speaker configuration, the longitudinal distance from the center speaker to the rear surrounds is defined as the layout length. However, due to the omission of the rear surround speaker positions in a 5.1.4 system, a virtual configuration length needs to be calculated using notional rear surround positions.

A circular arc is traced from one side surround to the other, forming an equidistant arc behind the mix position. The notional rear surround positions are at an angle of 135° from the Center speaker, but the positions also need to maintain a minimum 30° separation from side surrounds. The range for notional rear surrounds therefore extends from 135° to 150°. The elevation of the notional rear surround positions is presumed to match that of the side surrounds.

The layout length is defined as the longitudinal distance from the center speaker to the notional rear surround positions. When using the Dolby Audio Room Design Tool for Home Entertainment (DARDT_HE), this calculation is automated.

Note: In the tool, when in 5.1.4 mode, the configuration (or layout) length parameter becomes a room length parameter. To engage 5.1.4 mode in the tool, disengage the rear surround line item check box.

Figure 11: Equidistant layout plan view showing screen and surround speaker positions



Key

n° = Recommended angle
(n°-n°) = Angle limits
W = Speaker layout width
L = Speaker layout length

Top surround speaker placement

Once the notional position of the rear surrounds has been established, they can then be used to help define Ltr/Rtr top surround positions.

Refer to *Top surround speakers* section for more information on this topic.

Note:

If required, the Rtr/Ltr speakers can be mounted high up on the rear wall, as long as the subsequent layout height and angular positions fit within the guidelines.

Related information

Top surround speakers on page 17

2.4 Extended speaker layout design

The preferred speaker layout for Dolby Atmos home entertainment studios is 7.1.4. For larger studios, however, where extended layouts are needed, you can include additional speakers.

You can add as many as four speaker options in extending a layout:

- Wide speakers
- Side-surround arrays
- Rear-surround arrays
- Additional top surround speakers or top-surround arrays

You can deploy speaker options independently of one another, and you can apply all extended layout options to equidistant or orthogonal layouts.

Note: The design of arrays is intended for use with array mode in Dolby Atmos Renderer version 3.2 and later running with a Dolby Atmos Mastering Suite license.

Before designing an extended layout, optimize the base 7.1.4 layout to meet the guidelines in *Speaker layout design*. After completing the base optimization, you can consider extended layouts and their guidelines.

Note: Where possible, aim all speakers both horizontally and vertically toward the mix position. Where this is not possible, the mix position should be well within the dispersion angle of the speaker.

Related information

Speaker layout design on page 11

2.4.1 Wide surround speakers

You can add wide surround speakers to a 7.1.4 layout to create a 9.1.4 speaker layout. In a 9.1.4 Dolby Atmos setup, there are six standard-plane surround speakers. The additional speakers to create a 9.1.4 layout are left wide (Lw) and right wide (Rw).

Two main design aspects govern the position of the wide surround speakers:

- Horizontal angular placement and angular separation between adjacent speakers
- The desired elevation of the wide surround speakers, measured as an angle from the mix position

Wide surround speakers should be tonally similar to other surround speakers and meet the required sound pressure level (SPL) specification.

Wide surround speaker horizontal angles

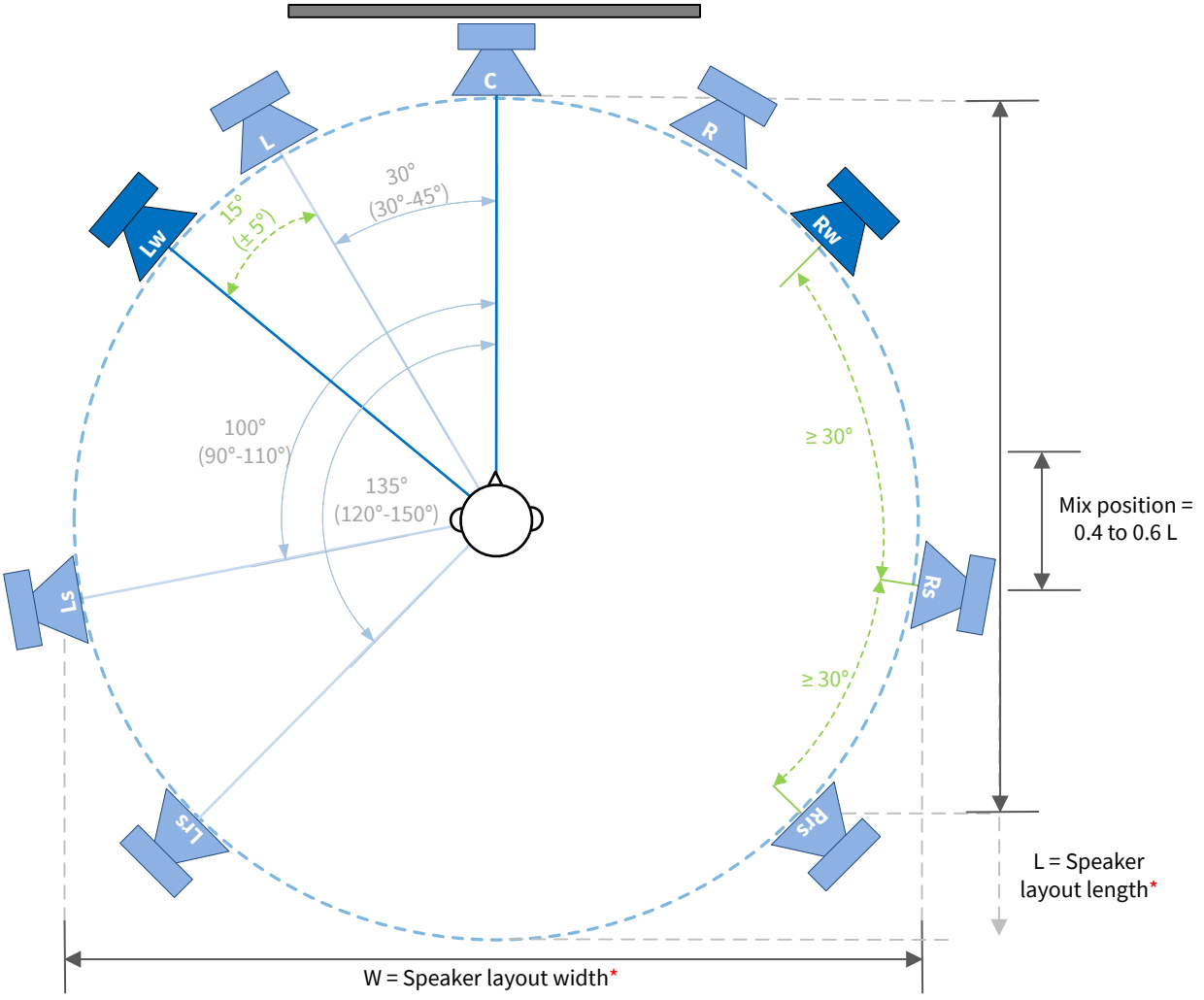
When using wide surround speakers, consider the room design, speaker placement, and type of layout to achieve the proper horizontal angles.

When using wide surround speakers, these guidelines apply:

- Before choosing the positions of the wide surround speakers, review the ideal placement and guidelines for the screen, side surround, rear surround, and top surround speakers. For more information, see *Room design dimensions, terminology, and fundamentals* and *Speaker layout design*.
- The ideal and suggested horizontal position of the wide surround speaker, measured as an angle from the mix position, is based on the angle of the left and right speakers, and is dependent on whether the layout is equidistant or orthogonal:
  - For equidistant layouts, the ideal wide surround position is calculated by adding 15° to the angle between the center and left speakers. A tolerance of ±5° is suggested.
  - For orthogonal layouts, the ideal wide surround position is calculated by adding 20° to the angle between the center and left speakers. A tolerance of ±5° is suggested.

These figures show the placement of speakers for each layout type. Refer to the appropriate figure for your layout.

