

# Surface-mount Loudspeakers

## Design Guide

English

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# Overview

## Introduction

Using this design guide, you will be able to create designs for applications that utilize DesignMax™ and FreeSpace™ surface-mount loudspeakers. We offer additional design guides for pendant-mount and in-ceiling loudspeakers, as well as dedicated design guides for EdgeMax™ and FreeSpace 3 sub-satellite systems. To learn more about our loudspeakers and technology capabilities, as well as access additional trainings and tutorials, visit [BoseProfessional.com](https://www.boseprofessional.com).

## System Design Resources

In addition to this guide, we offer the following tools at [BoseProfessional.com](https://www.boseprofessional.com) on the software and individual loudspeaker product pages:

**Modeler™:** Advanced acoustical design simulation tool, with direct and reflected energy, and Speech Transmission Index (STI). Free to download at [BoseProfessional.com/Modeler](https://www.boseprofessional.com/Modeler)

**EASE GLL files:** For use in the AFMG EASE application, and the EASE GLL Viewer application. EASE allows the simulation of reverberation times, speech intelligibility, and other acoustical parameters. EASE is a paid download. EASE GLL Viewer is free to download.

**BIM files:** Includes the Revit format. Revit is a paid download.

## Overview

All system designs begin with a set of requirements. The system requirements can be as simple as, “it has to sound great” or as detailed as, “it must play background-level music at 5 dB above the ambient noise level of the restaurant’s main dining room, which is 65 dB.” The challenge is to gather the right set of requirements, and then turn them into a set of criteria that you can use to create your design. It is important to remember that you are the designer and should use your own intuition and decision skills when planning a project in addition to calculations. Applications with mounting heights up to 10 meters (32 feet) are supported through the surface-mount loudspeaker models listed in this guide.

There are four key requirements that need to be identified to deliver the right system:

**Loudness:** What sound pressure level (SPL) is required for this application?

**Mounting Height:** What loudspeakers will work best for my planned mounting height?

**Response:** What bandwidth is required for the type of program material that will be used?

**Coverage:** How consistent must the sound be across the entire coverage area?

Each of these requirements can be easily converted into a specification that we can use to create our system design. If we understand the customer’s needs in these four areas, we can deliver a design that will—at a minimum—meet their needs and—at best—exceed their expectations.

For the purposes of this design guide, we will assume that you are familiar with the system requirements for a commercial audio system and are ready to focus on loudspeaker selection, creation of a loudspeaker layout, and defining the necessary amplifier power needed to power the design.

## Design Guidelines

When creating a design, you should consider the following:

Mounting Height

Maximum SPL for the application (for example 70 dB-SPL, Z-weighted)

# Design Worksheet

Use the following worksheet to create a design using Bose Professional loudspeakers.

## Choosing a Model

### Step 1: Loudness

#### Maximum SPL Capability

Confirm that your chosen loudspeaker model will meet your loudness requirement. Find your mounting height and follow the column down until you reach your desired maximum continuous output level. Models with a higher sensitivity and higher tap settings will be able to play at higher levels. Individual model tap charts are available at the end of this document.

