Selecting the right directional loudspeaker with well defined acoustical coverage

Abstract

A well defined acoustical coverage is highly desirable in open spaces that are used for collaboration learning, huddle spaces, digital signage, retail merchandising, etc. Audio loudspeakers utilizing different technologies have been used to address this issue in the marketplace, but most have limitations. Criteria for the selection of the most effective and appropriate loudspeakers with well defined acoustical coverage is described here.

Introduction

In collaboration learning areas, huddle spaces, video conference rooms, retail merchandising areas and other open venues, a need arises to control the sound-field without affecting the speech intelligibility and tonal quality of the acoustical signals. The Figure 1 below shows a typical application in an open space with a display and a desired coverage area.

Figure 1

The audio zone should be large enough to cover floor space occupied by 1-6 people as shown in the figure. The audio zone should coincide with the field of vision of the LCD display. The audio signals outside the desired zone should attenuate quickly and blend with the ambient noise of the environment.

Desired audio zone to cover the seating withing the visual range of the TV monitor at an airport waiting area

Figure 2

Collaboration learning spaces with multiple audio zones

Figure 3

Many different sound-field control technologies exist in the marketplace. Each technology has its own merits and limitations. Unfortunately, many times these products and technologies are marketed as the best solution and misapplied in the marketplace. Loudspeakers generally reproduce omni-directional sound that propagate in all directions with uniform sound-field intensity. Over the past few

decades, many companies have introduced directional loudspeakers based on various methods and technologies to provide a controlled sound-field. In the following sections different loudspeakers and techniques are described.

Parabolic dome speaker

One simple method is to place the speaker element in a parabolic reflector near its focal point. Figure 4 shows a typical parabolic reflector dome speaker. The sound emanating from the parabolic reflector speaker will beam along the central axis in a very focused beam. There will be a little dispersion off-axis due to the edge diffraction of the acrylic dome as well.

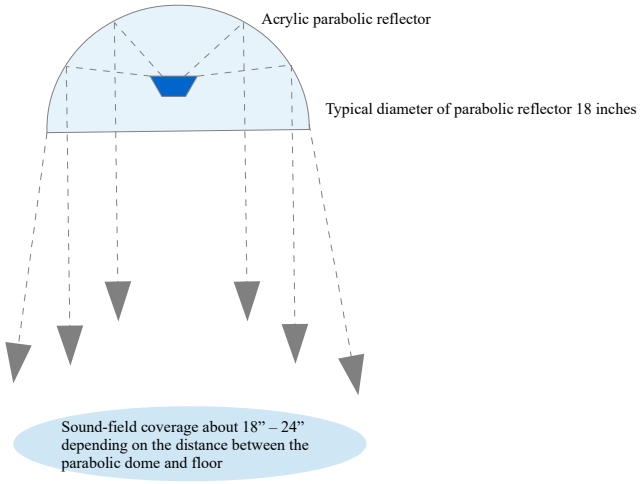


Figure 4

Low frequency signals have a higher tendency to propagate in all directions and higher frequencies are more directional. To control the dispersion area below the parabolic domes, a high-pass filter is applied to the audio signal to eliminate frequencies below 400 Hz. While this acrylic dome loudspeaker provides a controlled area of coverage, it is often too narrow and limited to no more than one or two individuals that occupy the acoustically covered space. Application of these type of parabolic dome reflector loudspeakers is inappropriate in zones where coverage is required to address 1-6 people in an area. Yet these type of loudspeakers are marketed and misapplied for directional audio applications.

Ultra-sonic transducer directional loudspeaker

Another loudspeaker technology utilizes ultrasonic frequencies to reproduce the sound-field by vibrating air mass at a distance from the transducer surface. This approach produces a very tight spot of sound-field but at the expense of amplifier power and frequency response. It takes tremendous amount of amplifier power to move air mass to reproduce low frequencies utilizing this method. Hence these loudspeakers do not attempt to reproduce frequencies below 500 Hz. The sweet-spot of acoustical coverage is a fixed distance from the transducers. Areas much closer or farther away from the sweet-spot do not offer much audio coverage.
Figure 5 shows the coverage pattern for an ultra-sonic transducer directional speaker.