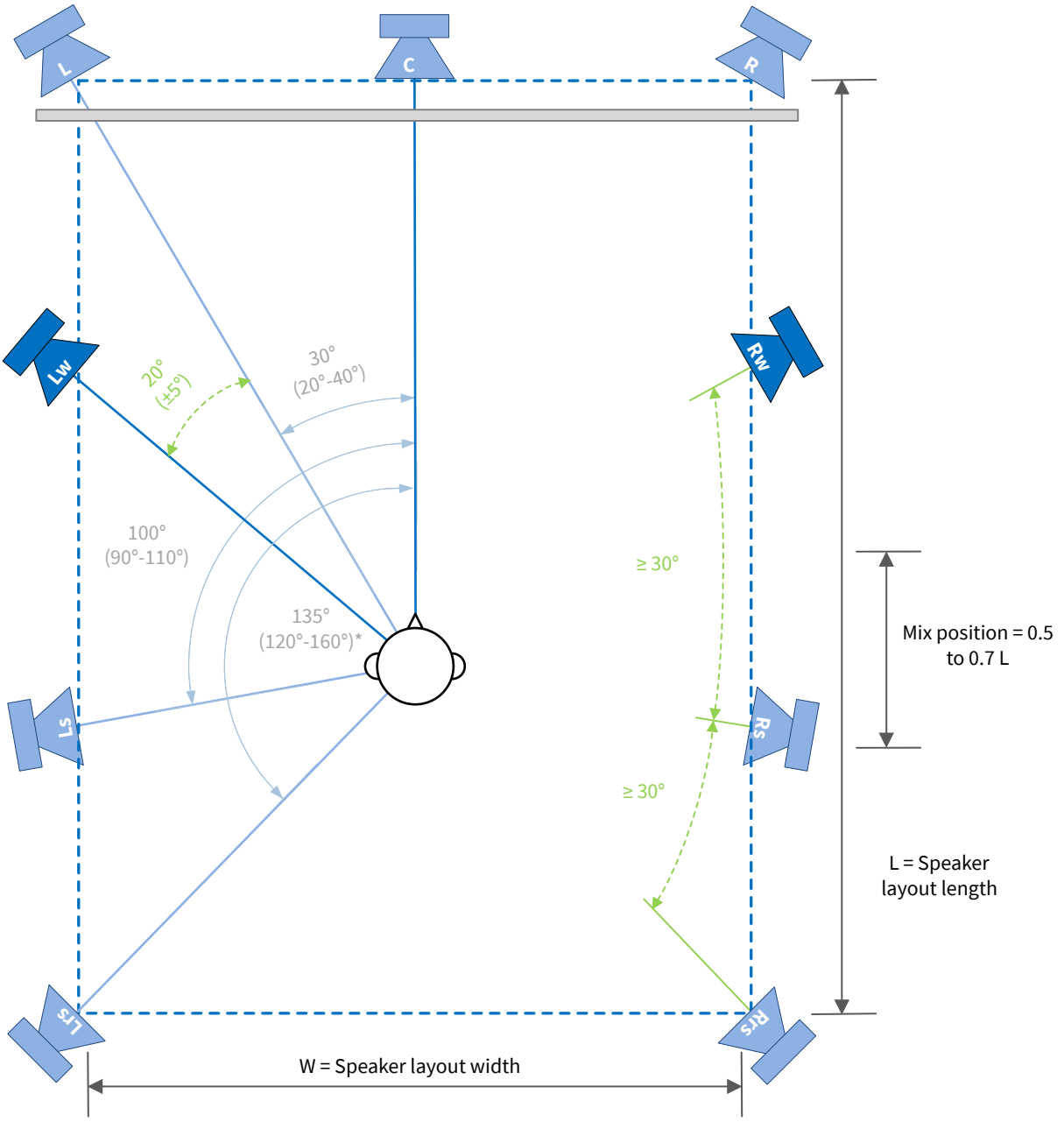
Figure 12: Equidistant layout plan view showing wide surround speaker positions



Key

Ls/Rs = Left and right side surround
Lrs/Rrs = Left and right rear surround
Lw/Rw = Left and right wide surround
n° = Recommended angle
(n°-n°) = Angle limits
W = Speaker layout width
L = Speaker layout length
≥ n° = Minimum separation angle
* Layout width and length: For circular layouts, use the circle diameter. For other configurations, use the width and length between speakers.

Figure 13: Orthogonal layout plan view showing wide surround speaker positions



Key

Ls/Rs = Left and right side surround
Lrs/Rrs = Left and right rear surround
Lw/Rw = Left and right wide surround
n° = Recommended angle
(n°-n°) = Angle limits
W = Speaker layout width
L = Speaker layout length
* = 120°-150° preferred, but 160° is acceptable to enable rear wall positioning.
≥ n° = Minimum separation angle

Related information

Room design dimensions, terminology, and fundamentals on page 9
Speaker layout design on page 11

Wide surround speaker elevation guidelines

The height at which you position wide surround speakers depends on the room geometry and room use.

We recommend that wide surround speakers be positioned at seated ear height (that is, approximately 1.2 m), matching the ideal height of the screen and other standard-plane surround speakers. It might be necessary, however, to elevate them due to room use, geometry, and architectural features.

To minimize the sense of height when wide surround speakers are elevated, and to ensure adequate separation from the overhead speakers, follow these positioning guidelines:

- The angle of elevation of the wide surround speakers should be no greater than 20°.
- The wide surround height should be no greater than 0.7 multiplied by the layout height. This provides vertical separation between top surround speakers and the other speakers.

Note: Surround speakers of differing heights should follow a smooth line from the screen speakers through the acoustic center of the surround speakers.

2.4.2 General use of arrays

You can use arrays for larger rooms where better client sound coverage is desired (typically, most applicable for rooms wider than six meters). In array mode, panning a sound to a surround bed reproduces the sound in all speakers of the array, whereas an object pans through each speaker individually.

To create an array, add one or two speakers to the side and/or rear surround positions. You can also include top surround speakers in top surround arrays.

Two main design aspects govern the position of the side and rear array speakers:

- Horizontal angular placement and angular separation between adjacent speakers
- The desired elevation of the array speakers, measured as an angle from the mix position

Surround array delays

The delay for each additional surround speaker in the array should be set to be the same value as the principal surround speaker (Ls, Rs, Lrs, or Rrs) for that array.

Note that spatial coding emulation cannot be enabled when monitoring a Dolby Atmos mix in array mode.

2.4.3 Side surround arrays

Creating side surround arrays by adding surround speakers to an existing or new configuration provides improved client sound coverage.

The side surround array speakers are labeled left surround 1 (Ls1), right surround 1 (Rs1), left surround 2 (Ls2) and right surround 2 (Rs2).

Side surround array speaker horizontal angles

Place side surround array speakers based on room design, number of speakers, and optimum separation to achieve the proper angles.

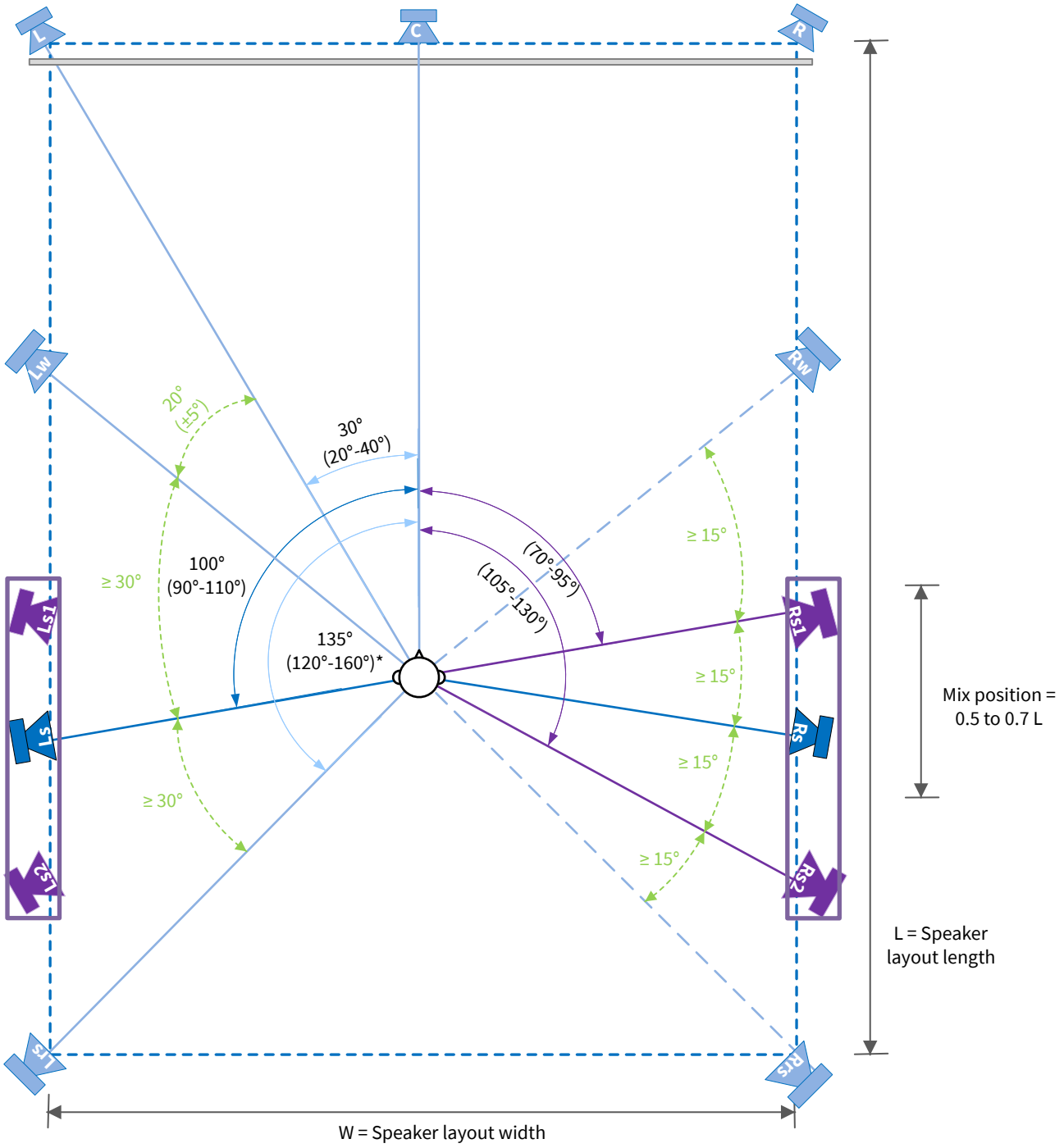
When designing a side surround array, these guidelines apply:

- Before choosing the positions of the wide surround speakers, review the ideal placement and recommendations for the Ls/Rs and Lrs/Rrs speakers. For more information, see *Room design dimensions, terminology, and fundamentals* and *Speaker layout design*.
- We recommend using all three speakers (rather than two) per side array, so as to best extend the coverage. If, however, you are using only two side surround speakers per array, choose the two positions that give optimum coverage.
- Irrespective of the number of speakers used, place Ls2 and Rs2 within the range of a 105° to 130° angle measured from the center speaker. If using Ls1 and Rs1, place them within the range of a 70° to 95° angle measured from the center speaker.

- When placing the side surround speakers, ensure that there is at least a 15° angle from the Lw and Rw speakers to Ls1 and Rs1, where these speakers are used. In addition, ensure that there is a 15° angle from Ls2 and Rs2 to the Lrs and Rrs speakers.
- Within the array, the angle of separation between adjacent speakers should be at least 15° and, ideally, no more than 20°.
- We recommend equal spacing between all speakers in an array.

This figure shows the recommended side surround array speaker positions for an orthogonal layout.

Figure 14: Orthogonal layout plan view showing side surround array positions



Key
Ls/Rs = Left and right side surround
Lrs/Rrs = Left and right rear surround
Lw/Rw = Left and right wide surround
Ls1/Rs1 = Left and right side array surround 1
Ls2/Rs2 = Left and right side array surround 2
n° = Recommended angle
(n°-n°) = Angle limits
W = Speaker layout width
L = Speaker layout length
* = 120°-150° preferred, but 160° is acceptable to enable rear wall positioning.
≥ n° = Minimum separation angle

Related information

Room design dimensions, terminology, and fundamentals on page 9
Speaker layout design on page 11

Side surround array speaker elevation guidelines

The height at which you position side surround array speakers depends on the room geometry and room use.

We recommend that array speakers be positioned at seated ear height, that is, approximately 1.2 m, matching the ideal height of the screen and other standard-plane surround speakers. It might be necessary, however, to elevate them due to room use, geometry, and architectural features.

To minimize the sense of height when side surround speakers are elevated, and to ensure adequate separation to the overhead speakers, follow these positioning guidelines:

- The angle of elevation of the side surround speakers should be no greater than 20°.
- The side surround height should be no greater than 0.7 multiplied by the layout height. This provides vertical separation between top surround speakers and the other speakers.

Note: Array speakers of differing heights should follow a smooth line from the screen speakers through the acoustic center of the array speakers to the rear surround speakers.

2.4.4 Rear surround arrays

You can add rear surround arrays, configured with either two or three speakers.

The rear surround array speakers are labeled left rear surround 1 (Lrs1), right rear surround 1 (Rrs1), left rear surround 2 (Lrs2), and right rear surround 2 (Rrs2).

Two-speaker rear surround array angles

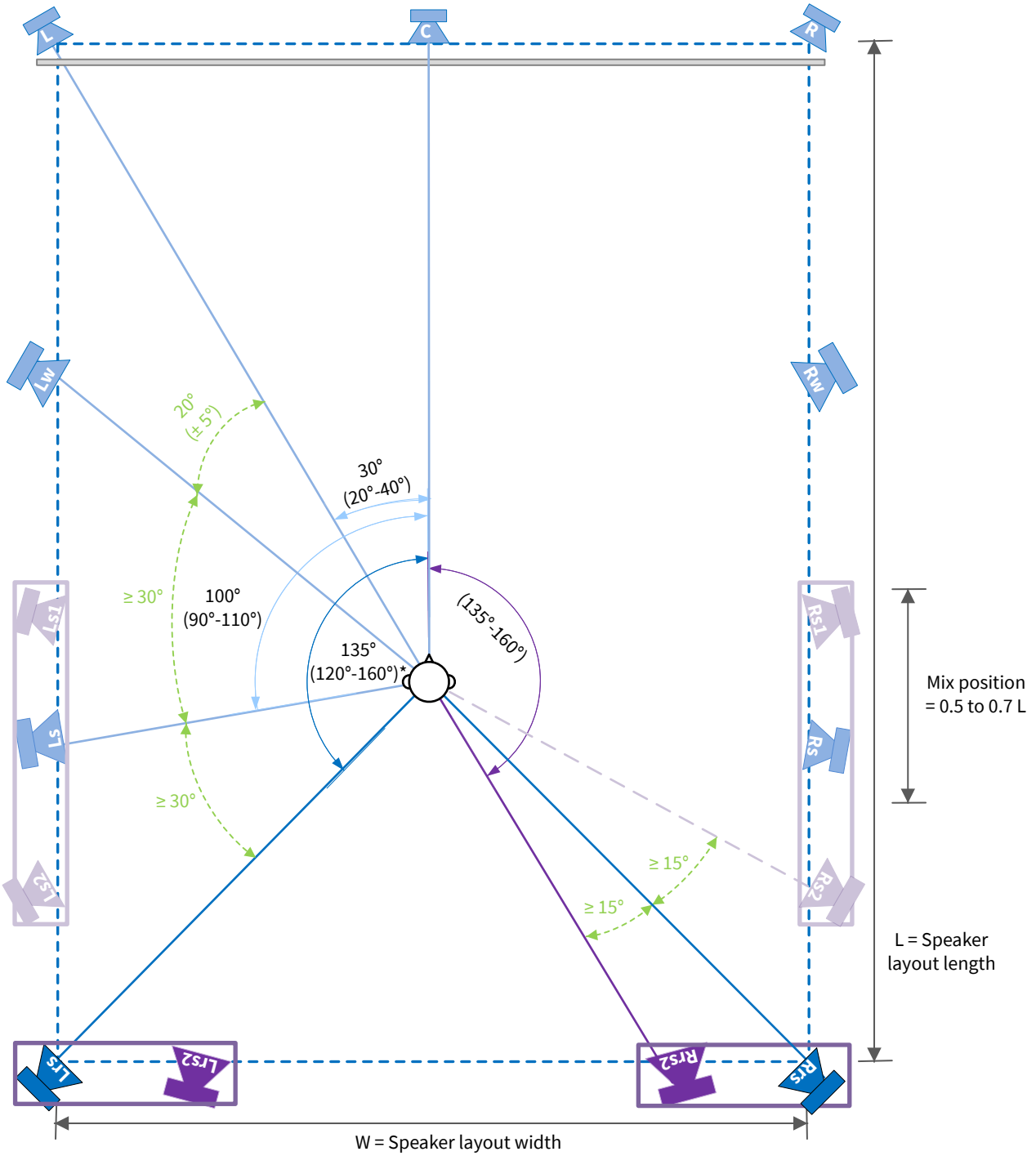
Place two-speaker rear surround arrays based on room layout and desired coverage area.

