

Sound field configurations for advanced multichannel sound systems

1 Introduction

The advanced multichannel sound systems described in this paper are categorized as channel-based sound systems derived by extending sound channels from the conventional 2-channel stereo and 5.1 channel sound formats. This approach requires a loudspeaker setup in which factors such as the number and positions of the loudspeakers are well defined.

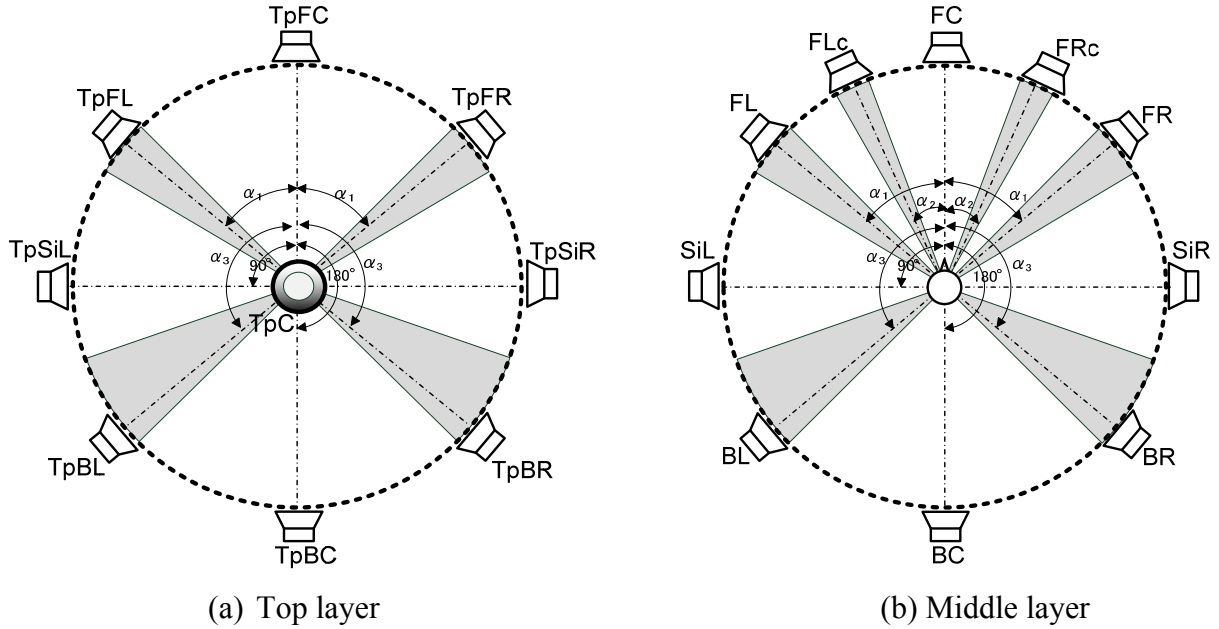
The sound field configuration for an advanced multichannel sound system is defined as the arrangement or configuration for a group of sound channels (loudspeakers) intended to be reproduced simultaneously.

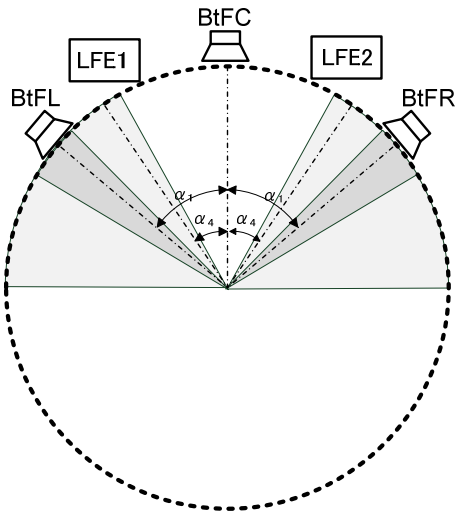
2 Sound system A: 22.2 multichannel sound system

Channel (loudspeaker) arrangements for the top, middle, and bottom layers are shown in Fig. 1(a) - (c), respectively. Fig. 1 (d) shows the channel (loudspeaker) arrangement for a vertically layered layout. The azimuth and elevation angles of each channel are shown in Table 1. The reference point is at the centre of the listening area. In typical sound studios, the distance between the reference point and each loudspeaker is assumed to be about 1.5-10 m.