**Example:** For a mounting height of 5 meters (16 feet) in a project that requires 90 dB, you would choose FS4SE.

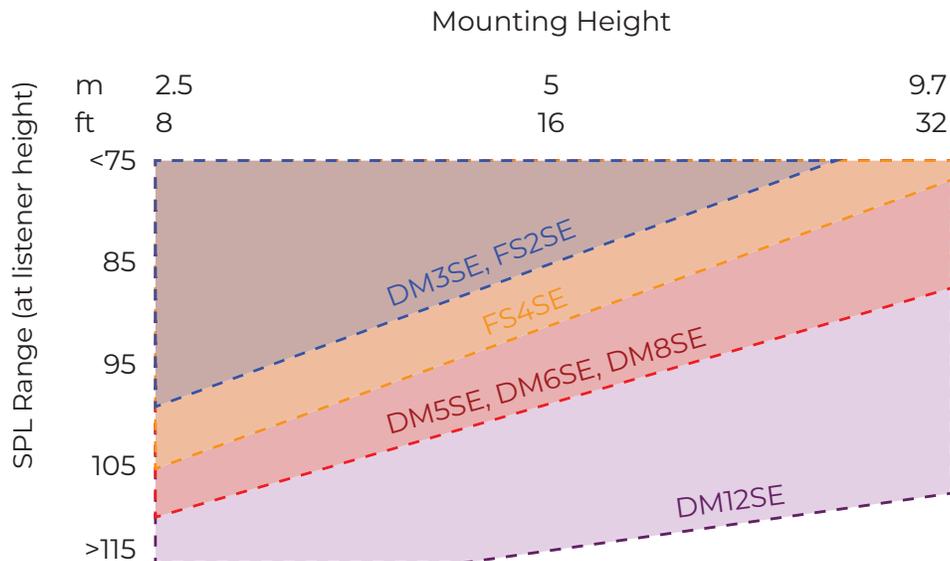
Surface-mount Models: Maximum Continuous Output Level														
Mounting Height	m	2.4	2.7	3	3.7	4	4.3	5	5.5	6	6.7	8	9.8	
		ft	8	9	10	12	13	14	16	18	20	22	26	
DM3SE	25W tap	97	94	93	90	89	88	86	84	83	82	80	78	dB-SPL
FS2SE	16W	98	96	94	91	90	89	87	85	84	83	81	79	
FS4SE	40W	102	100	98	95	94	93	91	89	88	87	85	83	
DM5SE	50W	103	100	99	96	95	94	92	90	89	88	86	84	
DM6SE	80W	106	104	102	99	98	97	95	93	92	91	89	87	
	8Ω	107	104	103	100	99	98	96	94	93	92	90	88	
DM8SE	80W	110	107	102	99	98	97	95	93	92	91	89	87	
	8Ω	112	109	107	104	103	102	101	99	98	97	95	93	
DM12SE	8Ω	119	118	117	116	115	114	113	112	111	110	109	107	

**Note:** The above table assumes standing ear height at 1.5 meters (5 feet), in standard-spacing (minimum overlap) configuration. Room reverberation could add as much as 4 dB system gain, which is not factored into the measurements above. Use of the transformer on 70/100V systems will introduce an insertion loss of 1 to 2 dB.

### Step 2: Mounting Height

#### Average Coverage and Woofer Sizes

Smaller woofer models have wider average coverage and provide better results at low mounting heights. Larger woofer models with narrower average coverage angles are better suited for higher mounting heights. Choose the models that will work with your mounting heights and rule out the other models.



Woofers Size	Model	Sensitivity (dB)	Highest Tap / Power Handling	Recommended Mounting Heights
2-4 in	FS2SE	87	16W	2.5 m-6.1 m (8'-20')
	DM3SE	86	25W	
	FS4SE	89	40W	
5-8 in	DM5SE	89	50W	3 m-10 m (10'-32')
	DM6SE (70/100V)	90	80W	
	DM6SE (8Ω)		100W	
	DM8SE (70/100V)	93	80W	
	DM8SE (8Ω)		125W	
12 in	DM12SE (8Ω)	94	300W	4.5 m-14 m (15'-46')

### Step 3: Response

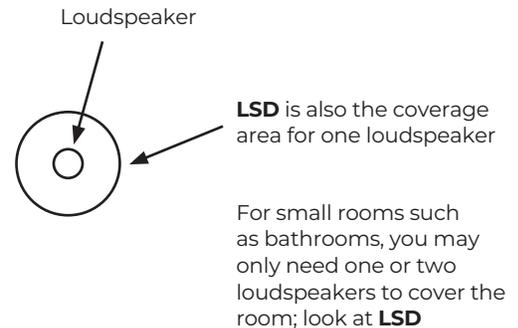
Confirm that the chosen loudspeaker will meet your low frequency response requirement.

