Optimizing Sound Field Distribution for Classrooms
The Extron FF 120T with Exclusive Flat Field® Technology

An important goal in designing an effective classroom sound system is to ensure uniform delivery of the instructor’s voice and other audio content to all students. In practice, achieving this is often difficult, due to the fact that conventional ceiling speakers usually provide uneven sound field coverage. As a result, students seated directly below a speaker receive full sound reinforcement while others sitting off-axis may have difficulty clearly hearing the audio. Studies have shown that students who experience hearing limitations within a classroom environment are impeded in achievement level.

A solution to improving sound field coverage is to increase the number of ceiling speakers. However, this increases cost, and budget restrictions usually necessitate a tradeoff between sound field uniformity and the number and cost of ceiling speakers deployed. The Extron FF 120 Flat Field ceiling speaker and FF 120T Flat Field ceiling speaker with 70 volt transformer solve this problem. They feature our exclusive, patent pending Flat Field Technology that redirects the sound to produce a flat sound field over a wide area, so that the same sound pressure level is perceived directly below the speaker and off-axis. With this wide, uniform sound distribution, two FF 120T speakers can deliver the audio coverage needed for all students in a typical 30 foot (9 meter) square classroom. A pair of FF 120 speakers is included with every PoleVault® System and VoiceLift® Microphone System.

The Challenge with Conventional Ceiling Speakers
A conventional speaker radiates outward in a conical pattern, with a specific area of coverage based on a solid radiation angle whereby speaker coverage increases with distance. As this coverage increases, the sound pressure level rapidly decreases for listeners located off the main radiation axis away from the speaker’s center. This is due partly to the fact that the distance from the speaker increases as a listener moves off-axis from the central on-axis location. Another contributing factor is the typical tendency of a conventional speaker’s off-axis response to be attenuated within the listening plane, when compared to the response measured on-axis.

The sound level perceived by the listener can also decrease in areas where radiation patterns between speakers overlap. In these areas, sound wave cancellation can occur, leading to a further drop in sound pressure level. See Figure 1. Together, all these effects of being seated off-axis can result in a student experiencing as much as a 12 dB drop in sound pressure level, or less than half of what would be heard if the student were seated within the “hot spot,” directly below the speaker.

As mentioned, increasing the number of speakers in the system increases the overlap in radiation patterns between them, improving overall sound field coverage, but this is usually cost-prohibitive. Alternatively, increasing the volume level may improve hearing somewhat for students seated off-axis, but will likely cause discomfort for those within hot spots.

How Flat Field Technology Improves Coverage
To understand how Extron’s Flat Field Technology works, consider the way in which a basic convex lens focuses light rays. In Figure 2, light rays enter the lens from a distant object. The light rays, for all practical
Did You Know?
Not all ceiling speakers on the market are UL listed. Those that are may be listed for commercial and professional use, but do not have the appropriate UL rating for installation and use in a plenum airspace.

Mounting ceiling loudspeakers is most often accomplished by modification of and insertion into suspended ceiling acoustic tiles. The space above the ceiling tile, in many cases, is used as an air return space for the building heating and cooling system. UL refers to this space as “other air handling spaces”, but in the A/V industry, this is typically referred to as a “plenum” space.

In order to comply with local building safety codes, ceiling speakers need to be “plenum rated” if mounted within a designated air handling space. The plenum rating requires listing specifically to UL 2043.

**FF 120T UL Listed and Plenum Rated**
A UL mark does not guarantee plenum applicability. The FF 120T, however, is UL listed indicating that it conforms to specified safety standards. Look closely at the label below. The FF 120T is UL 2043 listed for use in air handling spaces. It is also UL 1480 listed for commercial and professional use. Check a speaker’s certification on UL’s Web site, www.ul.com, before you specify it for a plenum ceiling application.

**Figure 2:** Light rays entering a convex lens are focused at some point behind the lens.

### Optimizing Sound Field Distribution for Classrooms — continued

Considerations, are parallel. The refractive attributes of the lens bend the light rays to converge on a point some distance behind the lens. The distance at which the rays converge to a single point is called the focal length of the lens.

This property of optics can be utilized in reverse. A lens positioned precisely at its focal length in front of a point light source will collect light from the source and redirect it to appear to the observer as a broad, flat light source. In fact, this is similar to how a large screen projector functions. Pixels on an imaging device resting at the precise focus of an objective lens are collected and projected as diverging rays toward the screen. The diverging rays allow for the magnification of the image to a larger size useful for audience presentation. Similarly, sound waves can be directed so as to realize a flat sound field even though those sound waves are diverging from a point source.