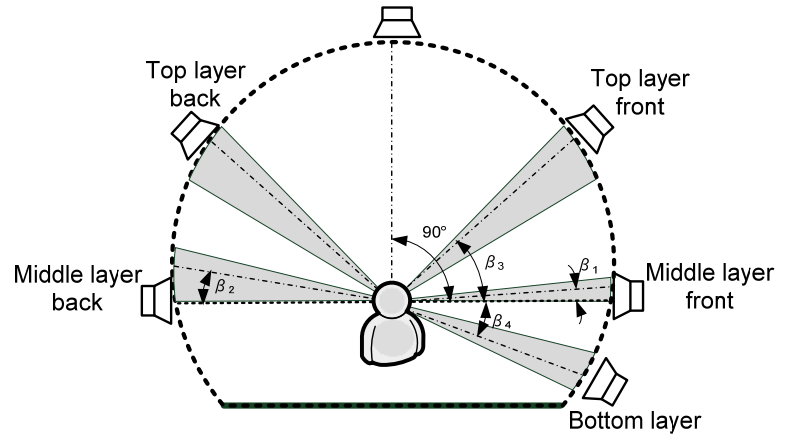
FIGURE 1

22.2 multichannel sound system loudspeaker layout





(c) Bottom layer



(d) Vertically layered layout

TABLE 1

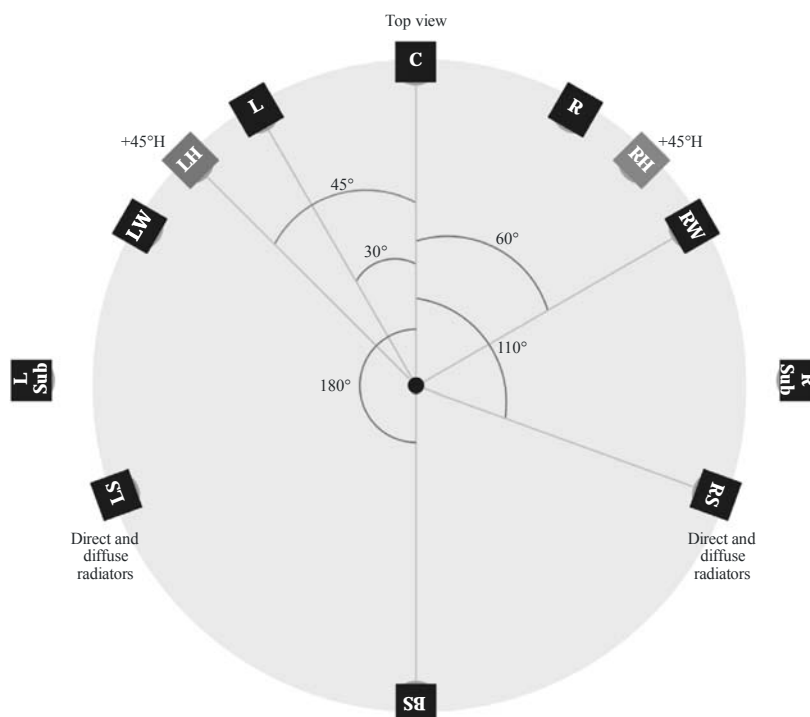
Channel arrangements for 22.2 multichannel sound system

Channel	Azimuth angle	Elevation angle	Remarks
FL, FR	$\pm (45^\circ \sim 60^\circ (\alpha_1))$	$0^\circ \sim 5^\circ (\beta_1)$	Front left, Front right
FC	0°	$0^\circ \sim 5^\circ (\beta_1)$	Front centre
FLc, FRc	$\pm (\alpha_1/2 (\alpha_2))$	$0^\circ \sim 5^\circ (\beta_1)$	Front left centre, Front right centre
SiL, SiR	$\pm 90^\circ$	$0^\circ \sim 15^\circ (\beta_2)$	Side left, Side right
BL, BR	$\pm (110^\circ \sim 135^\circ (\alpha_3))$	$0^\circ \sim 15^\circ (\beta_2)$	Back left, Back right
BC	180°	$0^\circ \sim 15^\circ (\beta_2)$	Back centre
TpFL, TpFR	$\pm (45^\circ \sim 60^\circ (\alpha_1))$	$30^\circ \sim 45^\circ (\beta_3)$	Top front left, Top front right
TpFC	0°	$30^\circ \sim 45^\circ (\beta_3)$	Top front centre
TpSiL, TpSiR	$\pm 90^\circ$	$30^\circ \sim 45^\circ (\beta_3)$	Top side left, Top side right
TpBL, TpBR	$\pm (110^\circ \sim 135^\circ (\alpha_3))$	$30^\circ \sim 45^\circ (\beta_3)$	Top back left, Top back right
TpBC	180°	$30^\circ \sim 45^\circ (\beta_3)$	Top back centre
TpC	-	90°	Top centre
BtFL, BtFR	$\pm (45^\circ \sim 60^\circ (\alpha_1))$	$-15^\circ \sim -30^\circ (\beta_4)$	Bottom front left, Bottom front right
BtFC	0°	$-15^\circ \sim -30^\circ (\beta_4)$	Bottom front centre
LFE1, LFE2	$\pm (30^\circ \sim 90^\circ (\alpha_4))$	$-15^\circ \sim -30^\circ (\beta_4)$	LFE1, LFE2