Vocal-range	Low Frequency (-10 dB)	Full-range	Low Frequency (-10 dB)	Extended-range	Low Frequency (-10 dB)
FS2SE	83 Hz	FS4SE	70 Hz	DM12SE or FreeSpace 3 system	40 Hz
DM3SE	75 Hz	DM5SE DM6SE DM8SE	65 Hz 59 Hz 52 Hz	Any vocal-range or full-range loudspeaker combined with DM10S-SUB subwoofer	35 Hz

### Step 4: Coverage

#### Determining Loudspeaker Quantity and Spacing

The goal is to fill a rectangle-shaped room with coverage circles at your desired density. Using the graph paper on the last page, create a sketch layout of the room. Using your sketch of the room, follow the steps below to create a layout with the loudspeaker spacing that meets your coverage requirement. Calculators or software can simplify this process. Medium-sized or larger distributed installed systems for background music or voice typically have four or more surface-mount loudspeakers in a room. Use **Loudspeaker Spacing Distance (LSD)** for small rooms that only need one.

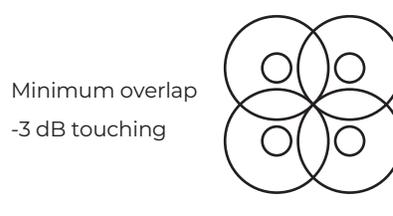
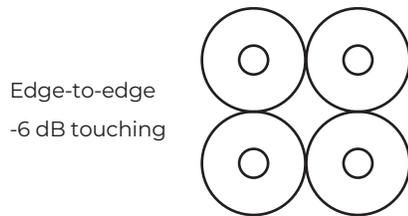
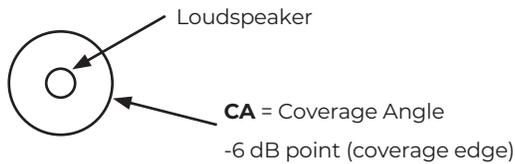


A. Calculate the Loudspeaker Spacing Distance (LSD)

We have found the following LSDs work for most applications. For more precise results, and to adjust for obstructions, use **Modeler**, **EASE**, or **EASE Evac** software or another calculator.

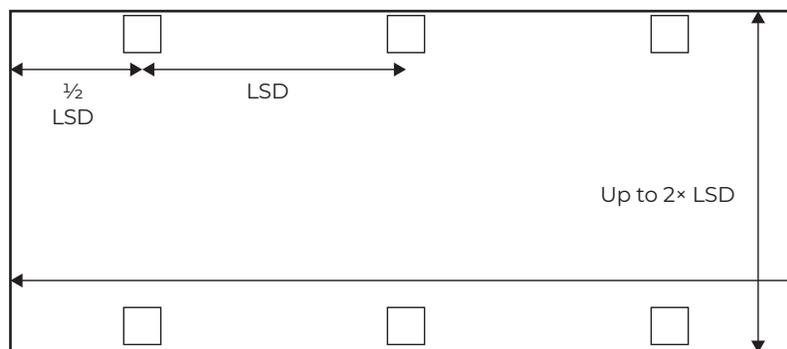
**Note:** For a fast average, start with 15 meters (44 feet) edge-to-edge, 10 meters (32 feet) minimum overlap, 8 meters (26 feet) center-to-center for LSD.