When designing a rear surround array with two speakers on either side (four rear surrounds in total), these guidelines apply:

- Before choosing the positions of the rear surround array speakers, review the ideal placement and recommendations for the Ls/Rs and Lrs/Rrs speakers. For more information, see *Room design dimensions, terminology, and fundamentals* and *Speaker layout design*.
- When using only two speakers per array, use Lrs/Rrs and Lrs2/Rrs2.
- Place the Lrs2 and Rrs2 speakers within the range of a 135 to 160° angle measured from the center speaker.
- When placing the rear surround speakers, ensure that there is at least a 15° angle of separation from the rearmost side surround speakers (either Ls/Rs or Ls2/Rs2) to the Lrs and Rrs speakers.
- Within the array, the angle of separation between adjacent speakers should be at least 15° and, ideally, no more than 20°.

This figure shows the recommended rear surround array speaker positions for an orthogonal layout.

Figure 15: Orthogonal layout plan view showing two-speaker rear surround array positions



Key

Ls/Rs = Left and right side surround
Lrs/Rrs = Left and right rear surround
Lw/Rw = Left and right wide surround
Lrs2/Rrs2 = Left and right rear surround array 2
n° = Recommended angle
(n°-n°) = Angle limits
W = Speaker layout width
L = Speaker layout length
* = 120°-150° preferred, but 160° is acceptable to enable rear wall positioning.
≥ n° = Minimum separation angle

Related information

Room design dimensions, terminology, and fundamentals on page 9
Speaker layout design on page 11

Three-speaker rear surround array angles

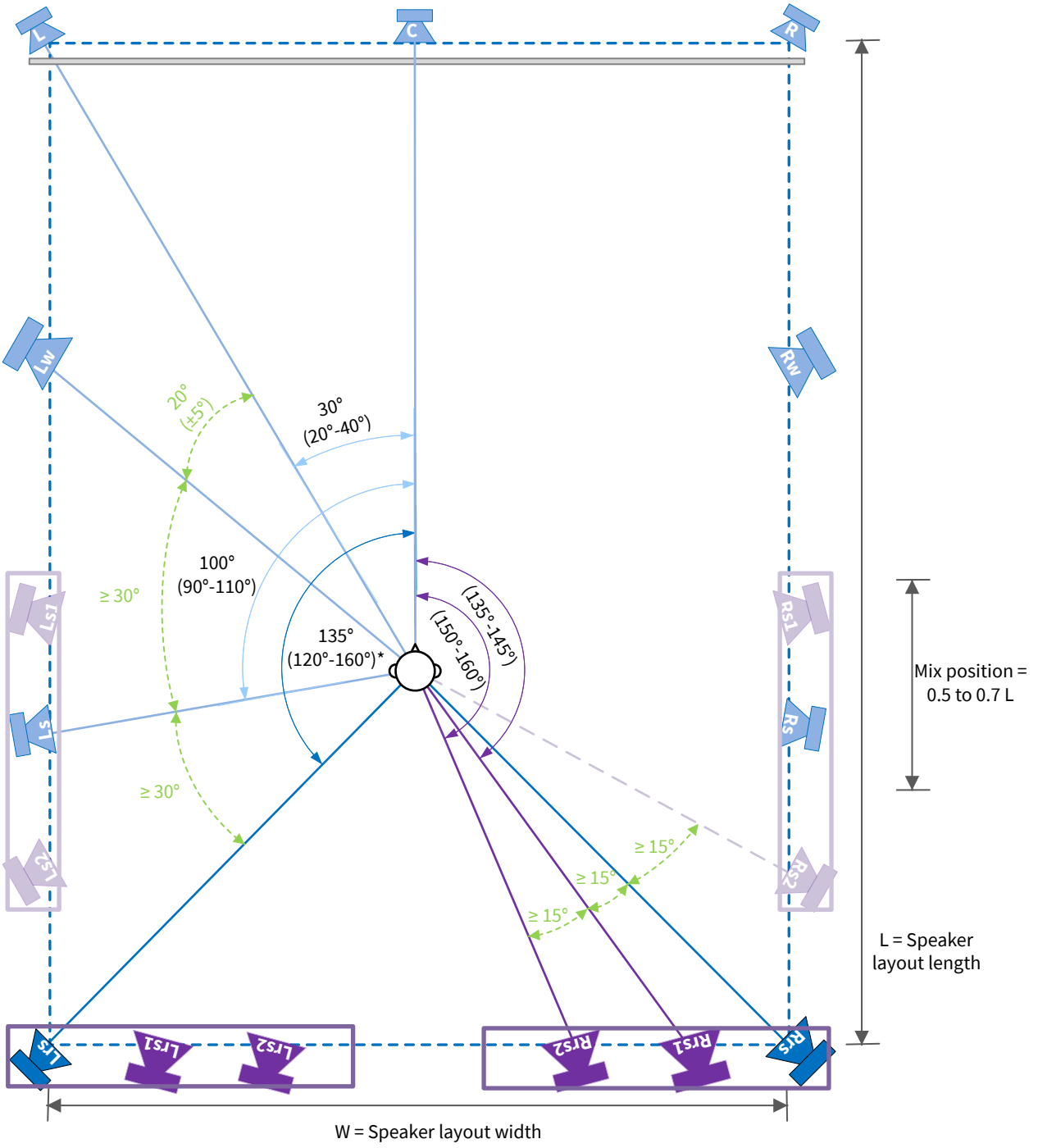
Place three-speaker rear surround arrays based on room layout and desired coverage area.

When designing a rear surround array with three speakers on either side (six rear surrounds in total), these guidelines apply:

- Before choosing the positions of the rear surround array speakers, review the ideal placement and recommendations for the Ls/Rs and Lrs/Rrs speakers. For more information, see *Room design dimensions, terminology, and fundamentals* and *Speaker layout design*.
- When placing the rear surround speakers, ensure that there is at least a 15° angle of separation from the rearmost side surround speakers (either Ls/Rs or Ls2/Rs2) to the Lrs and Rrs speakers.
- After the Lrs and Rrs speakers are positioned, place the Lrs1 and Rrs1 speakers within the range of a 135° to 145° angle measured from the center speaker, ensuring that there is at least a 15° angle of separation from Lrs and Rrs.
- After the Lrs and Rrs speakers are positioned, place the Lrs2 and Rrs2 speakers within the range of a 150° to 160° angle measured from the center speaker, ensuring that there is at least a 15° angle of separation from Lrs1 and Rrs1.

This figure shows the recommended rear surround array speaker positions for an orthogonal layout.

Figure 16: Orthogonal layout plan view showing three-speaker rear surround array positions



Key

Ls/Rs = Left and right side surround
Lrs/Rrs = Left and right rear surround
Lw/Rw = Left and right wide surround
Lrs1/Rrs1 = Left and right rear surround array 1
Lrs2/Rrs2 = Left and right rear surround array 2
n° = Recommended angle
(n°-n°) = Angle limits
W = Speaker layout width
L = Speaker layout length
* = 120°-150° preferred, but 160° is acceptable to enable rear wall positioning.
≥ n° = Minimum separation angle

Related information

Room design dimensions, terminology, and fundamentals on page 9
Speaker layout design on page 11

Rear surround array speaker elevation guidelines

The height at which you position rear surround array speakers depends on the room geometry and room use.

We recommend that array speakers be positioned at seated ear height (that is, approximately 1.2 m), matching the ideal height of the screen and other standard-plane surround speakers. It might be necessary, however, to elevate them due to room use, geometry, and architectural features.

To minimize the sense of height when rear surround speakers are elevated, and to ensure adequate separation to the overhead speakers, these guidelines apply:

- The angle of elevation of the rear surround speakers should be no greater than 25°.
- The rear surround height should be no greater than 0.75 multiplied by the layout height. This provides vertical separation between rear surround speakers and the other speakers.

Note: All rear surround speakers should be the same height.

2.4.5 Additional top surround speakers and top surround arrays

You can use additional top surround speakers for larger rooms where wider sound coverage is needed for specific seating positions. You can also include left and right top surround arrays, if desired.

You can add as many as three additional pairs of top surround speakers to the standard front and rear top surround pairs. These are the top surround speakers and their labeling:

- Standard top front surrounds: left top front (Ltf) and right top front (Rtf)
- Standard top rear surrounds: left top rear (Ltr) and right top rear (Rtr)
- Additional top middle surrounds: left top mid (Ltm) and right top mid (Rtm)
- Additional top front height surrounds: left front height (Lfh) and right front height (Rfh)
- Additional top rear height surrounds: left rear height (Lrh) and right rear height (Rrh)

Three main design aspects govern the position of all top surround speakers:

- Achievable height of the top surround speaker
- Lateral angle to the top surround speaker from horizontal at the mix position
- Longitudinal angle to the top surround speaker from horizontal at the mix position

Ideally, these guidelines result in a set of overhead speakers centered over the mixer. Additionally, you can achieve the best performance if each speaker in an array is the same make and model and meets the required SPL specification.