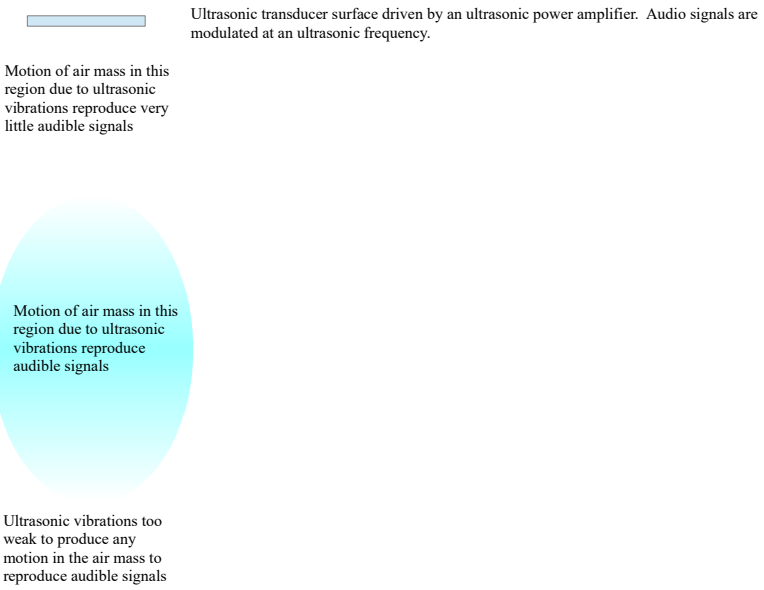


Figure 5

The cross-sectional area of the audible zone correlates with the cross-section of the ultra-sonic transducer surface. So typically this type of loudspeaker has even a much narrower spot beam coverage compared to the parabolic dome loudspeaker. These are only good for an audience of one person in the audio zone. Larger transducer surfaces would be required for broader spot beams and much higher power amplifier would be needed to drive the transducer. Transducer fatigue and amplifier failure are common when these ultrasonic speakers are powered continuously for long periods of time in applications such as digital signage. This type of loudspeaker is ideal for ship-board/maritime communications where high directionality is desired and the communications happens in short voice bursts. For applications addressing an audience of 1-6 people in collaboration learning, huddle spaces, digital signage, etc. the ultrasonic transducer loudspeakers are misapplied.

Line-array directional loudspeaker

Loudpeakers composed of an array of radiating elements can achieve the desired results of a well-defined acoustical coverage in the zone of interest and signal attenuation outside the zone of interest. A linear array of radiating elements will provide controlled sound-field on the axis and a broad sound-field in the off-axis. Control of the sound-field can also be enhanced by applying signal processing techniques to each of the radiating elements in the array. An array of radiating elements in a circular or grid pattern can be utilized to gain control of the sound-field dispersion in both axis. The coverage area of the zone can be enhanced by applying signal processing to the radiating elements in the array.

Pragmatic offers a family of line-array speakers with well-defined acoustical coverage for video conference rooms, retail merchandising, digital signage applications, etc., where the sound-field needs to be controlled only on a single axis. The acoustical coverage is controlled by the number of speakers in the line-array. The higher the number of speakers in an array, the tighter the acoustical dispersion of the speaker. An array with 48 speakers can offer a beam-width of 10 degrees. The PHA family of line-array speakers have been successfully deployed in the retail stores, pharmacies, health-care facilities, shopping malls, transportation hubs, school gyms, live theaters, houses of worship, etc.
Figure 6 below shows a typical application of the PHA line-array speakers in a digital signage in an airport terminal waiting area.