Loudspeaker Spacing Distance (LSD)															
Mounting Height		Listener Position		Standing 5 ft   1.5 m						Sitting 3.5 ft   1 m					
ft	m	Recommended Downward Pitch	Density	FS2SE		DM5SE		DM12SE		FS2SE		DM5SE		DM12SE	
				DM3SE	FS4SE	DM6SE	DM8SE	ft	m	ft	m	ft	m	ft	m
8	2.4	0°	Edge-to-edge	16	5	15	5	7	2	24	7	22	7	11	3
			Minimum Overlap	10	3	10	3	5	1	16	5	14	4	8	2
			Center-to-center	8	2	7	2	4	1	12	4	9	3	6	2
10	3.0	0°	Edge-to-edge	26	8	24	7	12	4	32	10	32	10	15	5
			Minimum Overlap	18	5	16	5	9	3	22	7	20	6	11	4
			Center-to-center	13	4	11	3	7	2	16	5	15	5	8	3
12	3.7	-15°	Edge-to-edge	34	10	30	9	17	5	40	12	35	11	20	6
			Minimum Overlap	21	6	20	6	12	4	26	8	24	7	15	4
			Center-to-center	17	5	15	5	9	3	19	6	17	5	11	3
14	4.3	-15°	Edge-to-edge	42	13	38	12	21	7	46	14	43	13	25	8
			Minimum Overlap	28	9	24	7	15	5	29	9	30	9	18	6
			Center-to-center	21	6	17	5	12	4	23	7	23	7	14	4
15	4.6	-30°	Edge-to-edge	42	13	36	11	24	7	46	14	40	12	27	9
			Minimum Overlap	28	9	24	7	18	5	30	9	28	9	20	7
			Center-to-center	23	7	19	6	13	4	25	8	23	7	15	5
16	4.9	-30°	Edge-to-edge	46	14	40	12	26	8	50	15	46	14	30	9
			Minimum Overlap	28	9	28	9	19	6	32	10	30	9	22	7
			Center-to-center	23	7	21	6	14	4	25	8	25	8	17	5
18	5.5	-45°	Edge-to-edge	48	15	42	13	31	10	52	16	46	14	35	11
			Minimum Overlap	32	10	30	9	23	7	33	10	32	10	26	8
			Center-to-center	25	8	23	7	17	6	29	9	25	8	19	6
20	6.1	-45°	Edge-to-edge	52	16	48	15	36	11	55	18	52	16	39	12
			Minimum Overlap	33	10	34	10	26	8	39	12	36	11	28	9
			Center-to-center	27	8	28	9	20	6	32	10	29	9	21	7
22	6.7	-45°	Edge-to-edge	55	18	54	16	41	12	55	20	55	18	44	14
			Minimum Overlap	41	12	36	11	30	9	46	14	40	12	32	10
			Center-to-center	33	10	31	9	23	7	35	11	33	10	24	8
24	7.3	-45°	Edge-to-edge	55	20	55	18	45	14	55	23	55	20	49	15
			Minimum Overlap	43	13	42	13	33	10	50	15	44	13	36	11
			Center-to-center	37	11	35	11	25	8	39	12	35	11	27	8
26	7.9	-45°	Edge-to-edge	55	23	55	20	50	15	55	24	55	22	54	16
			Minimum Overlap	44	13	44	13	37	11	52	16	50	15	39	12
			Center-to-center	37	11	39	12	28	8	43	13	41	12	30	9
28	8.5	-45°	Edge-to-edge	55	23	55	22	55	17	55	24	55	23	58	18
			Minimum Overlap	44	13	50	15	40	12	55	17	53	16	42	13
			Center-to-center	37	11	41	12	30	9	44	13	41	12	32	10



Edge-to-edge coverage can provide fidelity in fixed-location seating/standing and can generally work well for installations on a budget. It also works well for ambient-level and low-level background music. Center-to-center installations will have higher density and can accommodate people listening in many different positions and moving floor plans due to uniform coverage. They will also have fewer dead zones. Minimum overlap (or center-to-center) may also be needed if critical communication is happening over the system. **Modeler** or **EASE Evac** software can help with speech intelligibility evaluation.

- B. Place the first loudspeaker at  $\frac{1}{2}$  LSD from any corner of the room. Continue to place loudspeakers along the wall at LSD. Supported room width can be up to  $2 \times$  LSD, assuming loudspeakers are facing in from each opposing wall as shown.



- C. After the last loudspeaker is placed, center the loudspeakers in that row to create new offset distances out from each corner, which may be unique from  $\frac{1}{2}$  LSD.

### Subwoofers: Quantity and Placement of Subwoofers

The number of subwoofers to use, where to position them, and how loud to set them can vary depending on the individual situation. Details such as placement, boundary loading, room size, coupling quantity of multiple loudspeakers to subwoofers, type of music, type of activity, budget, and the expectations of the listeners should all be considered. The following guidelines are general rules to follow.

Add one subwoofer for every group of four vocal- or full-range loudspeakers.

Subwoofer spacing should be as far apart as is practical. 12.2 meters (40 feet) or greater subwoofer-to-subwoofer spacing distance within the same zone is desirable.