The position of the additional top surround speakers is determined by the guidelines for other top surround speakers. For more information, see *Top surround speakers*.

Related information

Top surround speakers on page 17

Top middle surround speaker longitudinal position

Consider room design and existing speaker layouts when positioning top middle surround speakers.

When using top middle surround speakers, these guidelines apply:

- Before choosing the positions of the additional top middle surround speakers, review the ideal placement and recommendations for the screen, side surround, rear surround, and front and rear top surround speakers. For more information, see *Room design dimensions, terminology, and fundamentals* and *Speaker layout design*.
- Ideally, the top height surround speakers should be the same height as the other top surround speakers.

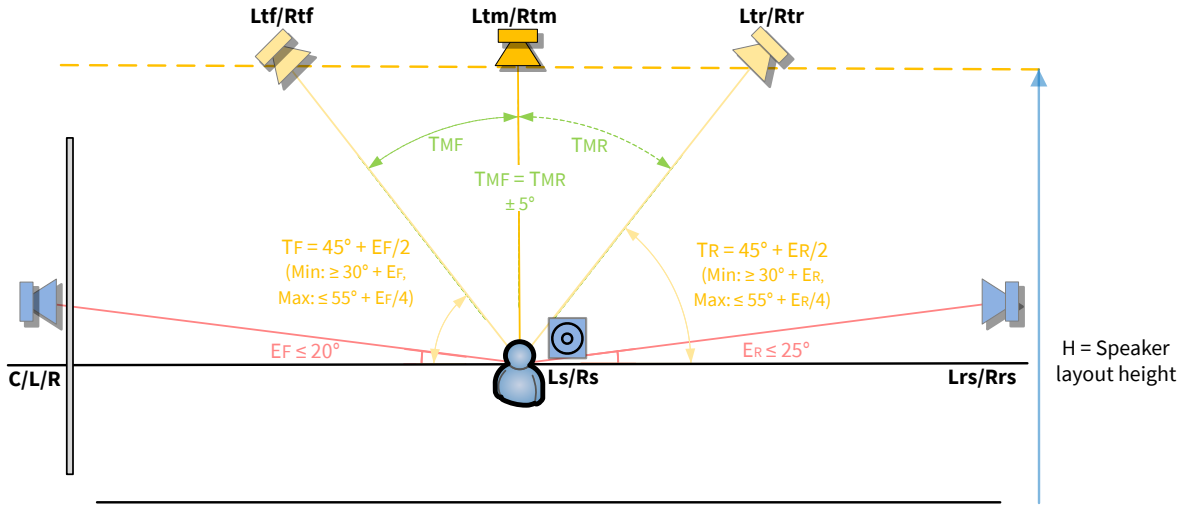
- Place the Ltm and Rtm speakers equally between the Ltf/Rtf and Ltr/Rtr speakers in terms of the longitudinal angle (as viewed on a side elevation diagram), such that the longitudinal angle between the top front surround speakers to the middle surround speakers is the same as the angle from the top rear surround speakers to the middle surround speakers. This can be written in equation form:

  $T_{MF} = T_{MR}$

  In this equation, angle T_{MF} is the angle from Ltf/Rtf to Ltm/Rtm, and angle T_{MR} is the angle from Ltr/Rtr to Ltm/Rtm (as seen in the figure *Side elevation view showing top middle surround speakers*). For these angles, a tolerance of ±5° is suggested.

This figure shows the side elevation view of top middle surround speakers.

Figure 17: Side elevation view showing top middle surround speakers



Key

TF/TR = Top surround recommended angle
(Min: Max:) = Top surround angle limits
TMF = Angle from Ltf and Rtf to Ltm and Rtm
TMR = Angle from Ltr and Rtr to Ltm and Rtm
EF = Angle from horizontal to C, L, and R
ER = Angle from horizontal to Lrs and Rrs
H = Speaker layout height

Related information

Room design dimensions, terminology, and fundamentals on page 9
Speaker layout design on page 11

Top middle surround speaker lateral position

The placement of the top middle surround speakers should be such that there is symmetry between the right and left halves of the room, on each side of the mixer (so that the lateral angle to each overhead surround is the same).

The minimum top middle surround position angle as viewed on a front elevation diagram is 45˚ + (E ÷ 2), where E is the position angle of the side surround loudspeaker from horizontal. This is also the ideal angle.

For more information, see *Top surround speaker lateral position*.

Related information

Top surround speaker lateral position on page 19

Top height surround speaker longitudinal position

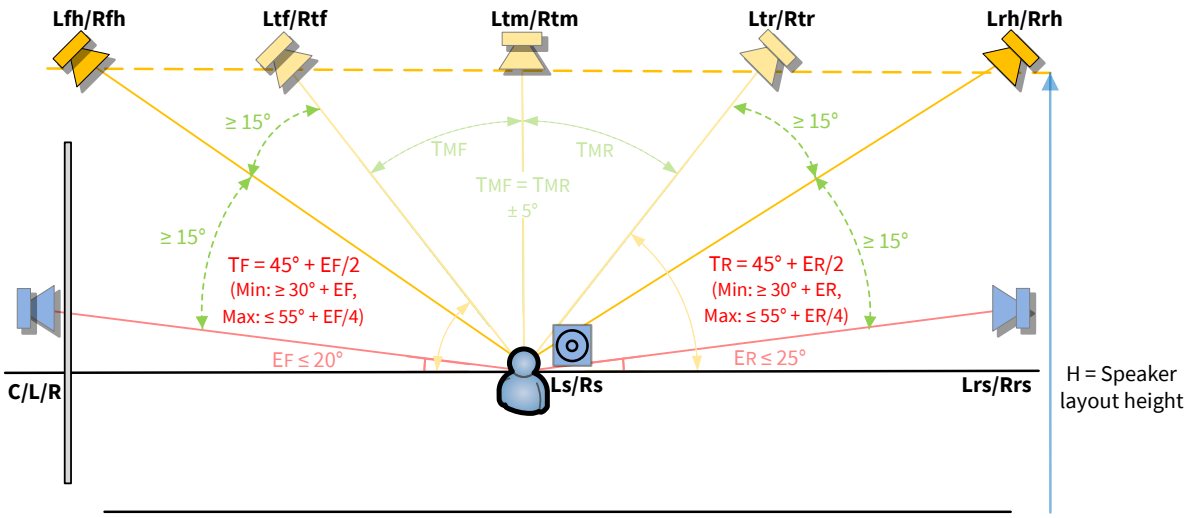
The use of top height surround speakers is not common; however, in some instances, they may be appropriate to the room setup.

In a situation where Lfh/Rfh and Lrh/Rrh are used, these recommendations determine the position of these additional top surround speakers:

- Before choosing the positions of the additional top surround speakers, review the ideal placement and recommendations of the screen, side surround, rear surround, and front and rear top surround speakers. For more information, see *Room design dimensions, terminology, and fundamentals* and *Speaker layout design*.
- Ideally, the top height surround speakers are the same height as the other top surround speakers.
- You should have at least a 15° angle of separation between the screen speakers and the front height surround speakers longitudinally, as shown in *Side elevation view showing top height surround speakers*. Similarly, you should have a 15° angle between the rear height surround speakers and the rear surround speakers longitudinally.
- You should have at least a 15° angle of separation between the front height surround speakers and the adjacent top surround speaker longitudinally, as shown in *Side elevation view showing top height surround speakers*. Similarly, you should have at least a 15° angle between the rear height surround speakers and the adjacent top surround speakers longitudinally.
- To create an X.1.8 layout, use either the Lfh/Rfh or Lrh/Rrh pairs. For an X.1.10 layout, use both the Lfh/Rfh and Lrh/Rrh pairs.

This figure shows the side elevation view of top height surround speakers.

Figure 18: Side elevation view showing top height surround speakers



Key

TF/TR = Top surround recommended angle
(Min: Max:) = Top surround angle limits
TMF = Angle from Ltf and Rtf to Ltm and Rtm
TMR = Angle from Ltr and Rtr to Ltm and Rtm
EF = Angle from horizontal to C, L, and R
ER = Angle from horizontal to Lrs and Rrs
H = Speaker layout height

Related information

Room design dimensions, terminology, and fundamentals on page 9
Speaker layout design on page 11

Top height surround speaker lateral position

The placement of the top height surround speakers should be such that there is symmetry between the right and left halves of the room, on each side of the mixer (so that the lateral angle to each overhead surround is the same).