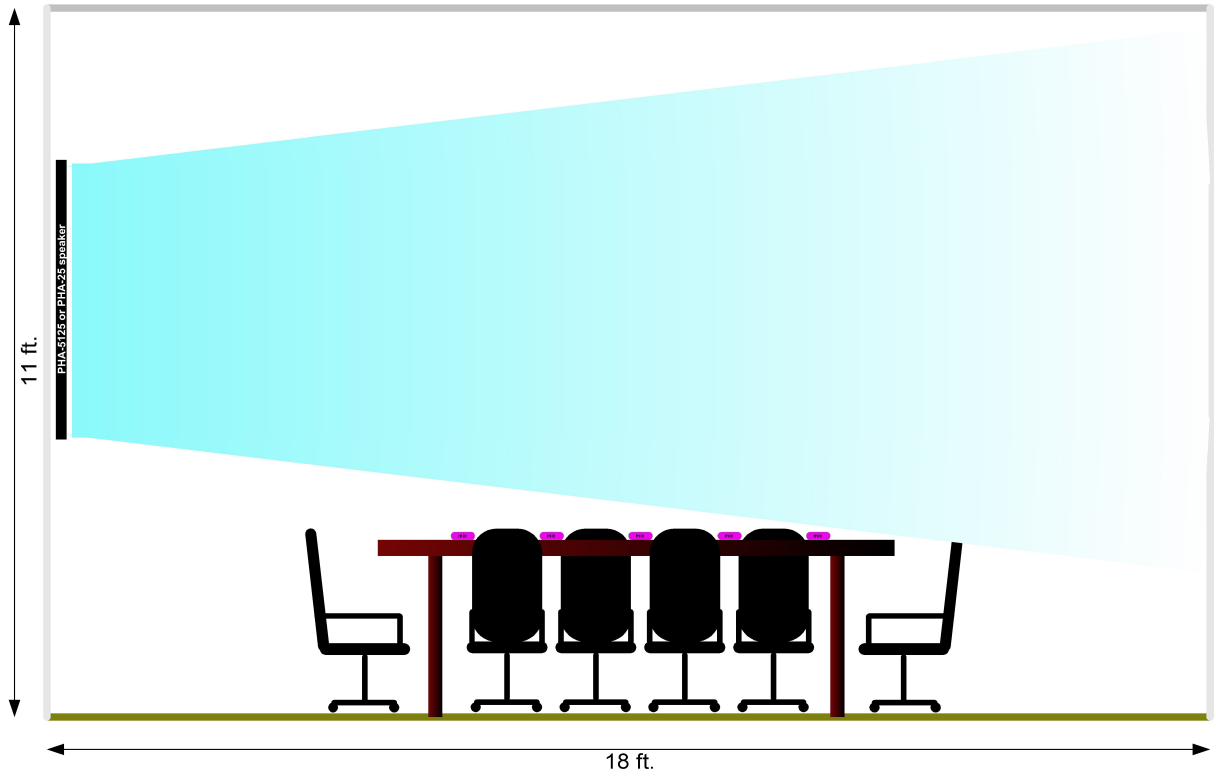
Figure 6

The PHA-5125 compact line-array speaker is mounted horizontally on the top of the monitor in the seating area. In this configuration the speaker has a broad vertical acoustical coverage but a narrow coverage across the horizontal axis in the seating area. The sound-field does not extend out into the passage hall and walkways. It is confined within the seating area.

A linear line-array speaker offers acoustical control on a single axis and offers coverage to a large audience. Advantage of this single axis acoustical sound-field control can be utilized in many different applications. If the speaker is mounted vertically, it will have a broad horizontal coverage but a narrow vertical axis coverage.

The compact line-array speakers such as the PHA-5125 also offer great advantage in video conference rooms when it is mounted vertically. The controlled sound-field field in the vertical dimension greatly reduce the far-end signal from the speakers being picked up by the table-top or ceiling mounted microphones. This greatly reduces the far-end echo and acoustic feedback problems in the video conference rooms. Reduced far-end echo and minimized acoustic feedback in the room coupled with the excellent speech intelligibility of the line-array speakers results in an exceptional meeting experience.

Figure 7 shows a typical application of the PHA-5125 or PHA-25 compact line-array speaker in video conference room. The speaker is mounted vertically on the wall and the conference microphones are placed on the table.