Our Flat Field speaker design treats the speaker, the sound source, as a point source. The mechanical design of the speaker and its enclosure represent a closely-coupled point source and “lens” combination. Radiated sound waves are redirected, somewhat like refraction, to better equalize the perceived sound pressure level over the divergent coverage area of the speaker. See Figure 3 below, which illustrates this concept, and compare it to the typical sound field from all other ceiling speakers shown in Figure 1. The speaker radiation pattern from all other ceiling speakers creates an on-axis hot spot plus zones of reinforcement and cancellation when grouped into ceiling arrays.

**How Extron’s Flat Field FF 120T Speaker Helps You**
Figure 4 illustrates a typical plan view for a classroom speaker sound field. Conventional speakers produce a circular sound field having 6 dB sound pressure level loss at the limit of their specified radiation angle. A sufficient quantity of speakers must be installed with significant overlap in order to accomplish full room coverage without perceived SPL loss over the listening area. At best, regions of sound reinforcement and regions of sound cancellation still occur as discussed earlier. System design and speaker selection must be done very carefully.

**Figure 3:** Coverage pattern of FF 120T speaker with Flat Field Technology showing equalized sound pressure levels.

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**Figure 3:** Coverage pattern of FF 120T speaker with Flat Field Technology showing equalized sound pressure levels.
On average, more speakers are needed in order to approach an even sound field for the room.

**Efficient Coverage**

Figure 5 shows the sound field created by the Extron FF 120T. Overlap requirements of the FF 120T are much less critical since the speaker’s radiation pattern is highly efficient and much wider than a conventional ceiling speaker. This means that fewer speakers are needed to ensure even coverage, which in turn translates to simpler installation and lower cost, both in speaker components and installation labor time. For example, in a room with a ten foot ceiling and an average listener ear height of four feet above the floor, the FF 120T provides an equalized coverage diameter of 20.75 feet that translates to 338 square feet. This is in contrast to the typical ceiling speaker technology which provides a 12 foot diameter of reasonably level SPL for a coverage area of only 113 square feet.

We believe that the FF 120T Flat Field Technology is an important and proactive step toward creating the optimum room sound field, which enhances student learning. Careful redirection and control of sound reinforcement at the outset just makes good sense while costing less in the long run.

**Simplified Installation**

In addition to delivering wide area sound coverage, the FF 120T is designed for quick and easy installation into standard suspended tile ceilings, with the appearance of an air handling vent that blends seamlessly into the ceiling. All that is necessary is to remove an existing ceiling tile, make the speaker wiring connections, and then place the FF 120T onto the T-bar support grid. Multiple seismic tabs simplify speaker anchoring. The process requires minimal effort and time without any pre-installation procedures necessary for the typical round speaker, such as cutting holes through ceiling tiles and mounting supporting hardware.

To complete the installation, simply cut the existing ceiling tile to fill out the space adjacent to the speaker and the included T-bar. The end result is a clean and inconspicuous speaker system that requires just minutes to install. With just two speakers required for the typical 30 foot square classroom, the FF 120T also offers substantial savings in cost and labor time.

**Theft Deterrent**

An additional benefit of the FF 120T design is that its appearance as an air handling vent makes it less prone to theft or tampering, since most people will not recognize it as audio equipment. We designed the FF 120T to blend into the ceiling structure as much as possible. Furthermore, its Flat Field dispersion characteristics make it even more difficult for individuals to localize in the room as a speaker component.

**Flat Field Technology and the Extron S3 Philosophy**

We are proud of our Flat Field speaker technology and invite you to listen to it yourself and decide. Extron is excited and motivated with the opportunity to provide meaningful technical solutions to our industry, our educators, and most of all to those whose life can be enriched through better learning. We see Flat Field Technology as yet another important Solution to offer you that exemplifies our S3 philosophy of Service, Support, and Solutions.

For more information about Extron Flat Field Technology, download the white paper at www.extron.com/flatfieldpaper

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Figure 4: A plan-view illustration of the typical layout for ceiling speakers to obtain enough overlap for sufficient sound field coverage.

Figure 5: A plan-view illustration of how the Extron FF 120T layout attains enough overlap with fewer speakers.

Figure 6: The FF 120T easily installs into a 2’x2’ or 2’x4’ suspended ceiling tile system.