The minimum top height surround position angle as viewed on a front elevation diagram is 45˚ + (E ÷ 2), where E is the position angle of the side surround loudspeaker from horizontal. This is also the ideal angle.

For more information, see *Top surround speaker lateral position*.

Related information

Top surround speaker lateral position on page 19

2.5 Speaker and amplification specification

The suitable sound pressure reference level for a studio will be dependent upon the content type being produced and precise delivery requirements. A calibration level of 79 dBC is recommended for a Dolby Atmos home entertainment studio, but an acceptable range would be from 79 to 85 dBC.

The ideal design requirement of the amplifier and speaker equipment reproduces the content, as recorded within the digital audio workstation (DAW), such that it does not add distortion. Each screen speaker should be capable of producing 20 dB above reference level, and each surround speaker should be capable of producing 17 dB above reference level. The subwoofer is aligned at +10 dB when compared to the center speaker, as per the SMPTE 202 specification, It should additionally be capable of producing at least 20 dB above reference level, which equates to a total of 30 dB above alignment level.

To check the suitability of speakers and amplifiers, use the Dolby Audio Room Design Tool `.xlsb` Excel file to help evaluate the correct headroom at mix position. This file is available for download at our Knowledge Base and Discussion Community.

2.5.1 Bass management

If using speakers with limited low-frequency response, you should use bass management to redirect low-frequency sounds to the subwoofer.

When redirecting low-frequency sounds, we recommend using the LFE subwoofer, as this is common in most homes; however, you can also consider using dedicated bass management subwoofers. Systems with dedicated bass management subwoofers in which not all speakers are bass managed require an external bass management processor. We recommend a crossover point of approximately 80 Hz or less to reduce the localization of the subwoofer.

2.5.2 Speaker frequency response

The frequency response guidelines are dependent on the speaker type.

The frequency response of all speakers other than the subwoofer should conform to the wide-range characteristic defined in International Organization for Standardization (ISO) 2969/SMPTE 202 standards, with or without bass management. The response should extend from 40 Hz at the low frequencies and ideally up to 18 kHz, with no variation greater than ±3 dB.

The subwoofer should have a frequency response of at least 31.5 to 150 Hz.

All speakers should have a similar frequency response. Therefore, it is recommended that they are all made by the same manufacturer and correctly aligned. Speakers in pairs (screen channels, side surrounds, rear surrounds, top surrounds) should also be of the same model.

2.5.3 Top surround speaker type

Our recommendation for a Dolby Atmos home entertainment studio is to install physical top surround speakers. If Dolby enabled speakers (upward firing) are desired for consumer up-firing simulation, these

should be in addition to the top surround speakers, and the appropriate reflective surface should be installed and correctly positioned.

2.5.4 Dispersion pattern

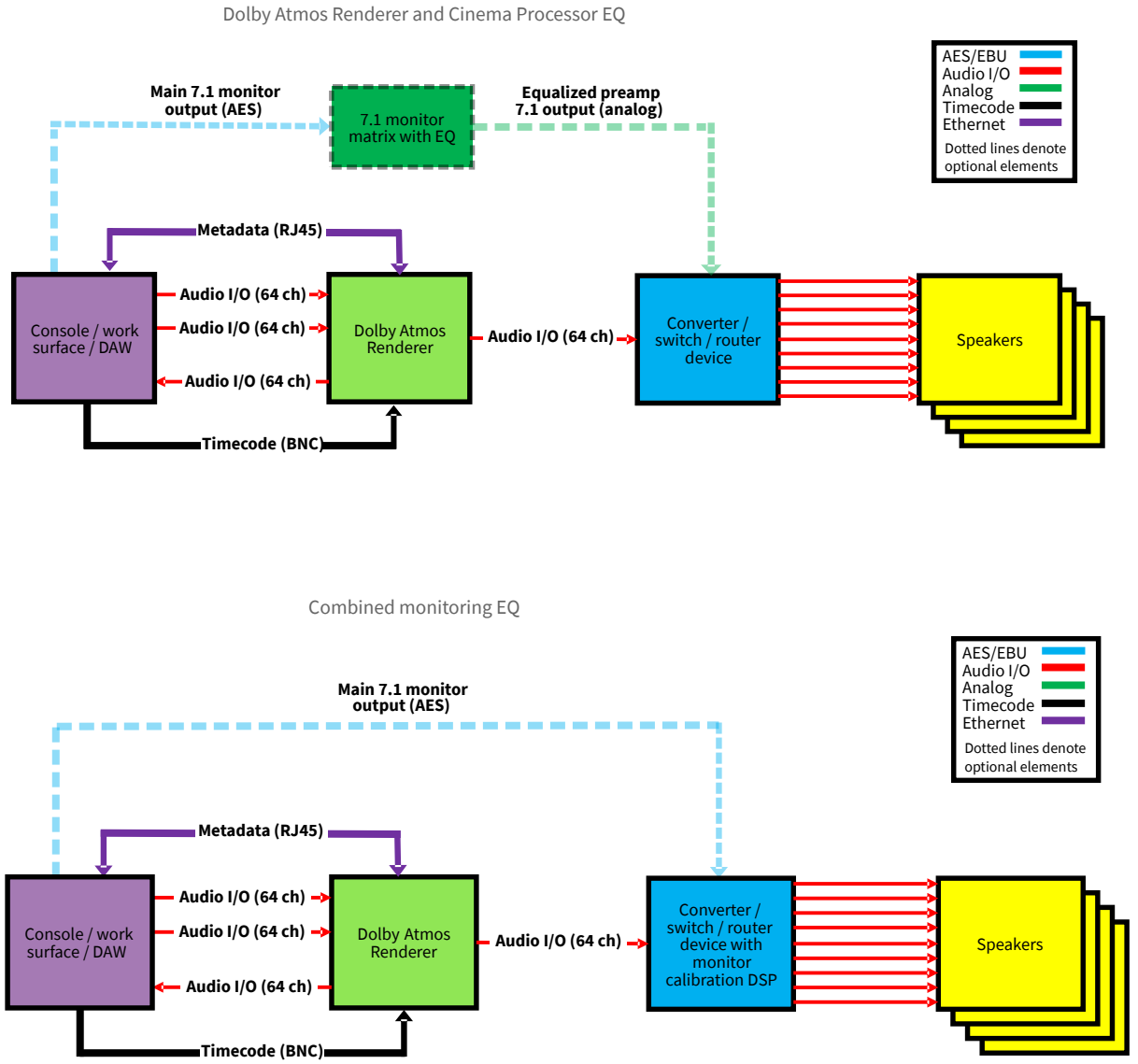
Surround speakers should have a wide directivity pattern of at least ±45° from 100 Hz to 10 kHz. The mix position should be well within the dispersion of the speaker, and speaker tilt applied if this is not the case.

Ideally, all speakers should be aimed directly at mix position.

2.6 Sample studio block diagrams

The sample studio block diagrams include the basic system components. The examples are provided for integration guidance.

Figure 19: Sample studio block diagrams



2.7 Speaker calibration

Speaker calibration includes setting monitor reference levels and speaker EQ.

2.7.1 Monitor reference levels

The monitor reference level should be set at the preferred level of the studio but must be between 79 and 85 dBC. Dolby pink noise should be used to align all speakers to required values, with measurements taken on the slow setting.

All speakers should be set to the same level, except for the LFE subwoofer. The subwoofer should have an additional 10 dB of in-band gain for the frequency range covered by the LFE, as compared to the center speaker.

2.7.2 Speaker EQ

Acoustic room treatment should be installed to address any acoustical problems. Corrective speaker EQ should also be applied if room coloration remains. Target curves should be applied as relevant.

For rooms with volume exceeding 125 m^3 (approximately 4,400 cu ft), we recommend applying the modified X-curve standard. Refer to SMPTE 222:1994.

Use reference material to gauge the timbre and consistency of the aligned speakers and, where possible, compare the mix translation in other replay environments.

2.8 Sample reference 7.1.4 layout diagrams

Example diagrams provide context on angle and distance measurements.

These example diagrams show the details needed in plans that are submitted as Dolby Atmos home entertainment studio drawings. The letters refer to angle and distance measurements that should be replaced with actual values and included in these diagrams.