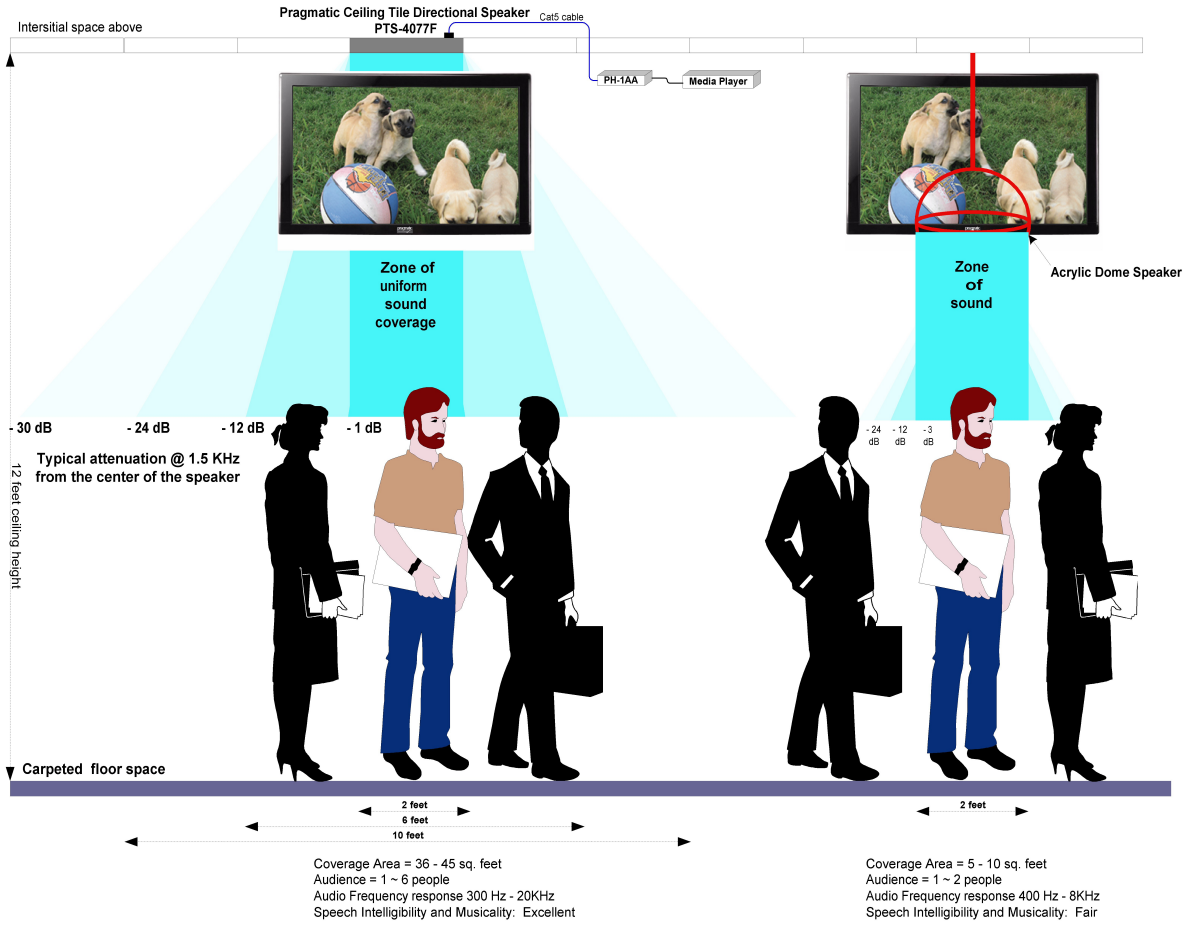


Typical conference room application

Figure 7

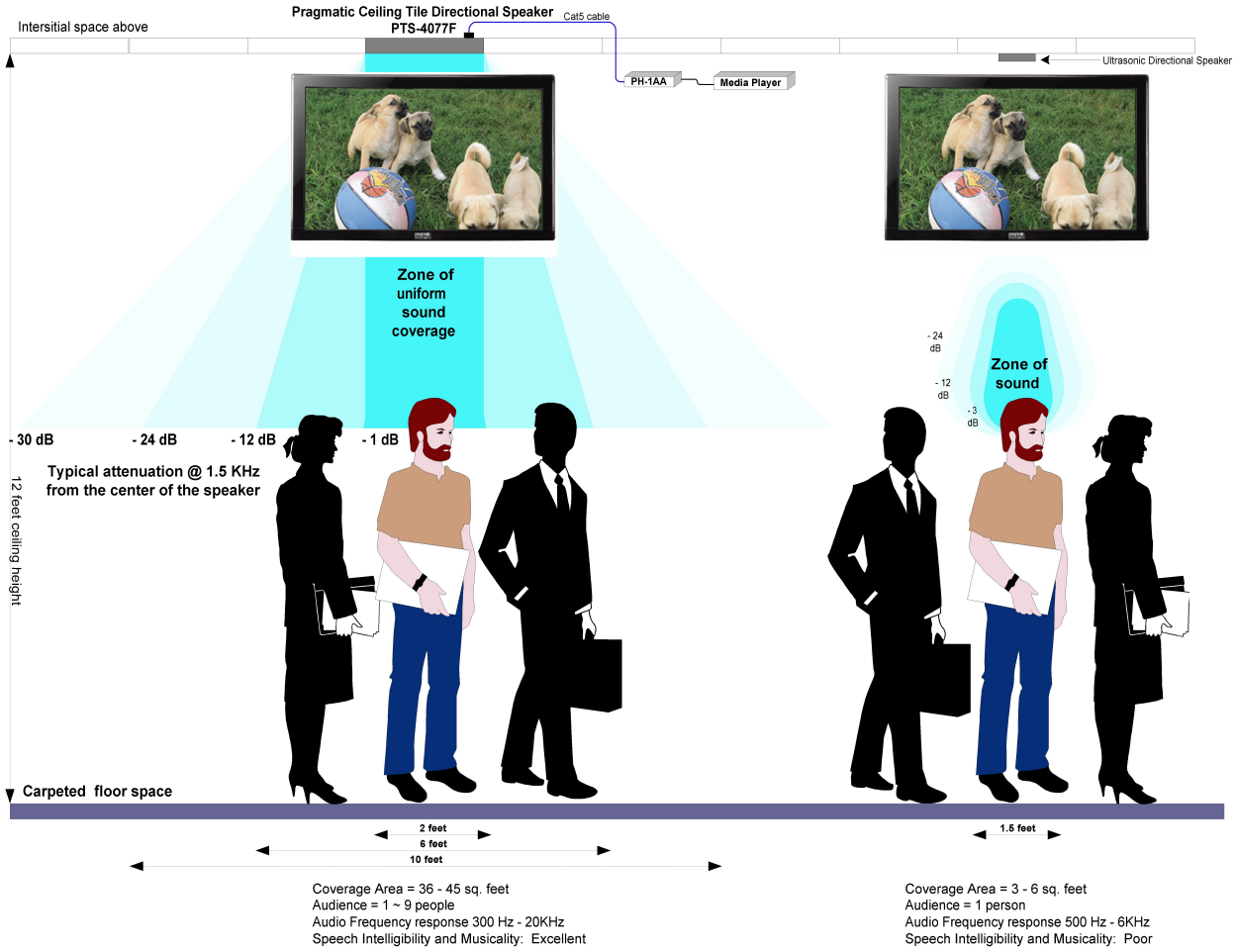
In many applications such as collaboration learning, huddle spaces, pharmacy consultation areas, etc. a circular sound-field with control on both axis is desired. Pragmatic PTS-4077F ceiling tile directional speaker offers an optimum circular zone coverage ideal for an audience of a small group of people in the visual zone of a 42" - 55" LCD monitor. It is an active speaker with an array of radiating elements in a geometric pattern to provide the desired acoustical coverage pattern. With a typical ceiling height of 12 ft., the speaker offers an acoustical sound-field of about 36 to 45 sq. ft. Since the acoustical control is achieved through the array of the radiating elements in a geometric pattern, full frequency spectrum is maintained within the zone. Outside of the controlled zone, the signal fades away quickly and blends into the ambient noise.

Figure 7 shows the difference in the coverage patterns between the PTS-4077F and a parabolic dome speaker. It can be seen that the PTS-4077F offers a coverage area to address an audience of about 6 people whereas the parabolic dome speaker has a much smaller coverage for a couple of people. The PTS-4077F offers a full frequency response providing an excellent speech intelligibility. Due to the limited frequency response of the parabolic dome speaker on the lower and upper frequency spectrum, its speech intelligibility is reduced.



Pragmatic PTS-4077F Ceiling Tile Directional Speaker vs Parabolic Dome Speaker
Figure 7