3 Sound system B: 10.2 multichannel sound system (Type 1)

A diagram of the 10.2 multichannel (type 1) loudspeaker layout is shown in Fig. 2. The azimuth and elevation angles of each channel are shown in Table 2. The reference point is at the centre of the listening area. In typical sound studios, the distance between the reference point and each loudspeaker is assumed to be about 1.5-10 m.

FIGURE 2

Diagram of 10.2 multichannel sound system (Type 1) loudspeaker layout

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This system actually employs 14 electrical channels. The 10.2 means the number of loudspeaker locations, since some loudspeaker channels can be combined into one physical location.

TABLE 2

Channel arrangements for 10.2 multichannel sound system (Type 1)

Channel	Azimuth angle	Elevation angle	Remarks
L, R	$\pm 30^\circ$	0° (Note 1)	Left, Right
C	0°	0° (Note 1)	Centre
LS direct, RS direct	$\pm (110^\circ \pm 10^\circ)$	0° (Note 1)	Left surround direct, Right surround direct
LW, RW	$\pm 60^\circ$	0° (Note 1)	Left wide, Right wide
LS diffuse, RS diffuse (Note 2)	$\pm (110^\circ \pm 10^\circ)$	0° (Note 1)	Left surround diffuse, Right surround diffuse
BS	180°	0° (Note 1)	Back surround
LH, RH	$\pm 45^\circ$	45°	Left height, Right height
L Sub, R Sub (Note 3)			LFE1, LFE2

NOTE 1 – Elevation is approximately 0° , but may be raised slightly for line-of-sight in multi-row listening for direct path sound, or the L screen channel in cinemas which are 2/3 of the way up the height of the motion-picture screen to the high-frequency section for instance.

NOTE 2 – For “small” rooms of a typical room volume of 85 m³: typically a dipole type loudspeaker radiation pattern (low bass excepted) at $-110^{\circ} \pm 10^{\circ}$ in plan, elevated above the LS direct (RS direct) loudspeaker. For “large” rooms (cinemas) which are typically $>1\ 000\ \text{m}^3$: typically a surround array composed of four to twelve loudspeakers laid out for uniform sound level coverage of the listening area.

NOTE 3 – Systems employ bass management. Bass below the operating frequency range of all of the left (right) channel loudspeakers (L, LH, LW, LS direct, LS diffuse) (R, RH, RW, RS direct, RS diffuse) and C are added together at equal level and L (R) LFE is added in at +10 dB in-band gain. Typical crossover frequency is 25-50 Hz. Typical L (R) LFE low pass filter frequency (brick wall) is 120 Hz. The combined signals are sent to one or more Subs located left of the listener. In cinemas they may be in the left (right) front corner. In small rooms they may be on the left (right) side of the room.

4 Sound system C: 10.2 multichannel sound system (Type 2)

Loudspeaker arrangements for the middle, top and bottom layers are shown in Figs. 3 and 4. The azimuth and elevation angles of each channel are shown in Table 3. The reference point is at the centre of the listening area. In typical sound studios, the distance between the reference point and each loudspeaker is assumed to be about 1.5-10 m.