Figure 20: Plan view diagram sample

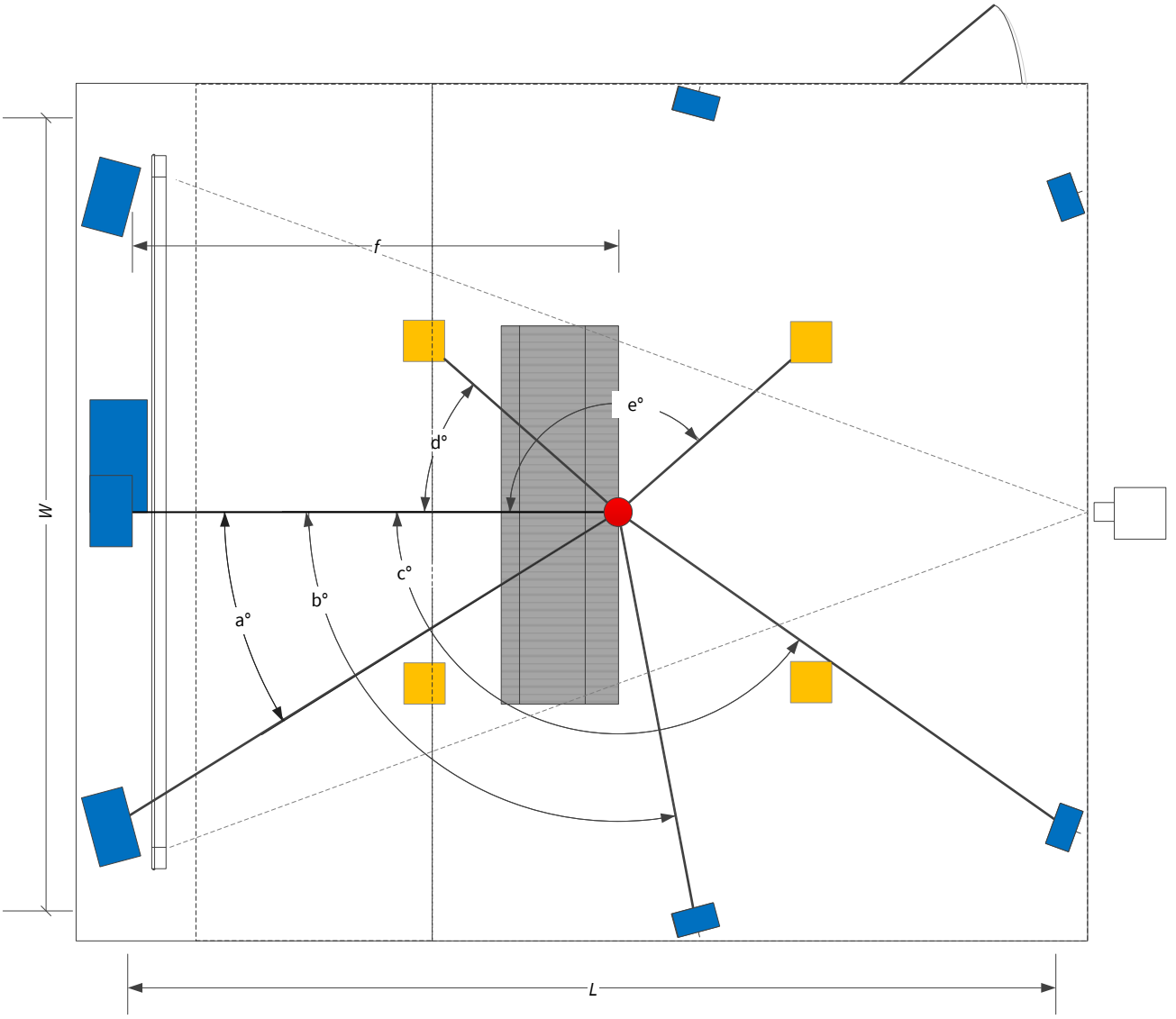


Figure 21: Side elevation diagram sample

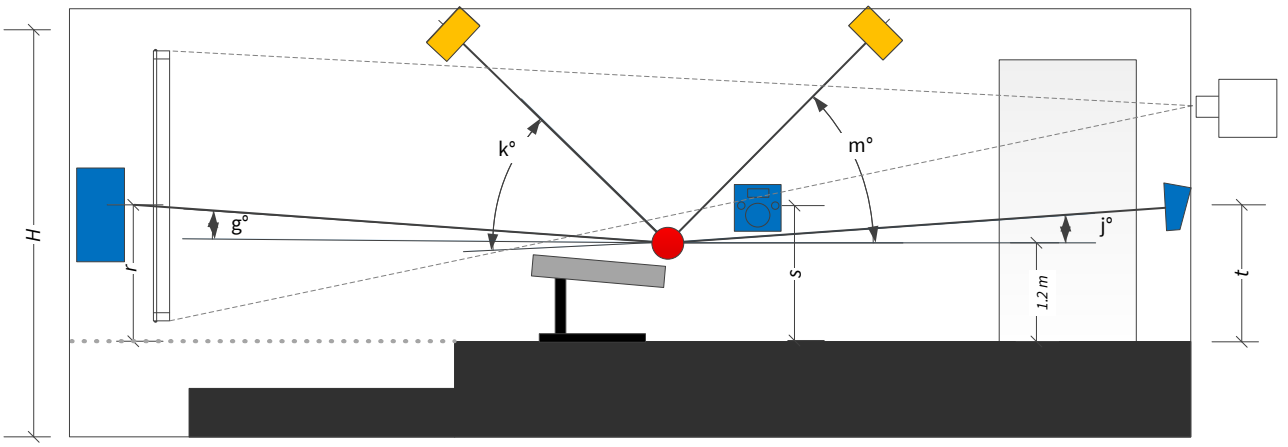
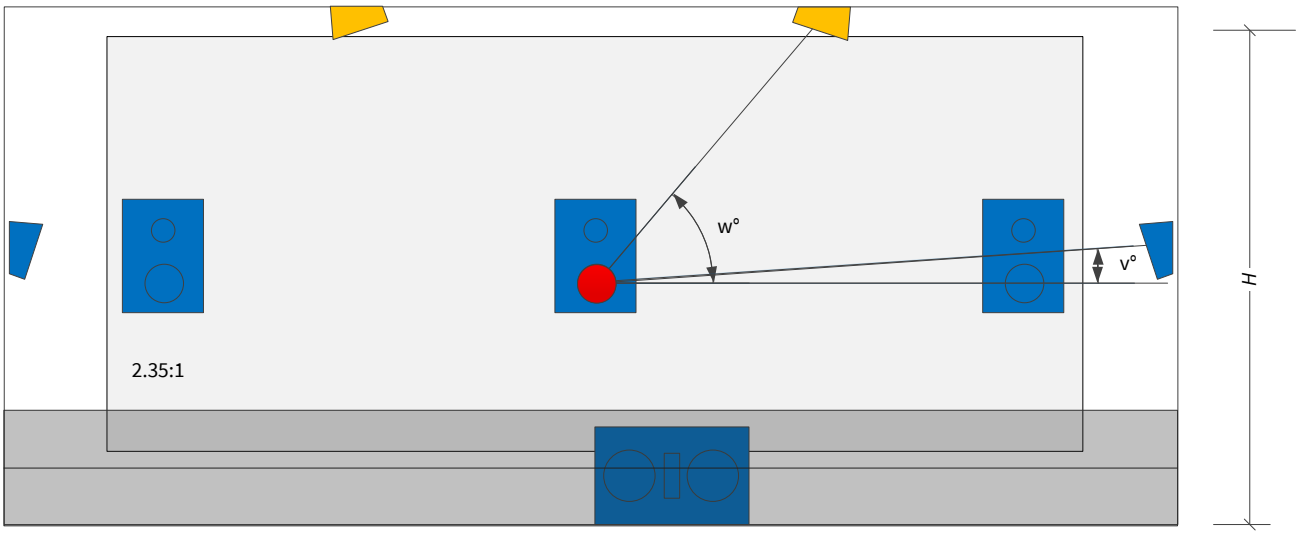