Figure 8 below shows the difference in the coverage patterns between the PTS-4077F and an ultra-sonic directional speaker. It can be seen that the PTS-4077F offers a coverage area to address an audience of about 6 people whereas the ultra-sonic transducer speaker has a much smaller coverage for a single person. The speech intelligibility of the PTS-4077F is excellent compared to the ultra-sonic transducer speaker due to its limited frequency response.



Pragmatic PTS-4077F Ceiling Tile Directional Speaker vs Ultra-sonic transducer Speaker

Figure 8

Conclusion

It is important to select the correct loudspeaker for the desired acoustical coverage area. Misapplying a directional speaker can result in lack of proper coverage area, inadequate frequency response and loss of speech intelligibility. In case of ultrasonic directional speakers, it also affects the long term reliability due to transducer fatigue and amplifier failure. Pragmatic PHA family of line-array speakers offer excellent acoustical control on a single axis and depending on the orientation of implementation are ideal for video conference rooms, retail stores, pharmacies, health-care facilities, shopping malls, transportation hubs, school gyms, live theaters, houses of worship, etc. Pragmatic directional ceiling tile speaker PTS-4077F offers the most optimum coverage on two axis, full frequency spectrum for highest level of speech intelligibility and excellent musicality for a wide range of applications including collaboration learning, huddle spaces, digital signage, medical and pharmacy consultation areas, retail merchandising, art galleries, museums, etc.