FIGURE 3

Middle layer and top layer for 10.2 multichannel sound system (Type 2) loudspeaker layout

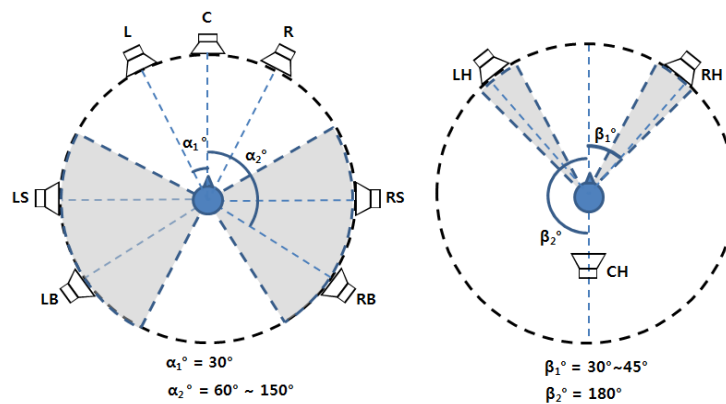


FIGURE 4

Top layer and bottom layer of 10.2 multichannel sound system (Type 2) loudspeaker layout

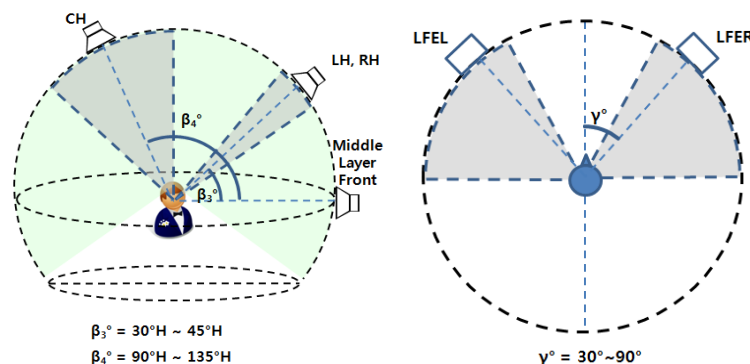


TABLE 3

Channel arrangements of 10.2 multichannel sound system (Type 2)

Channel	Azimuth angle	Elevation angle	Remarks
C	0°	0°	Centre
L, R	±30°	0°	Left, Right
LS, LB, RS, RB	± (60° ~ 150°)	0°	Left Side/Left Back, Right Side/Right Back
CH	180°	90° ~ 135°	Centre height
LH, RH	± (30° ~ 45°)	30° ~ 45°	Left height, Right height

APPENDIX

Features of advanced multichannel sound systems

Table A.1 provides information about the features of advanced multichannel sound systems with the 5.1 channel sound system specified in Recommendation ITU-R BS.775, “Multichannel stereophonic sound system with and without accompanying picture”. The columns correspond to the requirements described in Recommendation ITU-R BS.1909, “Performance requirements for an advanced multichannel stereophonic sound system for use with or without accompanying picture”.

TABLE A.1

Features of advanced multichannel sound systems

Sound field configuration				A (22.2ch)	B (10.2ch) (Type 1)	C (10.2ch) (Type 2)	5.1ch
Specification		Number of channels		24	14	12	6
		Number of loudspeaker locations (+ LFE loudspeakers)		22 +2	10 +2	10 +2	5 +1
Sound quality requirements	Coincidence between sound and video image position	Horizontal viewing angle		100°	60°	60°	60°
		Localization of “frontal sound image”	Horizontal direction	**	**	**	**
			Vertical direction	**	**	**	
	Localization of sound images “in all directions”	Horizontal plane	Front	**	**	*	*
			Side	**	*	**	
			Back	**	**	*	
		Above the listener	Top front	**	**	**	
			Top side	**			
			Top back	**		*	
		Below the listener	Bottom front	**			
	Sensation of a three-dimensional spatial impression	Listener's envelopment	Horizontal plane	**	**	**	*
			Above the listener	**			
	Listening area	Directional stability of the frontal sound image over the screen		***	**	**	**
Functional requirements		Backward compatibility with the 5.1ch sound system (Note 2)		**	**	**	ref
		Appropriate rendering for typical listening environments (computational complexity) Note3)		*	**	**	***
Operational requirement		Live recording, mixing and transmission		**	**	**	**

NOTE 1 – Codes of rating: ***: Fulfilled (much better), **: Fulfilled (better), *: Fulfilled (slightly better)

NOTE 2 – The advanced multichannel sound format is able to be rendered on existing 5.1ch sound reproduction systems.

NOTE 3 – Computational complexity may depend on the number of sound channels for an advanced multichannel sound system, on the reproduction sound quality and sound reproduction arrangement (e.g., the number and set-up position of loudspeakers), or on headphone reproduction.