When the suggested subwoofer count is two within a single zone, it may be preferable to use either one in a corner to avoid audible interference; or increase the count to three, which creates more audible interference locations but limits them to smaller sizes where the reverberant field (added room reflections) tends to mask them.

Placing a ceiling subwoofer within 0.9 meters (3 feet) of a wall increases its output by 3 dB. Placing it within 0.9 meters (3 feet) of a corner increases its output by another 3 dB (6 dB total) and also reduces reflections that can create audible interference (bass cancellations) in the listening area.

Listening positions located below the subwoofer should be supported by a nearby vocal- or full-range loudspeaker to provide better tonal balance in the low-frequency pressure zone.

**Step 5: Calculate Required Amplifier Size**

All FreeSpace FS and DesignMax loudspeakers are compatible with 70-volt, 100-volt, and low-impedance amplifiers.

**Use the Tap Charts to determine which loudspeaker tap is required for this design**

- A. Locate the loudspeaker tap chart and find the column for mounting height for this design.
- B. Follow the column to the desired maximum SPL.
- C. Follow the row across the chart to determine the required loudspeaker tap.
- D. Calculate the required amplifier power:

$$\frac{\text{Number of Loudspeakers Required}}{\text{Number of Loudspeakers Required}} \times \frac{\text{Required Loudspeaker Tap}}{\text{Required Loudspeaker Tap}} = \frac{\text{Power Required}}{\text{Power Required}}$$

- E. Calculate the required amplifier size:

$$\frac{\text{Power Required}}{\text{Power Required}} \times \frac{1.10}{\text{Headroom}} = \frac{\text{Amplifier Size}}{\text{Amplifier Size}}$$

**Amplifiers: Example Amplifier Configurations**

Modern amplifiers come in a variety of channel counts and configuration options to allow for different output configurations, zoning options, and varying loudspeaker quantities. A properly optimized system may only need a low 1- or 2-watt tap setting to achieve 70 dB in a typical room. The below example lists how many FS2SE loudspeakers can be handled at the loudspeaker’s highest 70/100V tap setting.

FreeSpace FS2SE Loudspeaker Amplifier Example	Maximum Loudspeakers at Higher Tap Settings	EQ Preset
FreeSpace IZA 190-HZ	5 at 16W, 10 at 8W tap	FS2C/SE/P
FreeSpace IZA 2120-HZ	6 at 16W, 13 at 8W	FS2C/SE/P
PowerShare PS404D	22 at 16W, 45 at 8W	FS2SE
PowerSpace P4150+	8 at 16W, 17 at 8W	FS2SE
Veritas 1100BH	5 at 16W, 11 at 8W	FS2SE
Veritas 2160BH	18 at 16W, 36 at 8W	FS2SE

**SmartBass™: Application of SmartBass processing**

If your design is using a PowerSpace™+ amplifier; or your design utilizes a dedicated Bose Professional DSP, such as the Commercial Sound Processor CSP models; or any of the ControlSpace™ ESP or EX models; you have the option of applying SmartBass to your loudspeaker output channel. This uses Bose Professional EQ presets, dynamic EQ, and excursion limiting tuned to each model and room calibration. This will prevent lower background-level music from sounding thin, but also ensures the sound is consistent at various SPL levels. At louder levels, SmartBass also allows for more musical limiting than traditional voltage limiters.

# Tap Charts

## Individual Loudspeaker Continuous Output Level

**Note:** The following tap charts assume standing ear height at 1.5 meters (5 feet) in standard spacing. Room reverberation could add as much as 4 dB system gain, which is not factored into the measurements. Designing without room gain will ensure you don't under-plan your design, and amp attenuation is possible at the job site if you exceed the average room SPL target during measurement. Values below 70 dB are omitted—select a higher tap.