Figure 22: Front screen elevation diagram samples

Projected image



Flat-panel monitor

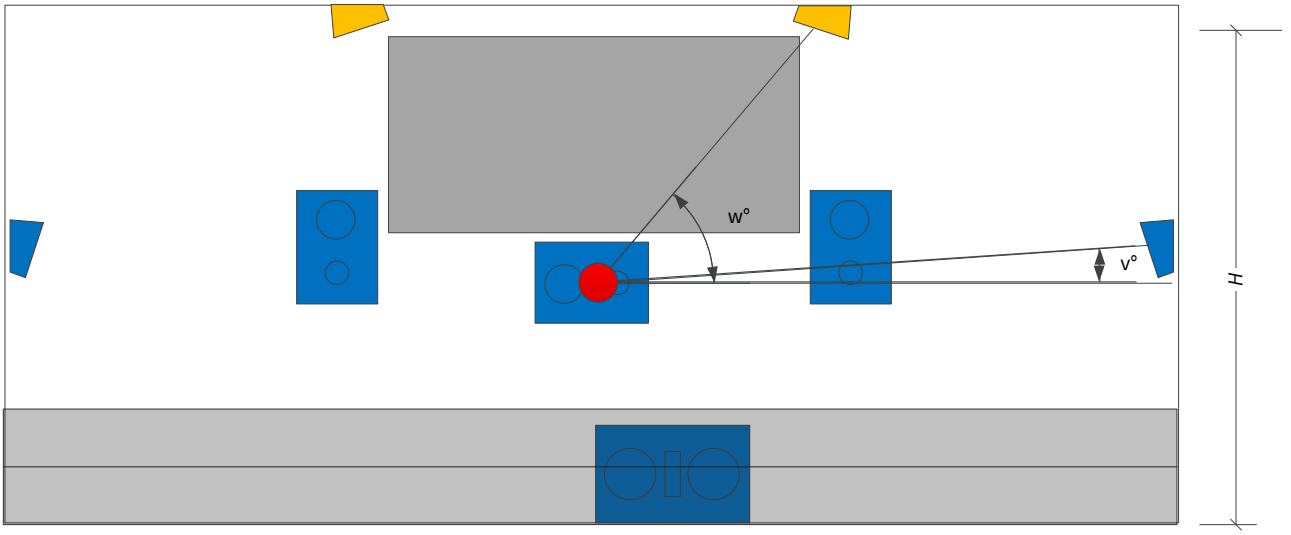
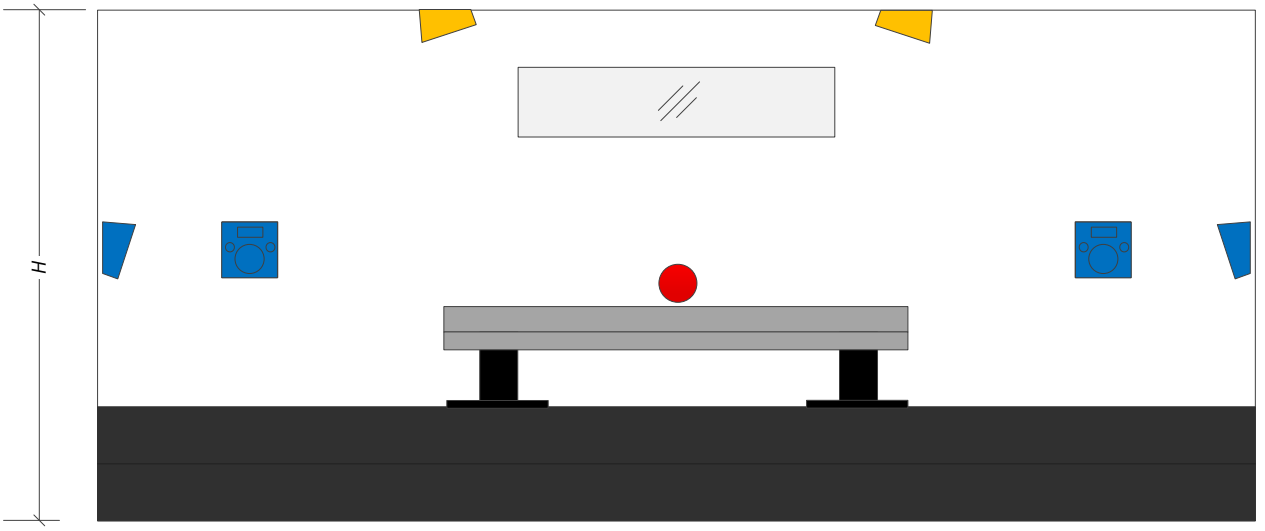


Figure 23: Rear elevation diagram sample



2.8.1 Estimating speaker output guidelines

To assist you in determining the speaker output capability requirements, Dolby provides recommended steps.

About this task

The performance guidelines for SPL in this documentation are given with respect to the mix position and are based on the capabilities and demands of a calibrated studio. Many variables affect playback levels, including B-chain processing, amplifier and speaker capabilities, and the room itself. Existing standards for the specification of speakers and amplifier performance cannot take into account the unique characteristics of each studio (screen loss, room EQ, SMPTE standards for level calibration and characteristic amplitude response, and so on). As a result, it is impossible to state with certainty the speaker performance requirements to achieve standard levels in all cases; one can only estimate.

Procedure

1. Determine the maximum continuous output SPL (SPL_{max}) of the speaker.

   This is often quoted in the speaker manufacturer literature. If SPL_{max} is not stated, compute it using the rated sensitivity (1 W at 1 m) and power handling (International Electrotechnical Commission (IEC) noise, with Audio Engineering Society (AES) duration of two hours) of the speaker, as follows:

   SPL_{max} = sensitivity + 10 × log10(power handling)
2. Measure the distance in meters (D2) from the speaker to the reference position, a point two-thirds back in the auditorium in the middle of the seating area.
3. Using this distance information, calculate the attenuation of sound pressure from the speaker to the reference position, as follows:

   Distance attenuation = 20 × log10(D1/D2)

   In this equation, D1 is one meter, D2 is the distance from step 2, and distance attenuation is a negative number representing level change (in decibels).
4. Add distance attenuation and SPL_{max}.

2.8.2 Notes on sound pressure level

Achieving sufficient sound pressure levels (SPLs) from each speaker can be a challenge. This topic presents the critical factors in achieving the specified SPL at the mix position.

- Distance: The distance from the speaker to the mix position.

- Speaker power handling.
- Speaker sensitivity: This takes into account speaker directivity. Directivity can increase the SPL at the mix position, but only for higher frequencies. The low-frequency transducer should be specified to produce sufficient output without any gain assumed based on directivity.
- Speaker aiming: Quoted speaker sensitivity and maximum SPLs are based on on-axis response. To achieve rated performance and uniform coverage, it is essential to aim each speaker toward the mix position.
- Bass management: Generating sufficient SPL at low frequencies is challenging, so Dolby Atmos supports bass management of the screen and surround speakers.
- Room loading: Screen speaker sensitivity can be increased by mounting in a baffle wall (half-space loading). Subwoofer sensitivity can be increased by clustering multiple subwoofers and by mounting at the junction of the wall and floor. Surround speakers should assume full space loading unless they are flush mounted to a wall or ceiling surface. Note that flush mounting of surrounds is not generally possible due to the need to properly aim each surround speaker through the listening area. See the manufacturer's guidelines for guidance on resulting gain.
- Speaker and room correction:
  - The frequency response of the speaker and room requires compensation with EQ to be applied. Large compensation gains will result in an additional load on the associated amplifier and speaker, limiting overall SPL capability.
  - Application of EQ according to SMPTE 202 will decrease the output requirements above 2 kHz. This is a small effect for surround speakers, but it can significantly ease the requirements for the screen speakers, which must overcome screen losses.

These factors should not be assumed to contribute to increased SPL at the mix position:

- Loss of less than 6 dB per doubling of distance (inverse square law loss presumed).
- Room gain: Modern studios have low reverberation.

Glossary

acoustic center
The point at which sound waves seem to originate from a speaker driver.

AES
Audio Engineering Society. An international organization that promotes advances in audio and disseminates new knowledge and research.

baffle
A surface or structure on which a speaker driver is mounted to prevent the front and rear sound waves from interfering with each other, thereby causing cancellation.

directivity
The extent to which a speaker driver emits sound in different directions.

Dolby RMU
Dolby Rendering and Mastering Unit.

EQ
Equalization. The adjustment of audio frequency responses for practical or aesthetic reasons.

frequency response
The range of frequencies that a speaker or headphones can reproduce.

IEC
International Electrotechnical Commission.

ISO
International Organization for Standardization.

ITU
International Telecommunication Union.

LFE
Low-Frequency Effects. A band-limited channel specifically intended for deep, low-pitched sounds.

MADI
Multichannel Audio Digital Interface. A communications protocol for an interface that carries multiple channels of digital audio, defined by the Audio Engineering Society. Also known as AES10.

SMPTE
Society of Motion Picture and Television Engineers.

SPL
Sound pressure level. A logarithmic measure of the force of sound on a surface area perpendicular to the direction of the sound.

up-firing
A speaker driver orientation whose output is directed upward to a ceiling.