### DM3SE

Mounting Height		m	2.4	2.7	3	3.7	4	4.3	5	5.5	6	6.7	8	9.8	
		ft	8	9	10	12	13	14	16	18	20	22	26	32	
<b>TAP</b>	3W		88	85	83	80	79	78	77	75	74	73	71	69	dB-SPL
	6W		91	88	86	83	82	81	80	78	77	76	74	72	
	12W		94	91	89	86	85	84	83	81	80	79	77	75	
	25W		97	94	93	90	89	88	86	84	83	82	80	78	
	8Ω		97	94	93	90	89	88	86	84	83	82	80	78	

### DM5SE

Mounting Height		m	2.4	2.7	3	3.7	4	4.3	5	5.5	6	6.7	8	9.8	
		ft	8	9	10	12	13	14	16	18	20	22	26	32	
<b>TAP</b>	3W		91	88	86	83	82	81	80	78	77	76	74	72	dB-SPL
	91		94	91	89	86	85	84	83	81	80	79	77	75	
	12W		97	94	92	89	88	87	86	84	83	82	80	78	
	25W		100	97	96	93	92	91	89	87	86	85	83	81	
	50W		103	100	99	96	95	94	92	90	89	88	86	84	
	8Ω		103	100	99	96	95	94	92	90	89	88	86	84	

### DM6SE

Mounting Height		m	2.4	2.7	3	3.7	4	4.3	5	5.5	6	6.7	8	9.8	
		ft	8	9	10	12	13	14	16	18	20	22	26	32	
<b>TAP</b>	2.5W		91	88	87	84	83	82	80	78	77	76	74	72	dB-SPL
	5W		94	91	90	87	86	85	83	81	80	79	77	75	
	10W		97	94	93	90	89	88	86	84	83	82	80	78	
	20W		100	97	96	93	92	91	89	87	86	85	83	81	
	40W		103	101	99	96	95	94	92	90	89	88	86	84	
	80W		106	104	102	99	98	97	95	93	92	91	89	87	
	8Ω		107	104	103	100	99	98	96	94	93	92	90	88	

**DM8SE**

Mounting Height		m	2.4	2.7	3	3.7	4	4.3	5	5.5	6	6.7	8	9.8	
		ft	8	9	10	12	13	14	16	18	20	22	26	32	
<b>TAP</b>	2.5W	95	92	87	84	83	82	80	78	77	76	74	72	dB-SPL	
	5W	98	95	90	87	86	85	83	81	80	79	77	75		
	10W	101	98	93	90	89	88	86	84	83	82	80	78		
	20W	104	101	96	93	92	91	89	87	86	85	83	81		
	40W	107	104	99	96	95	94	92	90	89	88	86	84		
	80W	110	107	102	99	98	97	95	93	92	91	89	87		
	8Ω	112	109	107	104	103	102	101	99	98	97	95	93		

**DM12SE**

Mounting Height		m	2.4	2.7	3	3.7	4	4.3	5	5.5	6	6.7	8	9.8	
		ft	8	9	10	12	13	14	16	18	20	22	26	32	
8Ω		119	118	117	116	115	114	113	112	111	110	109	107	dB-SPL	

**FS2SE**

Mounting Height		m	2.4	2.7	3	3.7	4	4.3	5	5.5	6	6.7	8	9.8	
		ft	8	9	10	12	13	14	16	18	20	22	26	32	
<b>TAP</b>	1W	86	83	82	79	78	77	75	73	72	71	—	—	dB-SPL	
	2W	89	87	85	82	81	80	78	76	75	74	72	70		
	4W	92	90	88	85	84	83	81	79	78	77	75	73		
	8W	95	93	91	88	87	86	84	82	81	80	78	76		
	16W	98	96	94	91	90	89	87	85	84	83	81	79		
	8Ω	98	96	94	91	90	89	87	85	84	83	81	79		

**FS4SE**

Mounting Height		m	2.4	2.7	3	3.7	4	4.3	5	5.5	6	6.7	8	9.8	
		ft	8	9	10	12	13	14	16	18	20	22	26	32	
<b>TAP</b>	2.5W	90	87	86	83	82	81	79	77	76	75	73	71	dB-SPL	
	5W	93	90	89	86	85	84	82	80	79	78	76	74		
	10W	96	93	92	89	88	87	85	83	82	81	79	77		
	20W	99	96	95	92	91	90	88	86	85	84	82	80		
	40W	102	100	98	95	94	93	91	89	88	87	85	83		
	8Ω	102	100	98	95	94	93	91	89	88	87	85	83		

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# Graph Paper

